IKEM

July 2018

Decarbonization policies for the building sector in Berlin, Mecklenburg-Vorpommern and Baden-Württemberg

Mapping of selected policies and analysis of their replication potential to other regions in Germany

---

Kopernikus Projects Enavi
Working Package 4 | Task 7 “Technical-systemic analysis with a focus on energy efficiency in buildings”

Conducted by

Alexander Klinge

Task lead by

Dr. Aleksandra Novikova

KOPERNIKUS PROJEKTE
Die Zukunft unserer Energie

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Forschungsinitiative Kopernikus

The Federal Ministry of Education and Research (BMBF) has allocated a total of EUR 400 million to fund the Kopernikus program until 2025. The objective of the program is to develop innovative technological and economic solutions that can facilitate the transition to a more sustainable energy system. Over a period of 10 years, more than 230 partners from science, business and civil society will conduct research in four subject areas: "New Network Structures", "Storage of Renewable Energies", "Reorientation of Industrial Processes" and "System Integration". Researchers are adopting a holistic approach to these four subprojects in order to examine specific issues relevant to the individuals and institutions that play key roles in energy generation, transmission, supply, and distribution. The program's 10-year lifespan ensures that the initiative will include a long-term interchange between theory and practice.

System integration: ENavi

As a participant in the "ENavi" subproject, IKEM is partnering with roughly 90 institutions from the fields of science, business, and law to develop a navigation system that promotes the transition to sustainable energy. Because system integration is vital to the success of comprehensive energy reforms, the program partners' integrative approach includes research on heat, gas, and fuel use. IKEM plays a key role in ensuring that the findings from theoretical analyses can be applied in practice. From the outset, field tests are conducted to assess the concrete technical, economic, and legal implications of the energy transition. Test results can then be applied to other regions. Program partners intend to expand the initiative to include research on 50 municipally owned power generation and electricity distribution companies, or *Stadtwerke*.

This report should be cited as

Klinge, A. 2018. Decarbonization policies for the building sector in Berlin, Mecklenburg-Vorpommern and Baden-Württemberg. Mapping of selected policies and analysis of their replication potential to other regions in Germany. Deliverable of Working Package 4, Task 7. Report of the BMF funded project Enavi. IKEM – Institute for Climate Protection, Energy and Mobility, July 2018.

IKEM – Institut für Klimaschutz, Energie und Mobilität e.V.
Magazinstraße 15 – 16 | 10179 Berlin
+49 (0)30 40 81 87 010 | ikem@info.de

Table of Contents

List of Figures and Tables

I. Introduction

1. Background

European regions play an increasingly important role in the implementation of decarbonization measures. The European Cohesion policy developed eleven objectives, from which the sixth is "Preserving and protecting the environment and promoting resource efficiency. For the planning period 2014 till 2020 with the goal to support "smart, sustainable and inclusive growth" (European Commission, 2010) through investments amounting to EUR 351.8 billion (European Commission, 2015). In light of a widely used European multilevel governance approach the empowerment of the regions and a mix of bottom-up, planning and implementation by regional authorities, and top-down, developing framework and allocating funding, strategies is essential (European Commission, 2011) to fulfill the greenhouse (GHG) emission goals stated in the Europe 2020 Strategy (European Commission, 2010).

Germany has in comparison to other countries like France or the UK a decentralized governance system. German municipalities are granted local self-governance under the German constitution Article 28, § 1-2, if it not interfering with limits set by the German law itself. The sixteen German federal states are working basically as the umbrella organizations of the municipalities and implement the policies to incentivize energy efficiency (EE) measures in the region.

Due to this, German federal state policies play a big role in the implementation chain of EE measures since they are the last policy maker before the actual executive stage and general with a bigger influence radius then a single municipality. Since Germany is moving to a decentralized energy supply system the regions are the most important actors to implement EE measures and prepare the citizens for adoption. From this viewpoint it is not surprising that different federal states and cities have different approaches towards the energy transition and varying measures to achieve their goals. Therefore, it is important to build on regional advantages and respond to particular social and economic barriers to implementation.

EE is one of the most promising and fast to implement measures to achieve lower GHG emissions in a limited time frame (Corrales *et al.*, 2014, p. 9). Therefore, a big variety of policy elements is existing to either set incentives or enforce higher EE among all sectors. The building sector generates in most European regions the highest emissions compared to others. Therefore, it is the most important field of action to implement EE policies.

The paper will explore and group regional policies related to building sector decarbonization implemented in Berlin, Baden-Württemberg and Mecklenburg-Vorpommern in a policy map to make them comparable and test the transferability of policy measures to other regions. The regions are selected because they are representative for the different federal policy environment in Germany. Berlin representing the capital and city state. Baden-Württemberg is representative for the south and has already advanced EE policies implemented. Whereas, Mecklenburg-Vorpommern is located in the former eastern part of Germany and even though it has a high share of renewable energy sources it has no main climate law in place.

While multiple studies identify and qualify important energy efficiency policies implemented at European or German level, a gap of research is existing on the regional sphere. As (Ringel *et al.*, 2016) describe it, there is a considerable expansion of instruments to foster decarbonization measures in the building sector and the development of evaluation tools at federal level realized. But, "It should be noted that the federal states can and do apply additional instruments. However, the impacts of these supplementary instruments are not tracked systematically in the national action plans." (Ringel *et al.*, 2016, p. 1296)

Simultaneous, many decarbonization approaches stress a bottom up implementation strategy and a development in regional policies to empower the execution stage. This generates an importance for a comparison of different policies applied at regional level and an evaluation of their outcomes to advance actual and future policies in European regions.

Furthermore, the visualization of policies is a perfect tool to establish a learning mechanism for all actors involved in the building sector and encourage an information exchange on all policy stages. Therefore, the present report will rely on visualization to promote further knowledge exchange and get new actors involved. It also serves as an information basis for stakeholder, planning on implementing EE measures in their building stock.

2. Aim, objectives and tasks

To address the gaps mentioned above the aim of this report is to assist the evidence based improvements of GHG mitigation policies in the building sector at regional level by visualizing implemented policies via mapping and facilitate learning mechanisms between different German regions.

To address this aim, the objectives of the paper are:

- To identify, analyze, classify and visualize the EE policies at regional level in several representative regions in Germany

- To highlight the interconnection of policy elements by pointing out similarities in implementation or goal setting and tracing back source laws and strategies on German/European level.
- To compare implemented policies among different regions in a descriptive policy map, identify differences and test their transferability to other regions

To realize the objectives above, the report tasks are:

- Conduct a literature review to:
    - Detect the emission volume of the building sector and distinguish exiting barriers to EE policy implementation
    - Classify the approaches detected in existing literature
    - Combine reviewed studies and their results to establish consistent approach for the report goals
    - Develop the report methodology based on the beforehand conducted analysis
- Identify relevant policies at the European, German and regional level for the selected federal states
- Classify and compare the allocated policies using a policy map approach developed in the methodology and based on reviewed mapping schemes
- Draw conclusions on lessons learned by comparing similarities and differences of these policies
- Expand conclusions in regional case studies to develop best practice examples
- Discuss in how far the best practice examples are replicable to other regions

3. Report structure

The report is structured in 8 chapters. After the justification of the importance and contribution of the research and stating its aim, goal, objectives, and task in Chapter 1.

Chapter 2 reviews studies about the current state of emissions from the building sector and the barriers associated with its decarbonization. Then it describes the present state of research literature concerning policy identification and classification, European multilevel governance and policy mapping. In particular, the literature focusing on decarb policies for the building sector will be reviewed, if available.

Chapter 3 details the methodology of the present research based on the review of methods conducted in the previous chapter to identify, test, compare and map policies.

Chapter 4 summarizes applied policies on European, German and regional level while also attempting to classify them under the beforehand established categories using the methodology above.

Chapter 5 will condense the conducted research in the previous chapters to one policy map using the combination of mapping approaches developed beforehand.

Chapter 6 discusses the findings from the previous sections to narrow down the content to answer the research question. Moreover, the best practice examples through in depth case studies of the selected regions will be developed and tested in terms of the transferability to the other regions.

Chapter 7 will summarize the results and give recommendations for further policy development and research

II. Literature Review

1. Background information

a) Emissions in the building sector

Direct or both indirect and direct GHG emissions associated by the building sector in Germany steadily increased during which years?? and peaked in 2013 at 9.5 gigatons CO2-eq. from there a reduction to 9.0 Gt in 2016 was realized. While the emissions generated by the building stock decreased due to new energy production policies, the energy consumption of the building stock experienced a steady growing development since 2010. Also due to an increasing floor area in the same time period energy consumption rose from 119 EJ in 2010 to 124EJ in 2016. (IEA, 2017, p. 78)

In Germany a different path of development in building relevant CO2 emissions and energy consumption can be observed. With a peak of 3.62 EJ in 2010 the overall trend was a declining energy consumption by 11% in the building sector to 3.07 EJ in 2015. Recognized by the statistic are all residential and commercial buildings and hereby the spheres of heating, hot water, cooling. And in the case of residential buildings also the installed lightning infrastructure. The energy used in all spheres was generated to 87.2% from fuel and 12.8% from electricity. The development of building relevant CO2 emissions was similar to the energy consumption. While the peak with 255 Mt CO2 emissions was in 2010, the overall development was a decline about 18% from 2008 to 2015. The emissions declined from 254 Mt in 2008 to 208 Mt in 2015 and the lowest realized emissions were in 2014 with 205 Mt. Important to note is the fact that CO2 emissions in the building sector are calculated in form of the polluter balance. Hereby, all emissions generated by the operation of the building are attributed to the CO2 balance sheet. In contrast, the direct emission balance is calculated with the source principal. In the case of the building sector this would mean just the emissions generated by the actual heating of the building and electricity needed for lightning and ignoring the emissions generated by the production of distance heating systems or thermal pumps. Since energy efficiency measures are most often tackling the polluter this is the balance of choice (BMWi, 2017, p. 35).

b) Barriers to energy efficiency improvements in buildings

In 2010 the GHG emissions of the building sector amounted to 19% of the energy related total and accounted for 32% of the global final energy use. Therefore, the building sector represents

a big challenge for future GHG reductions and a way into a low carbon future. Even though improving EE standards in buildings is a widely recognized, promising environmental strategy there are nevertheless barriers to implementation. But the approached towards higher EE in the building sector varies widely from country developing to developed countries. While the biggest challenge in developing countries is to offer a sufficient energy supply for energy service in new building types, in developed countries the energy demand by existing buildings is highly inefficient and energy use is uneconomical. The paper will concentrate on the European building sector due to the high saving potential through energy efficiency measures. To understand the slow development of energy saving in buildings it is important to point out the barriers existing in the building sector towards increased energy efficiency. (Brown *et al.*, 2007) produced a major list of barriers hindering the uptake of cost-effective measures towards increased energy efficiency.

Hereby, the strongest discovered barriers are institutional. This means that the decision-making process and the environment are highly complex and fragmentated. The resulting clash of interests between investors, tenants, owners, architects, energy service providers and all further market players slows down the process of widely deployed GHG mitigation technologies and further research in that area.

Distorted information about existing cost-effective technologies is a further problem. The information needed to evaluate measures important for a specific actor is hard to obtain or incomplete. Since energy use in most cases is calculated as a whole and not broken down into the different cost units, benefits from new implemented technologies is quite difficult to appropriate to singe their costs. Here again the fragmentated market structure comes into play, since an information obtained by one actor might not be interesting for him but for another player on a different stage who has no possibility to access that information and vice versa.

Moreover, the high upfront costs to realize energy efficiency improvements in buildings are a key problem. While many households and building owners see the benefits of efficient technologies the sensibility to the acquiring costs is way higher then benefits obtained over the life cycle from the purchased technology.

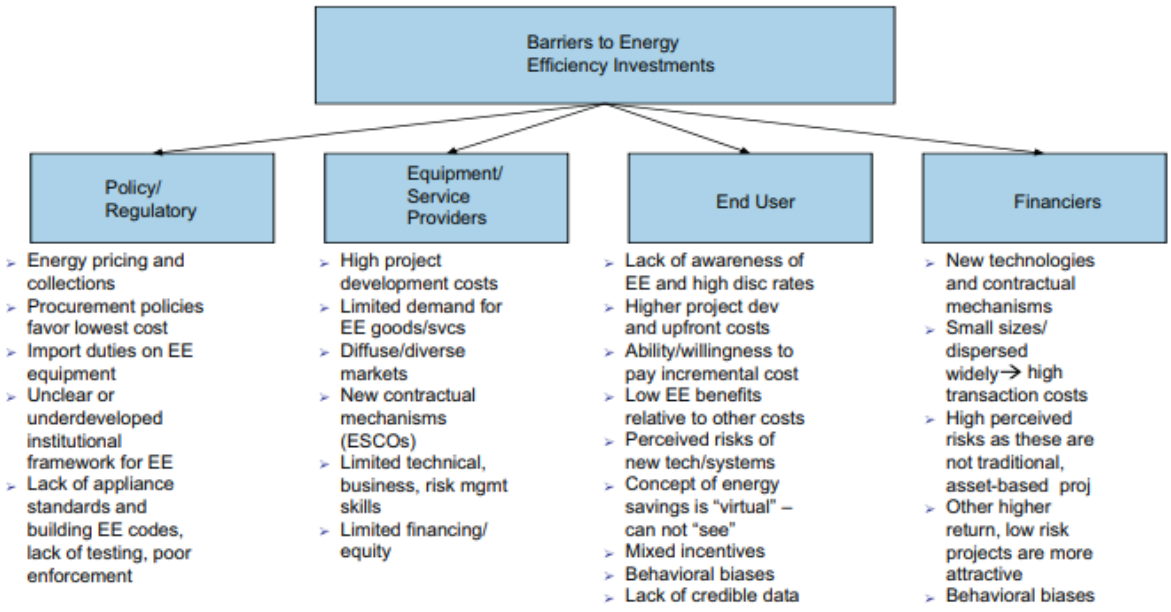
Besides the high upfront costs new technologies also inherit the risk of low performance due to different circumstances. The cost effectiveness of energy efficient equipment is highly situation dependent and can be difficult to predict.

Furthermore, the existing split incentives in advanced building energy performance is an often-cited barrier to implementation. While the building owner or constructors bear the costs for the replacement or installation of energy use improvements the tenants and apartment owners are the ones benefitting from them. Since 90% of all households in multifamily buildings are renters this is a major obstacle to overcome and the reason why most landlords do nor invest into energy efficient retrofits and construction parts.

In the case of low income households and small businesses the uncertainty about future energy prices and policies combined with a more difficult access to the financial market hinder investments into energy efficiency.

Besides the mentioned economic barriers there are also deeply rooted social barriers. The main obstacle is the lack of information the average society can obtain. While the scientific discourse incorporated many measures to boost the topic of energy efficiency in the building sector many energy consumers have nearly no knowledge about existing technologies or their environmental impact. This leads to a wasteful energy consumption behavior, where new technologies are ineffective if they are not combined with an educational approach (Allouhi *et al.*, 2015). A comprehensive list of discovered barriers to EE improvements is shown in Figure 1.

Figure 1: Barriers to EE investments



Source: (Sarkar and Singh, 2010, p. 5562)

2. Theoretical Background

a) Policy identification and classifications

Various attempts have been conducted to classify different policies under categories and instrument groupings. One was made by (Koeppel and Ürge-Vorsatz, 2007) as a background research for the IPCC IV AR in their work: "Assessment of policy instruments for reducing GHG emissions from buildings", where they developed twenty worldwide used key policy instruments for GHG emission reduction in buildings and classified them under four categories. Namely, control and regulatory instruments; economic and market-based instruments; fiscal instruments and incentives; as well as support, information and voluntary actions.

The other major piece of research is summarized in the MURE database coordinated by the French Environment and Energy Management Agency (ADEME) together with 37 partners from 31 countries (MURE, 2018h). The database condenses energy policies for all European countries in one database. In the field of EE in the building sector they developed seven policy types:

- Legislative/Normative,
- Legislative/Informative,
- Financial,
- Fiscal/Tariffs,
- Information/Education/Training,
- Co-operative Measures,
- Cross-cutting with sector-specific characteristics

(Girod *et al.*, 2017, p. 229) condense these seven policy types to four categories in, namely: Standards, monetary incentives, information, voluntary agreements and others, to conduct their research about the innovation potential of different EE policies in European countries

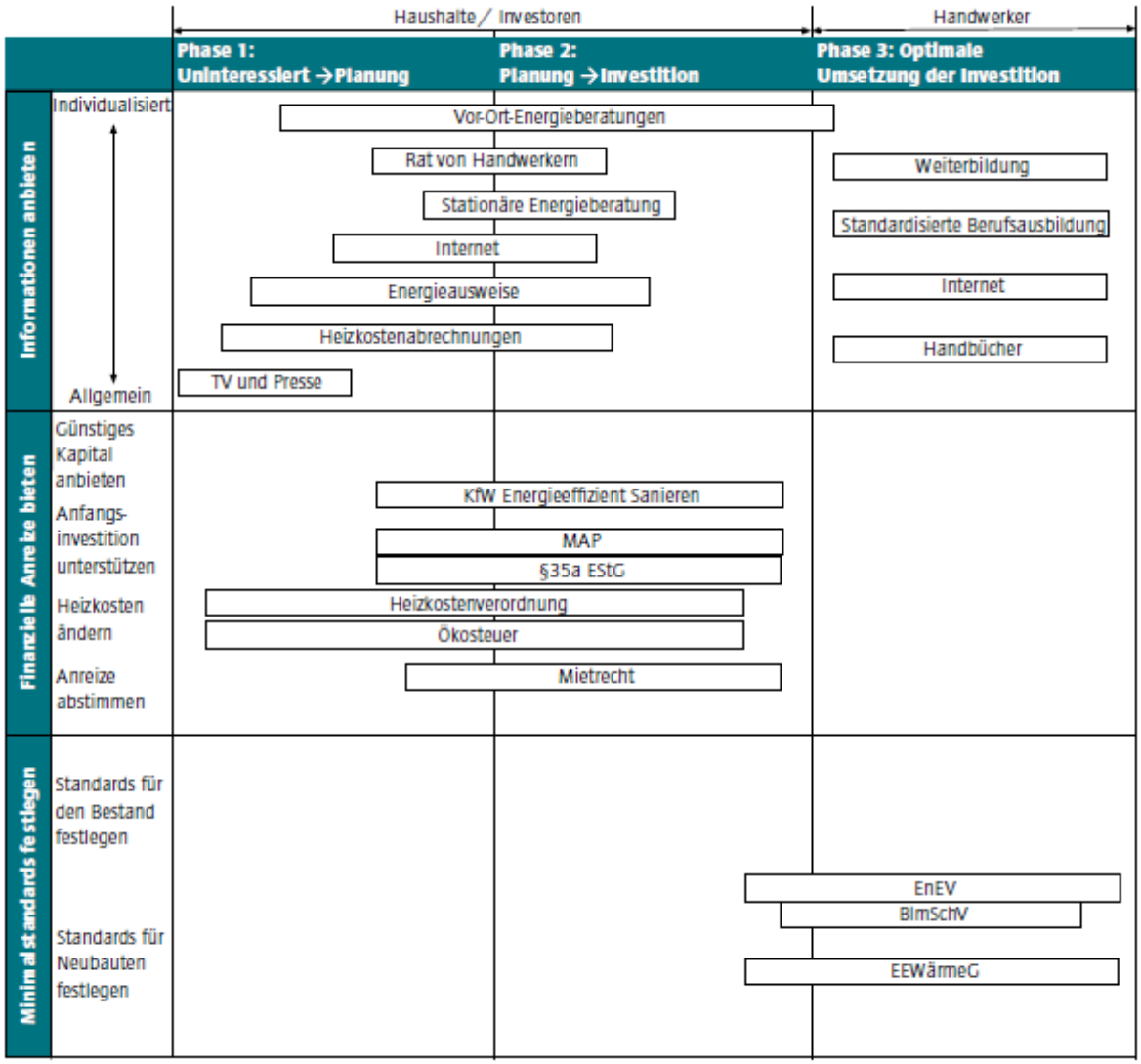
There is various literature existing concerning the classification of policies, so the work for the MUSE database and the background research for the IPCC IV AR were reviewed as the most comprehensive ones worldwide. In conclusion, there are multiple ways to establish a consistent classification approach. It depends on the research question as well as the policy environment focused on. What is clear is a basic split off between market based and command and control instruments. From there more subcategories are possible, depending on the specific research focus and the policy environment. The developed methodology for the present report will be presented in the following chapter. (Koeppel and Ürge-Vorsatz, 2007).

b) Policy mapping

The mapping of polices in the building sector is used by this research to visualize complex relations between laws, policies and strategies to make an abstract concept easier to understand and manageable. In fact, mapping approaches in the building sector are often used to enhance consumer responsibility about their energy consumption by visualizing collected consumer data. While this consumption approach is resulting in geographical energy use maps, the idea can be also taken to show relations and effects of policy instruments (Reul and Michaels, 2012). To give an overview, this section will review different approaches towards policy mapping established in selected research papers.

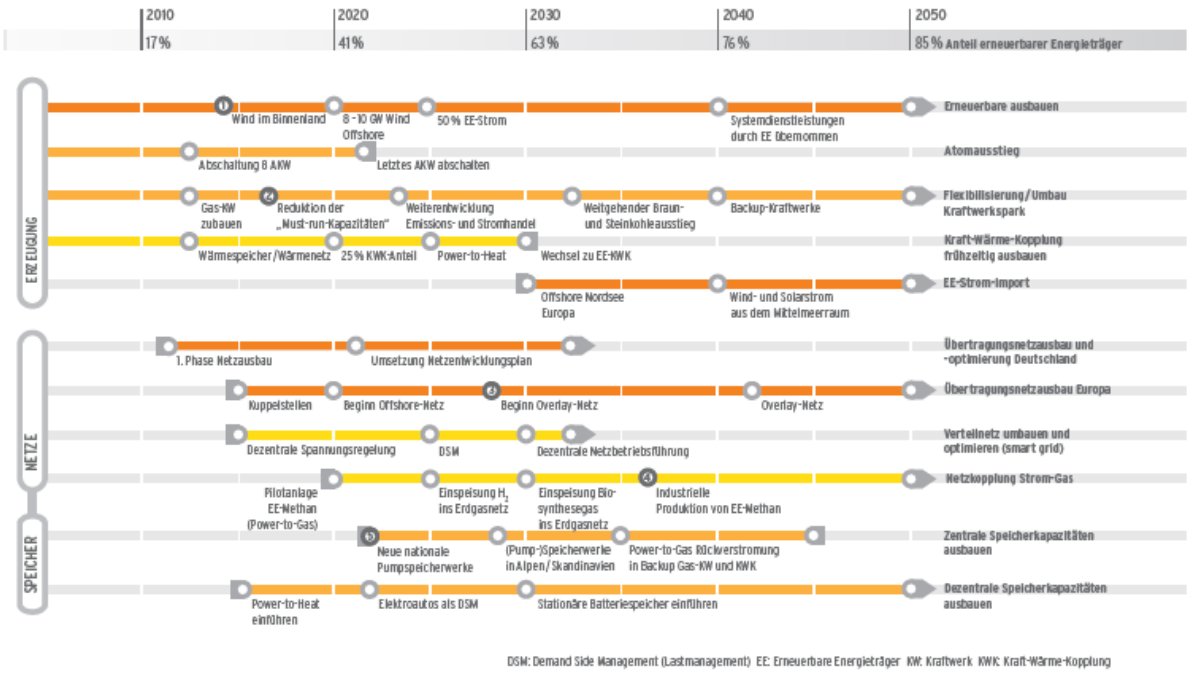
(Neuhoff *et al.*, 2011) for example summarized Instruments and programs for a reduction of energy used for heating in a map, combining three phases of individual adaption and three categories of political instruments. On the vertical axis they used the three instrument classifications: establishing minimal standards, set financial incentives and offer information about optimizing energy use for heating. The horizontal axis offers an overview of the different adoption phases separated into crucial changing points: From disinterest to planning, from planning to investment and at least the execution of the investment. The specific instruments, for example subsidy programs for energy efficiency updates, are grouped to one of the categories and spanned over the phases where they are important. The map is illustrated in Figure 2.

Figure 2: Policy map developed by (Neuhoff *et al.*, 2011)



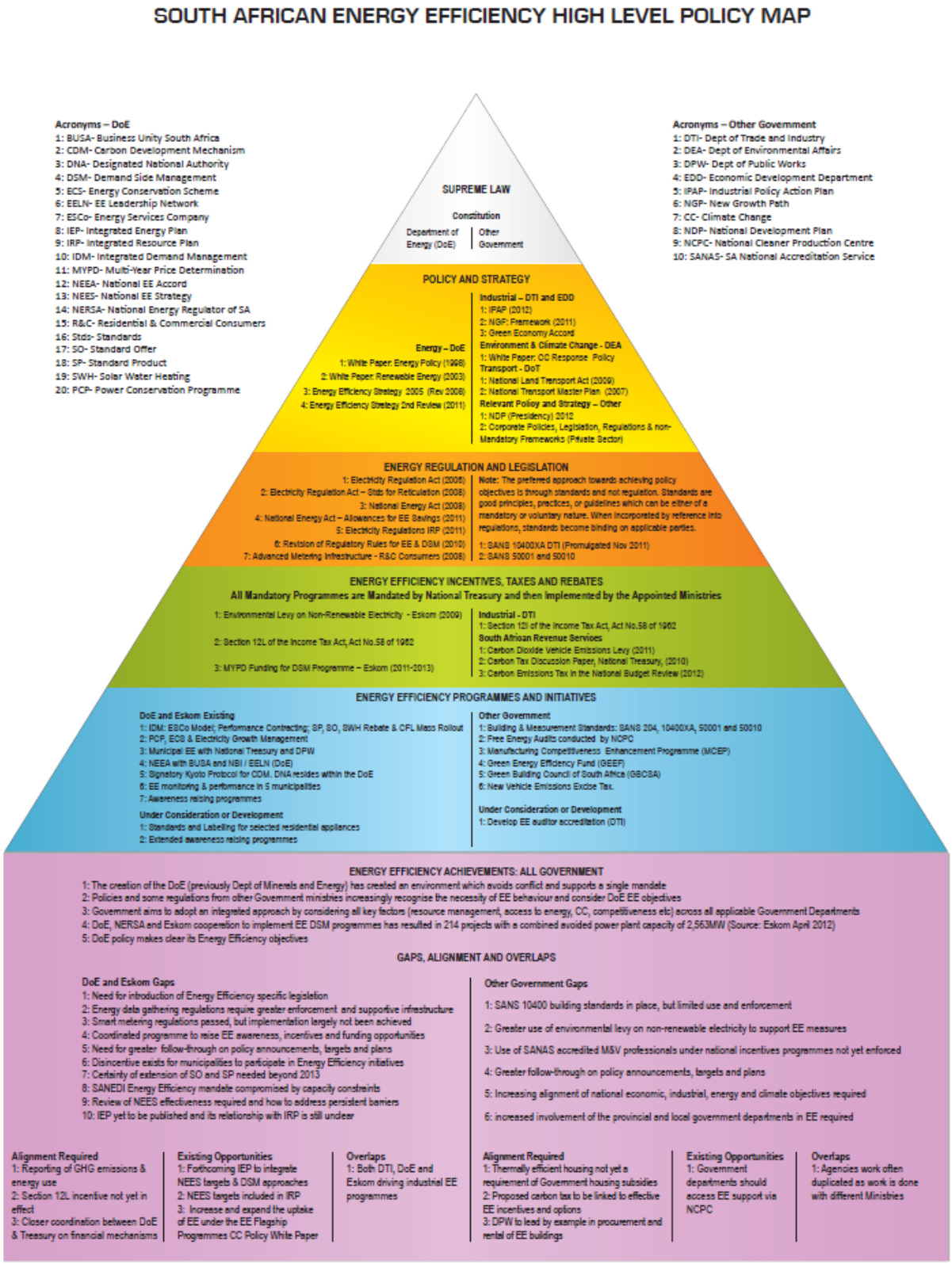
Whereas, (Pehnt *et al.*, 2012) developed a comprehensive roadmap of the German energy transition over time and for different fields of action. They made a single map for every field of action, e.g. energy production, and split the vertical side into the different affected sectors. Over the horizontal side they span a time series from 2010 to 2050. In different colored arrows the essential steps towards the central goals of the energy transition strategy are visualized and result in a map resembling a metro timetable.

Figure 3: Energy transition roadmap developed by (Pehnt *et al.*, 2012)



Furthermore, (Covary and Averesch, 2013) developed a policy map for the South African legal environment. They used the shape of a pyramid to visualize the what or hierarchy of energy efficiency laws, directives and policies and separated it vertically into two spheres of origin, the Department of Energy and other decision-making bodies. The fundament of the pyramid is a square block summarizing the achievements generated by the implemented policies and regulations as well as existing gaps and overlaps.

Figure 4: Energy efficiency policy map developed by (Covary and Averesch, 2013)



Overall, the mentioned reports, even though they are extremely different in content and mapping approach, follow the same objective. The goal is to visualize a complex interrelation of policies by condensing them into one diagram and make them easy to understand through different graphical strategies. Thus, the findings of the studies get easier to perceive for every interested party, regardless their background.

c) Best practice examples

The in beforehand developed policy classification will be used, in combination with further indicators, to identify best practice policies. Best practice in the political sphere could be defined as a policy instrument generating the best outcomes compared to other similar implemented policies (Bergek and Norrman, 2008, p. 6). Therefore, it is the chosen method in the present report to condense findings into real examples and give recommendations for implementation.

(Mosselman *et al.*, 2004) conducted an evaluation study about state aid and defined evaluation as: *"the systematic investigation of the effectiveness of (economic) intervention whereby the performance of support measures is judged against pre-specified standards or criteria" (Mosselman et al., 2004, p. 23).* In conclusion an evaluation of outcomes of a political intervention can also be conducted by measuring its effectiveness and the performance. The effectiveness can be derived from the policy comparison and the performance refers to the realization of the intended goal setting during the introduction of the political intervention.

d) Transferability of regional policies

(Williams and Dzhekova, 2014) conducted a comprehensive research about the transferability of policy elements. Hereby, they detected two main spheres of importance, namely the applicability (feasibility) in the receiver country and the general transferability (generalizability) of the policy element. They based their results on the study about health care policy transfer by (Buffett *et al.*, 2007), who developed main attributes for the two spheres:

1. Attributes for *Transferability*: magnitude of issues in local setting, magnitude of reach or coverage, cost-effectiveness, target group characteristics
2. Attributes for *Applicability*: political climate, political barriers, social acceptance, locally tailored intervention, available essential resources and identified organization(s) to provide intervention; organizational expertise; and capacity

The research project TRANSPOSE, funded by the German ministry of research and education (BmBF), is focusing on the transfer of political instruments for energy savings in private

households. Within the Project, working package 7 is analyzing the transferability of policy instruments, implemented to encourage private households to save energy, from other European countries to Germany. In two working paper for the project (Bürger, 2011) and (Tews, 2011) tested the transferability of two policy elements, an electricity saving quota and electricity efficiency tariffs for consumers, from European countries, where they are implemented, to Germany, where an employment of these instruments would be favored.

Both studies conclude that there is a neither the political nor the legislative framework in Germany to implement one of the both policies at the moment. Furthermore, they develop fields of action in the German policy environment to make a transfer of policies possible. Bürger (2011) draws these conclusions from comparing Germany with the example countries in the light of six, for the implementation relevant, context factors, namely: number of obliged stakeholders, distribution of size between obliged enterprises, competitor structure, institutional framework, degree of additionality and depth of monitoring.

Tews (2011) is using a similar approach without a transferable category set but a rather specific mix of dimensions applying in the examined policy case. Overall, both transfer test approaches follow the paradigm of finding crucial dimensions for successful implementation and then test if these are also given in the policy environment the instrument should be transferable to.

III. Methodology

1. Policy instrument classification

At first, the selected regions, Berlin, Baden-Württemberg and Mecklenburg-Vorpommern, will be analyzed concerning EE-related policies implemented to decarbonize the building sector. These policies will then be classified and categorized into sub-sectors where they mostly apply. The results will then be summarized in a policy map.

To archive this target, an in-depth literature review was chosen to start with. Secondary literature about policy mapping in different policy environments will be considered and will be analyzed to establish a consistent approach for the categorization of the different dimensions in the policy map.

The selected Instrument classification is based on the reviewed studies in section two. By comparing the different approaches to each other and considering the building sector as field of action for decarbonization measures, a condensed classification method will be established. The policy categories of regulatory, informative and financial tools were derived for the present report from the conducted studies.

To assess regional policies and group them into categories, the review will be conducted based on a mix of online sources, state environment agency websites and published reports by governments or other public and semi-private sources.

2. Policy mapping

A mix of the above reviewed mapping approaches will serve as the foundation to establish a policy map suitable for the policy environment applied to decarbonize the building sector. After the collection of important data and the detailed review of regional policy elements the in beforehand classified policy instruments will be grouped after sectoral importance. Following the idea of (Pehnt *et al.*, 2012) the policy instruments will be grouped to the sectors where they apply, namely residential and non-residential buildings.

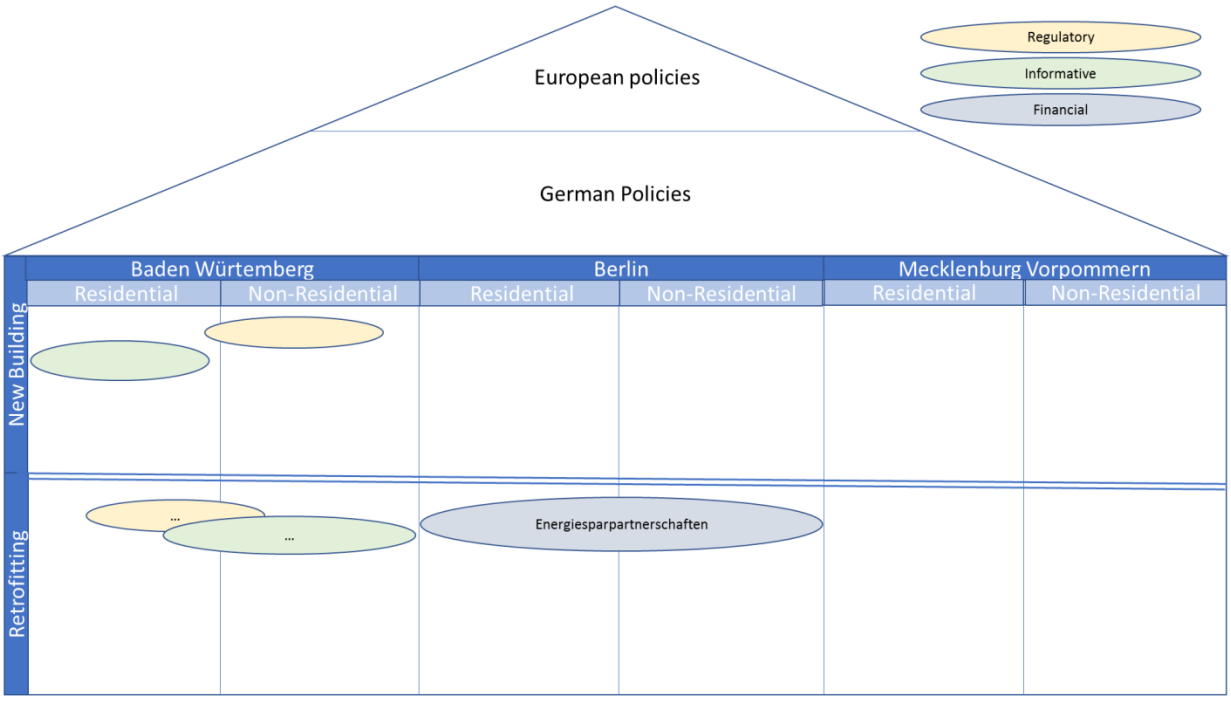
Furthermore, the map will be divided into measures promoting the retrofitting of existing buildings or the construction of new buildings. Thus, applied policies most often focus rather on one of the two categories of energy efficiency updates. Through the separation the map will be more lucid and comparable.

After the grouping, the differences of strategies and applied policy instruments will be visualized and collected in a table. The method of presenting the results in the table is similar to (Covary and Averesch, 2013), but instead of a pyramid used by these authors, a house shaped diagram will be established to show the hierarchy of policies. In this case, the European policies on top and the German policy landscape underneath will build the "roof", while the "body" of the house will be split between the federal states. These will be divided vertically into the residential and commercial building sector on the x-axis and between retrofitting or new building measures on the y-axis.

With different colors the categorization of policy elements should be highlighted and by this lead to a comparable policy map of the different federal states. So, the horizontal axes will build the split off between residential and non-residential buildings.

The policy instruments will be visualized with colored ellipses stretched out over the sectors where they apply, comparable with the mapping approach of (Neuhoff *et al.*, 2011) where the instruments were stretched out over different phases of adoption. The different colors will then show the different classifications of policy instruments, so financial, regulatory or informative. Therefore, the policy map will summarize the important strategies and measures for EE in the building sector for commercial and residential buildings as well as the differences to the other regions and can help to give future recommendations for advanced EE policies in the building sector at regional level. The prototype or sample is presented in Figure 55

Figure 5: Policy map prototype



3. Regional case studies: best practice examples and transferability

As a final step, in-depth case studies for the selected federal states will be developed. Hereby, the effects of the implemented policies and strategies will be stressed and outcomes will be evaluated. Best practice examples will be developed based on the policy evaluation.

Best practice policies provide the evidence of policy achievements by being examined in terms of success factors and quantifiable outcomes. The reviewed literature about best practice determination follow the logic of evaluating the effectiveness and the performance of a policy. In this case, the effectiveness can be understood in how easy the policy can be implemented and how efficient is the regulatory framework and the performance can be quantified in how far the policy meets the goals set for it. (Bergek and Norrman, 2008).

The extracted best practice examples of applied policies in the federal states will furthermore be tested in their transferability to other regions. Hereby, a set of political and legal framework dimensions, essential for a successful implementation of decarbonization policies, will be derived from the reviewed literature in chapter two. Since the reviewed study by Bürger (2011) was focusing on energy saving policies in different European countries, the developed dimensions have to be modified to serve also a regional transferability study. Hereby the developed attributes by (Buffett *et al.*, 2007) will be considered to establish transferability attributes to test regional transferability of applied decarbonization policies in the building sector.

Following Bürger (2011), the by the policy affected stakeholder groups will be examined, which already includes the target group characteristics, as referred to by Buffet *et al*. (2007). Based on the attributes, "available essential resources and identified organization(s) to provide intervention; organizational expertise; and capacity", also the inner state institutional framework will be evaluated in regard of leeway for implementation. To combine the attributes, "magnitude of issues in the local setting and magnitude of the reach or coverage" the composition and noteworthy characteristics of the building stock will be contrasted with the constellation in other states. Also important to evaluate are the funding possibilities available in one policy environment and which can differ strongly from region to region (European Commission, 2011).

Based on the literature review, the preliminary list of indicators to test the transferability of policies applied to decarbonize the building sector includes:

- Similarity of Stakeholder interests.
- Magnitude of issue in regional framework.

- Addressed target group characteristics.
- Degree of additionality.

These are chosen based on the reviewed literature and combining the applicability and the transferability of policy elements This list will be reviewed and finalized during the course of research. The test will be based on a qualitative evaluation of the indicators, which can be used to suggest or oppose further research on how to implement a specific policy element in another region.

IV. Policy Elements

The chapter will offer a comprehensive overview of applied decarbonization measures in the building sector at different policy levels. Therefore, the following paragraphs will summarize the most important policies implemented on the European and German level. Afterwards energy efficiency policies implemented at regional level will be examined in detail for the German federal states, Berlin, Mecklenburg-Vorpommern and Baden-Württemberg.

1. European Policy Environment

European buildings contribute to 40% of the energy consumption and are responsible for 36% of CO2 emissions in the EU. Since new buildings consume three to five liters of oil per square meter and older buildings consume an average of twenty-five liters for heating, incentivizing EE building updates as well as further fostering EE in new buildings is a key challenge for European environmental policies. Moreover, 35% of buildings in the EU are older than 50 years, which makes retrofitting measures a main field of action. The estimates of the European Commission conclude that an EE improvement in the building sector would result in a 5% emission reduction. Therefore, the 2010 Energy Performance of Buildings Directive and the 2012 Energy Efficiency Directive were developed to set an European EE framework containing reduction targets and mandatory measures and represent the EU's main legislation to reduce energy consumption of buildings (European Commission, 2017a). The contents as well as main funding possibilities and financial incentives are summarized in the following paragraphs.

a) Energy Performance of Buildings Directive

At the European level the Energy Performance of Buildings Directive (EPBD) (European Commission, 2002) was a major step towards increased energy efficiency in the building sector. Key aspects of the Directive are minimum standards for energy performance of new buildings and retrofitting measures as well as the introduction of a certification scheme in the residential and non-residential building sector. The directive got renewed by its recast in 2010, which further specifies actions Member States (MS) are obliged to and reinforced the 2002 directive in more detail.

In short, the directive obliges MS to introduce:

1. Building codes setting minimum energy performance requirements for new buildings and retrofitting measures.
2. Actions that all new buildings will be nearly zero energy buildings by the end of 2020.

3. Building energy performance certificates.
4. Inspection schemes for the Heating, Ventilation and Air Conditioning (HVAC) systems.
5. National financial incentives to foster EE in buildings (European Commission, 2017a).

The obligations in the directive follow the logic of minimum standards, leaving the leeway to implement stricter regulations at national level (EPBD Recast, 2010, Article 1 (3)). Furthermore, the minimum standards set up in the directive are only obligatory if they are economically cost effective over the implementation period in the MS (EPBD Recast, 2010, Article 4 (1)). The minimum standards are calculated with a universal established method and implemented at national level. Therefore, they are part of the national reports on energy performance requirements and are updated every five years (European Commission, 2017a).

While the minimum standards for building codes are country dependent, the obligation for all new buildings being nearly zero-energy buildings by the end of 2020 is universal. Public owned buildings should be updated even until the 31.12.2018. Compared to national implemented minimum standards this is stated as a clear goal with an implementation deadline (EPBD Recast, 2010). Moreover, detailed national energy efficiency action plans (NEEAP) on how to reach this goal have to be submitted to the Commission in a three-year interval, containing comprehensive financial, regulatory and informative actions.

The introduction of energy efficiency certificates for buildings is mandatory for all MS. They must contain the national minimum standards set by the building codes to establish a comparative information mechanism for flat owners or tenants about the energy performance of their buildings. This applies for new buildings as well as after retrofitting measures. While they also contain proposals for actions to enhance the EE in the related building, the implementation of these actions is not mandatory (EPBD Recast, 2010, Article 11,12)

After the same logic as the building certificates also a detailed inspection of the HAVC system in buildings is mandatory after the EPBD. While it is obligatory to get the efficiency factor and further aspects of the HAVC system checked by independent professionals in a regular time interval, the frequency of the inspections can be defined at national level and is further restricted by the cost effectiveness. (EPBD Recast, 2010, Article 14 ff.) The outcoming update recommendations are not backed up by penalties for non-compliance and therefore a pure informative law as the beforehand described certificate scheme.

Complementary to the soft regulatory and informative policy instruments, the directive also calls for the development of appropriate financial instruments to incentivize EE updates in the

building sector. Therefore, MS have to develop an inventory of all applied and planned financial incentives at national level and submit it to the Commission every three years as updated list. The Commission will then test the applied instruments concerning their adequacy, effectiveness and coordination (EPBD Recast, 2010, Article 10)

In general, the EPBD builds rather a soft law framework, since sanctions are applied at national level and defined by the MS themselves. The directive states that the sanction must be "effective, proportionate and deterrent" (EPBD Recast, 2010, Article 27), which leaves a big interpretation and implementation leeway for the MS. This is also apparent through the big variety of energy efficiency laws on national basis in the EU.

b) Energy Efficiency Directive

The 2012 Energy Efficiency Directive builds another key law for EE improvements in the European building sector. The directive is building rather on a strategic framework for EE improvements instead on clear achievement goals. In line with that, MS are obliged by the directive to formulate clear EE goals in terms of primary energy as well as energy end use savings until 2020. These have to be explained by available data and must be in accordance to the overall EU 2020 energy saving goal of a primary energy consumption of 1 474 Mio. t oil equivalent (Energy Efficiency Directive, 2012, Article 3).

Moreover, MS are obliged to develop a strategy to incentivize retrofitting measures for EE updates on existing buildings. Through an overview of the national building stock for every MS and a determination of cost effective retrofitting concepts the foundation for effective strategies and measures incentivizing EE building updates should be established. This strategy was first summitted by all MS on the 30. April 2014 and must be updated in a three-year period since then. (Energy Efficiency Directive, 2012, Article 4)

In the further Articles the directive refers mainly to the EPBD in concreate goal setting and thereby builds the strategic framework for the implementation of it. It also further summarizes EE measures and strategies in other sectors and is the main piece of European legislation in the EE field. These sector specific strategies are then further specified in other directives, such as the EPBD.

c) European financial incentives

Over the past years an increase in public funding at European level for energy efficiency measures was realizable. But following estimates of the European Commission additional EUR 177 billion a year from 2021 to 20130 are needed to achieve the 2030 energy and climate ob-

jectives. Therefore, the EU is further allocating funds and grants to support energy efficacy updates in the residential and non-residential building sector (European Commission, 2017b).

Numerous funding possibilities are existing at the European level as increasing public and private investments into sustainable energy projects is a key priority. EE projects can be funded under the Cohesion Fund, the European Regional Development Fund, as part of the European Structural and Investment Funds (ESIF) or by The European Investment Bank (EIB).

As an addition to the ESIF and in cooperation with the EIB the Smart Finance for Smart Buildings Initiative (SFSB) was launched in 2016 to unlock additional EUR 10 billion of public and private funding. The goal setting is to achieve further EE projects through financial intermediaries and investment platforms. Furthermore, the fund aims at a higher effectivity of public funding and the development of further energy financing models, such as energy performance contracting. Also the assistance in the project development from European side should be reinforced and improved (European Commission, 2016).

There are multiple options to allocate funding for EE improvement project at European level. The structure of funding is dependent on the exact EE update which should be undertaken, but the most important funding options are named above. The SFSB can be seen as the most recent development in the EE for buildings funding at European level and is therefore explained in more detail.

2. German Policy Environment

Germany is ranked as the eighth largest emitter in terms of energy use of the world and the biggest European energy consumer in 2012. Simultaneous Germany is the fourth biggest economy worldwide and in its energy demand completely dependent on imports due to low fossil fuel reserves. Tis gave the pre- conditions for the pole position of German EE policies in an international comparison. The circumstances of 97% oil and 87% gas imports of demanded energy gave rise to the importance of the development of RES and the ambitious EE goals. Thus, EE improvements generate higher energy security with a limited production from RES and should lead in the long term to further energy independency of Germany (Nejat *et al.*, 2015, p. 853)

The political environment in Germany is also under the leading political programs in terms of strict EE measures in the building sector. Due to the strict subsidiary system implemented in Germany a steady tightening of measures is taking place. At state level the implemented political instruments represent the consensus of all federal states and the obliged policy implemen-

tation resulting from European directives. If a federal state implements instruments exceeding the standards agreed at state level and which then prove to have positive impacts the federal state can try to make the measure mandatory at state level for all other states.

Which additional measures are implemented at federal state level will be summarized in the next section. In the following the decarbonization policies applied in the building sector of Germany will be explained. The policies will be categorized into regulatory, financial and informative instruments and will be discussed by their impact in terms of energy savings.

a) Regulatory instruments

The mayor regulatory policy instrument in Germany to decarbonize the building sector is the building code. Building codes got established in Germany at state level in the late 1970s. In the beginning of 1977 the codes were introduced to regulate the use of building components in new buildings. Over the past 40 years the codes got further developed to establish a holistic approach towards higher EE in the building sector. Minimum requirements were tightened in existing dimensions and further requirements for new buildings as well as retrofitting measures were added over time.

Requirements set by the building codes are covering the following energy uses and functions:

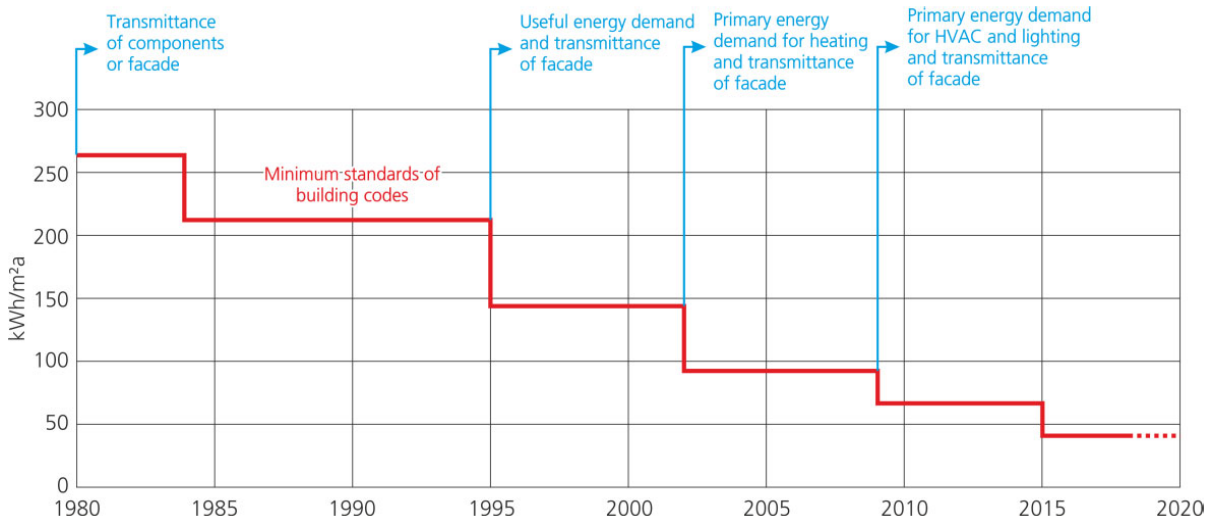
- Heating
- Cooling
- Dehumidification
- Ventilation
- Airtightness
- Thermal bridging
- Hot water
- Technical installations
- Lighting
- Design, position & orientation of building
- Passive cooling
- Renewable Energy (solar, PV, others):
  Requirement of heat supply based on renewable energy 15 ~ 50% depending on the type of renewable energy and building. (GBPN, 2017)

Primary energy demand requirements are set by minimum standards dependent on the size and type of building and requirements for different building components are defined by specif-

ic u-values. The requirements are set by the German energy savings ordinance, Energieeinsparverordnung, (EnEV), which is tightening the minimum standards for new buildings and retrofitting over time (ACEEE, 2016). The EnEV 2014 is setting the minimum standards for retrofitting measures while the standards for new buildings got strengthened again in the EnEV 2016. The performance of renovation is not mandatory, but if a landlord decides to retrofit the building the measures have to comply with the EnEV 2014 standards

The development of minimum requirements over time for new buildings is summarized in Figure 6:

Figure 6: Minimum energy performance requirements for new buildings in Germany



Source: (ACEEE, 2016, 9-4)

As shown in Figure 6, over time more appliances get allocated to the primary energy demand and simultaneous the minimum standard for new buildings in kilowatt hours per square meter and year get further tightened with every new EnEV release. From the first introduction of the EnEV in 2002, as a recast for the in 1978 established thermal insulation ordinance, Wärmeschutzverordnung, (WSchV), with a minimum requirement of 100 kWh/m^{2}a to the planned goal of 0 kWh/m^{2}a in 2021 (Michelsen and Ritter, 2017, p. 788).

Since building codes are a part of the mandatory actions defined by the EPBD and also part of the NEEAP, the realized savings have to be reported and estimated for coming years. Furthermore, Article 7, EED, obliges MS to introduce an EE obligation scheme as well as further policy measures to foster EE updates in all sectors. Moreover, it is mandatory to include an assessment of the taken policy action into the NEEAP and report them to the Commission (Energy Efficiency Directive, 2012)

The results of the impact evaluation for building codes in Germany are summarized in Table 1. The impact evaluation is not split in residential and non-residential sector but gives a good overview of the impact of the building code in Germany over time. The yearly new savings are decreasing in both, the existing and new building stock, over time due to a decreasing saving potential with increasingly applied EE measures and tighter restrictions over time (Ringel *et al.*, 2016, p. 1296).

Table 1: Impact assessment of the EnEV 2014 in terms of energy savings

Energy Savings Ordinance (Energieeinsparverordnung - EnEV)	**Article 7 notification**									
	Existing Stock									
Final Energy (PJ)	2009-2013	Milestone 31.12.17	2014-2020	2014	2015	2016	2017	2018	2019	2020
Yearly new savings	-	-	-	10.7	10.7	9.7	9.7	9.7	9.7	9.7
Yearly savings with lifetime (estimate)	-	-	-	10.7	21	31	41	50.5	60	70
Cumulative savings	338	104.3	283.5	10.7	32	63	104	154.5	214.5	284
	New Construction									
Yearly new savings	-	-	-	4.1	4.1	2.5	2.5	2.5	2.5	2.5
Yearly savings with life time (estimate)	-	-	-	4.1	8	10.5	13	15.5	18	20.5
Cumulative savings	144	36	91	4.1	12	22.5	35.5	51	69	90

Source: (MURE, 2018f)

There are some further regulatory instruments established in Germany, but mostly with minor impact. Such as the climate-friendly building and housing strategy, which is the long-term political framework strategy of Germany aiming at focusing the EE approaches of different government stages. By that trying to combine strategies for cities, neighborhoods and single buildings under one development strategies. Measures under the strategy include the aim of a climate neutral building stock until 2050 and the energy efficiency strategy for buildings (ESG), which was decided in 2015 by the federal cabinet.

Since the strategy is aiming at a holistic and inclusive approach it incorporates different spheres of the German urban development approach. Therefore, trying to combine strategies associated with housing in general by developing concrete solutions for problems associated with demographic change, urban and rural development and gentrification. It is rather a soft law for goal setting than a concrete legislation backed with penalties, but offers some legislative backed up policy elements.

For Example, one outcome of the strategy is a training program sponsored by the state for construction workers and employees in related areas of the building sector. Through EU funds a vocational training and online training platforms could be established, which is called "BUILD UP Skills – QUALITRAIN" (MURE, 2018f).

In general, the strategy is not offering any new concrete legislation. The aim is simply to have a framework in which different strategies can be combined to a holistic approach which generates a higher impact than single measures going in different directions.

b) Financial instruments

The major funding institution in the field of EE grants is the German development bank, the KfW. There are several programs launched by the KfW to foster EE updates in the residential and non-residential building sector combined with overlapping credit optimization, consultation and control mechanisms. Moreover, there are also further financial initiatives launched outside the KfW funding framework. The financial incentives for EE updates in Germany are a mix of consultation, conditional funding dependent on primary energy savings and stimulating programs. The main instruments are summarized in the following.

The main pillar of EE funding in Germany is built by the KfW, which is offering soft loans with minimum requirements for eligibility exceeding the standards set in the building codes. The main program, KfW CO2 renovation program, as well as the included extra funding programs, KfW Energy-Efficient Renovation and KfW Energy-Efficient Construction are the essential grants to fulfill the objectives decided at European level. Support for EE updates in the residential and non-residential sector are offered through grants and interest rate discounts (MURE, 2018i). The 2017 NEEAP states that funding was increased to EUR 2 billion per year (NEEAP, 2017, p. 17) and the primary energy savings are estimated to amount to 292 PJ in the period from 2014 until 2020 (NEEAP, 2017, p. 35).

For both, the renovation and the construction scheme a holistic approach combining soft loans and grants was established. The categories, KfW energy-efficient building 115, 100 and mon-

ument (only for renovation), 70, 55, 40 (plus) and low energy building standard were developed for different funding possibilities. The number is representative for the primary energy demand in kWh/m²a. Therefore, a efficiency building 40 is using just 40% of the annual primary energy demanded compared an equivalent house (MURE, 2018d, 2018c). While from 2014 onwards, only buildings from the categories 55 and lower were eligible for the construction scheme for renovations more categories are still available. The funding possibilities as well as the primary energy demand are summarized in Table 2.

Table 2: KfW Energy-Efficient Renovation and Construction scheme

Category	**Indicative primary energy demand**	**Grant**
Construction scheme		
Energy efficient building 40 plus	40% of the EnEV minimum standard + RES, electricity storage and heat recovery	15% of loan, up to 15.000 € for every dwelling
Energy efficient building 40	40% of the EnEV minimum standard	10% of loan, up to 10.000 € for every dwelling
Energy efficient building 55	55% of the EnEV minimum standard	5% of loan, up to 5.000 € for every dwelling
Renovation scheme		
Energy efficient building 55	55% of the EnEV minimum standard	27,5% of loan, up to 27.500 € for every dwelling
Energy efficient building 70	70% of the EnEV minimum standard	22,5% of loan, up to 22.500 € for every dwelling
Energy efficient building 85	85% of the EnEV minimum standard	17,5% of loan, up to 17.500 € for every dwelling
Energy efficient building 100	100% of the EnEV minimum standard	15% of loan, up to 15.000 € for every dwelling
Energy efficient building 115	115% of the EnEV minimum standard	12,5% of loan, up to 12.500 € for every dwelling

Data source: (ACEEE, 2016), (KfW, 2018)

The KfW initiative has a major impact on energy savings in Germany. In 2014 around 230000 houses and dwellings got renovated due to a KfW credit and under the efficiency house scheme and further 110000 new constructions where built in the framework. This is accounting to around 45% of all new buildings and an impact in terms of primary energy savings of 292 PJ in the period 2009 – 2013 (MURE, 2018i; ACEEE, 2016, 9-4). To achieve the ambitious goal that all buildings should be nearly zero energy buildings until the end of 2020, as stated in the EPBD, this already high impact has to increase strongly. But it is noteworthy that already in 2014 nearly half of the finished constructions in Germany were surpassing the minimum building code standard by 55% more energy savings as mandatory.

The grant and loan programs are closely connected to free or supported energy consulting instruments also supported by the KfW. Further partners offering energy efficiency checks and consultation are the Caritas, a social service provider, and the Federal Office for Economic Affairs and export Control (BAFA). Caritas is offering free energy efficiency checks especially for low income households, while the BAFA is supporting on-site consultation for EE renovations with grants for 50% of consultancy costs. In 2016 the BAFA program volume amounted to EUR 6.1 million and an estimated saving potential of 1.6 PJ (MURE, 2018a, 2018b).

In total there are sixteen financial measures on energy efficiency and renewable energy in buildings in place at federal level. From which are many directly resulting from European directives and some are additional added in line with the national market structure. The impact, according to the constant evaluation due to the implemented Article 7 notification resulting from the EED, of the financial instruments is considerable high compared to other European countries. But to fulfill the stated goals at European level a steady increase of generated savings is necessary (ACEEE, 2016).

c) Informative instruments

The main information instrument at German level is the obligatory energy efficiency certificate for every building in the residential and non-residential sector. The certificate was introduced 2008 as a result of the EnEV recast in 2007. After the introduction the first applied certificate was not mandatory and had to be specific requested by an interested buyer for a building (Steininger *et al.*, 2017, p. 4). Furthermore, the first introduced certificate design was simply an energy demand or consumption report which lead to unclear results and information due to a high dependency of a user behavior of people living in the building. Therefore, the certificate got renewed with the EnEV 2014 and got into force in 2015. Hereby, the duty of certificates for

every building and the right of tenants to review them before signing a contract got introduced and backed up with a monetary penalty for noncompliance (ACEEE, 2016, 9-4).

Many of the concerns about the information value have been addressed and incorporated into the steadily changing EnEV guidelines. There is still much criticism about the implementation design of the certificate. A general problem is that even though to a high heterogeneity in EE performance for different dwellings in one building, the certificate is issued for the complete building. Additionally, the incorporation of the different criticized shortcomings in every new EnEV recast are in a way valuable, but also lead to incomparable information over time and an increasing variety in the design and data of issued certificates even in the same time period (Steininger *et al.*, 2017, p. 24).

While energy efficiency certificates in general are associated with a reasonable impact on increasing EE updates, the German implementation due to its shortcomings has a rather low impact on overall energy savings (MURE, 2018g). Even with a penalty mechanism in influence of the instrument could not be increased because of the information inconsistency within it. Since the implementation in 2015 Suggestions for improving this information tool are a centralized database with a standardized design and more specific data, such as detailed thermal transmittance values or the efficiency of components (Henger *et al.*, 2017, p. 46).

Additional to the certificate scheme there are further complementary information initiatives launched. Examples for advertisement campaigns are the initiative “Germany makes it Efficient” (Deutschland macht´s effizient), which is advertising the introduction of smart metering in private households or the “Initiative Energy Efficiency” (Initiative Energieeffizienz). With these advertisement measures the German state tries to incentivize EE sensible decisions and foster technological research in this field (MURE, 2018e; Henger *et al.*, 2017, p. 26). An impact evaluation for these tools is so far not available.

3. Regional Policy Environment

As shortly discussed above, German federal states have the opportunity to implement own legislations which have to fulfill the standards set at the state level but can consist of further and more ambiguous policies. When a policy at federal state level is proven to be effective the federal state can propose to implement the law at state level. Therefore, the proposed law has to get approved by the two chambers (Bundestag; Bundesrat) and gets implemented at state level after a majority acceptation.

The regional laws implemented at federal state level in Germany and the initiating party are summarized in Table 3. It gets clear that there is a big variety of laws and different federal state policies all fulfilling the standard set at state level but offering additional policies to build on regional advantages. This leads to a situation of a steady increase of environmental targets in line with the state energy transformation strategy as a combination of top-down and bottom-up implementation processes (Ringel, 2016, p. 758).

The regional policy programs implemented in Berlin, Baden-Württemberg and Mecklenburg-Vorpommern will be in depth analyzed and summarized in the following. Therefore, also the regional policies will be categorized into regulatory, financial and informative policies to make them comparable. Furthermore, the policies will be analyzed in terms of the sector where they apply (residential, non-residential) to later visualize them in the policy map.

Table 3: German federal state energy laws/concepts

Federal state	Law/energy strategy	Date enacted	Governing coalition parties adopting
Baden-Wuerttemberg	Energy concept 'Integrated Energy and Climate Change Concept 50–80-90'	Dec. 2012, update Jul 2014	Greens/SPD
Bavaria	Energy concept 'Energie innovative'	May 2011	CSU
Berlin	Energy concept 'Berliner Energiewendegesetz'	Feb 2014	CDU/SPD
Brandenburg	Energy concept 'Energiestrategie Brandenburg 2030'	Mar 2014	SPD/Linke
Bremen	Energy concept 'Energie- und Klimaprogramm 2020'	Dec 2009	SPD/Greens
Hamburg	Energy concept 'Hamburger Klimaschutzkonezpt'	Jan 2011	SPD
Hesse	Energy concept 'Hessisches Energiekonzept'	Oct 2011, update Dec 2013	CDU/Greens
Lower Saxony	Energy concept 'Niedersächsisches Energiekonzept'	Feb 2012	CDU/Greens
Mecklenburg-Vorpommern	Energy concept 'Landesenergiekonzept'	Dec 2013	SPD/CDU
North Rhine-Westphalia	Klimaschutzgesetz and Klimaschutzplan	Jun 2013	SPD/Greens
Rhineland-Palatinate	Klimaschutzgesetz	Feb 2014	SPD/Greens
Saarland	Energy concept 'Masterplan Energie'	Nov 2011	CDU/SPD
Saxony	Energy concept 'Sächsisches Energieprogramm'	Nov 2011	CDU/FDP
Saxony-Anhalt	Coalition Agreement	May 2011	CDU/SPD
Schleswig-Holstein	Coalition Agreement	Jun 2012	SPD/SSW
Thuringia	Energy concept	Dec 2009	CDU/SPD

Source: (Ringel, 2016, p. 758)

a) Berlin

The building sector of berlin is responsible for 49% of all GHG emissions in 2012 which equals a 10.3 Mio. t CO2 pollution. The challenges for a decarbonization of the building sector in Berlin are various. A main challenge builds the high renting rate and low ownership of condos and

therefore a high tenant landlord barrier for EE updates. Furthermore, a big part of the building sector is listed as historical monuments

To realize an 85% reduction of CO2 emissions until 2050 as stated in the Berlin climate protection goals further development in the political instrument mix is needed. The main spheres where the most potential through further GHG mitigation measures in the building sector can be realized are the renovation rate of old buildings as well as the renovation depth. Further development areas with high potential are the building stock density, subsidy rate and the living area per person. To influence these factors is the main goal of the EE policy instruments applied in Berlin.

The main restrictions for the EE update potentials in Berlin are social compatibility and economic efficiency. Energetic and EE modernization of flats is causing increased renting prices due to the possibility of the landlord to allocate the cost for EE updates on the net rent of the renovated areas. Consequently, to high modernization rates is specific districts are cause social repression and are leading to special division of social milieus since low income households cannot afford the 11% of appropriated cost from modernization measures additional to the rent (Berlin Senate, 2017, 64 f.).

Due to this different potentials and challenges Berlin is an interesting policy environment to analyze in terms of building sector mitigation policies. Due to the high share of the building sector on the total CO2 emissions and the special challenges resulting from the social structure in the city. In the following the regulatory, financial and informative policy environment will be summarized and explained to get an overview of applied measures and strategies in Berlin to build on regional advantages and potentials and deal with the regional disadvantages and restrictions.

(1) Regulatory Instruments

Additional to the regulatory framework set at state level the federal state Berlin established, as described above, its own legislative framework for climate protection. The Berlin energy transition law (Berliner Energiewendegesetz (EWG)) was passed and came into force in 2016 and since then builds the main piece of legislation aiming at the decarbonization of all sectors including the building sector. The main climate targets are similar to the German targets but a little more ambitious in the long-term perspective. While the state of Berlin as well as Germany are aiming at a 40% CO2 until 2020 compared to 1990 Berlin commits to a 60% reduction in 2030 whereas the German target is 55% (Berlin Senate, 2016, §3). To achieve the stated GHG reduction targets Berlin developed the Berlin energy and climate protection program 2030

(Energie- und Klimaschutzprogramm 2030 (BEK 2030)) as a catalogue of measures and strategies supplementary to the EWG. The regulatory policy instruments supporting the decarbonization of the building sector resulting from them are summarized in the following.

Exemplary function of the public sector

A main regulatory dimension of Berlins EE policy environment is the role model function of public bodies. As at European and German level it is the easiest sector to influence and can serve as an informative example for the private sector to initiate further EE improvements. In line with the German and European goals berlin aims at a climate neutral administration until 2030 with a full action plan how to fulfill that goal.

Supplementary to the measures from the action plan public bodies are obliged to develop a detailed restructuring strategy to reach the EE goals. The plan is not already available since the deadline for the submission of the plans is ending in 2019. Furthermore, a part of the role model function enshrined in the EWG is a mandatory installation of energy management systems in all publicly owned buildings. The gathered data about electricity use in the buildings will be published on the internet to make it available for the public (Berlin Senate, 2016, §6-9).

Climate protection as part of education

Further stated in the EWG is the plan to incorporate climate sensible education topics into the educational system. Thereby, students should get early sensitized about unsustainable behaviors and the importance of climate mitigation. A main part is the responsible consumption of energy and the explanation of saving potentials through for example EE updates or EE appliances. A second layer of this measure is the sponsoring by the Senate for school projects enhancing EE including student participation (Berlin Senate, 2016, §14)

Climate protection agreements

An important aspect of Berlins EE policy environment is the so-called climate protection agreements with large associations and enterprises of the private economy. Especially associations and enterprises from big interest for climate protection and energy. Therefore, the Berlin Senate is negotiating with strategically important partners, such as energy providers or large cooperative housing associations, contracts which are binding the partners to the climate protection goals enshrined in the EWS. For accepting stricter regulations and developing measures for GHG emission reductions in the enterprise the partners receive a share of the climate protection investments of Berlin. The measures have to aim at the goal of higher EE as well as the use of RES and the resulting savings have to be reported to the responsible senate (Berlin Senate, 2016, §10)

Energetic optimization of listed historical buildings

The goal of the measure GeS-6 and GeS-7 in the BEK 2030 strategy is an increased renovation rate of historical buildings in Berlin. As pointed out above the historical building stock is a main challenge to EE updates in the built environment. Therefore, the BEK 2030 states that the definition for historical buildings laid out in the EnEV should be used by all Berlin district representations to establish a Berlin wide consistent approach. Supplementary, new energetic consultancy specialized on historical protected buildings as well as new financial subsidy programs should be established to overcome the barrier and enable an efficient use of historical building maintenance to incorporate EE updates in anyway conducted renovation measures (Berlin Senate, 2017, p. 70).

Living area reduction

The measure GeS-10 is aiming at a better distribution of living area combined with a general reduction of used living space per person. Through a better distribution the increasing demand for new construction could be slowed down and the CO2 emissions of the building sector can be effectively reduced when for example single households do not heat a three-room apartment. This goal should be reached through the establishment of a flat exchange platform where Berliners can offer their flat in exchange for a better suitable one (Berlin Senate, 2017, p. 71).

The flat exchange is a suitable solution for Berlin since the distribution of living space is highly inefficient. In average every person in Berlin could have a personal living space up to 38 m^2, while other capitals, such as Paris or London, have an average of 22 m^2 per person. Thus, through a better distribution of flats to suitable tenants the average of Berlins population could maximize their living space and increase EE through a more efficient use of living area and less empty heated rooms. The measure should be supported by the self-interest of tenants to find a more suitable flat be an easy exchange and possible financial subsidies offered to efficient changing tenants (Schönball, 2018).

Climate Advisory Council

To institutionalize climate protection at the federal level the state of Berlin through the EWG established a climate advisory council. The councils main task is to consult the senate about new climate protection and EE policy tools which have to be established. Furthermore, the council is in charge to monitor the development of CO2 emissions and energy consumption to give evaluation based recommendations (Berlin Senate, 2016, §11).

(2) Informative Instruments

Supplementary to the regulatory instruments the BEK 2030 is also incorporating a variety of informative tools to enhance CO2 mitigation in the building sector. Information offers to public and civil society are enshrined in three of the main instruments named to fulfill the BEK 2030 goals. Literal the strategy names target group specific information, networking promotion and pilot tests for EE demonstrations as the first three instrument categories to achieve the set emission reduction targets (Berlin Senate, 2017, p. 28). The explicit measures are summarized and analyzed below.

dIBEK

The IT infrastructure system dIBEK is part of the regulatory monitoring task of the Senate which is enshrined in the EWG. The goal is to collect all available data from all different public bodies in one central database and use it as information and planning tool simultaneous. All climate protection relevant indicators should be made available in scandalized format and made available to the public while being used as baseline inventory for decision making bodies in the political, economic and administrative sphere. Thereby, it should get the main information platform about the status quo of the BEK 2030 goal achievements (Berlin Senate, 2017, p. 50).

Renovation network

Also stated in the BEK 2030 strategy is the establishment of a stakeholder network for all actors in the sphere of climate protection. Through the bundling of all information and consultancy offers a good overview for building owners about the possibilities of energetic renovations should get established. Thereby, the Berlin senate realized the problem for private actors to filter all the different information from multiple websites and a variety of diverse offers. A second goal is to increase the quality of service supply for EE improvements through a closer competition of craftsman, consultants, architects, etc. (Berlin Senate, 2017, p. 74). Similar to the renovation network a second networking platform, “berlin saves energy” (Berlin spart Strom) should be established. The focus here is on SMEs to establish a knowledge exchange about feasible EE measures.

Informative energy billing

Through a volunteer agreement with the housing industry, energy providers and metering service the transparency of energy billings for private households should be enhanced and made understandable. Additionally, the increased information of the billings should foster EE updated in the private sector through the detection of the greatest energy consumers or long stand by times. The process should be organized by a step by step introduction and could be

also part of specific contracts between the Berlin and the housing industry. Especially the development of extensive use of smart metering is a part of the measure and the expected reductions amount to 1.5 to 3% per year per household.

The measure is a reaction the EU EE-Directive where Article 10 states that energy consumers should be offered extensive information about their energy consumption. While there is no regulation at German level to fulfill this Article Berlin is aiming at an exemplary role at regional level (Berlin Senate, 2017, p. 109).

Visiting consultancy

The state of Berlin is offering its citizens a target group specific visiting consultancy for households with free initial consultancy about possible renovation measures, appliances exchanges and funding opportunities (Berlin Senate, 2017, p. 109). Additionally they have a similar free energy consultancy instrument for SMEs concentrating on energy saving potentials of machinery or the building as well as energy use sensitization for the personnel (Berlin Senate, 2017, pp. 81–82). Moreover, an online energy saving consultancy platform should be established to simplify the information process for private actors. The measure is quite expensive due to the specific targeting of consumer groups, but has an average impact of a 600kWh energy use reduction of consulted households without the calculation of a cooling appliance exchange (Berlin Senate, 2017, p. 109).

Regional completions

Additionally, berlin is trying to enhance awareness about energy use and EE improvements through regional fairs and completions. The main information week for the energy transition, called “Berliner Energietage”, is held in Berlin as well as a complementary action week, called “Berlin spart Strom” (berlin saves energy) to enhance public awareness and participation. Furthermore, the project “Energiesparmeister2 (energy saving champion) is awarding best practice examples for energy saving measures in Berlin (Berlin Senate, 2018a).

(3) Financial instruments

		Type of funding		
Financial Instrument	**Eligible entity**	Grant	Loan	Guarantee
Environmental loan: Loan with special interest subsidy when used for EE updates. Min. energy savings of 20% compared to the three-year average energy use. 100% of the investment costs covered	SMEs		x	
	Education/Research			
	Public			
	Private		x	
	Associations			
BENE[1] (focus area 1 and 2): Grants partly from the ERDF for EE updates. Eligible for 60 t CO2/a savings from EUR 1 mio. funding volume. SMEs: 30-80% of eligible costs. Public: 25-75% (in exceptions 90%) of eligible costs	SMEs	x		
	Education/Research			
	Public	x		
	Private			
	Associations			
BENE (focus area 3): Grants partly from the ERDF for introduction of energy management systems. Grant for 80% of eligible costs, max. EUR 75,000	SMEs	x		
	Education/Research			
	Public	x		
	Private			
	Associations	x		
BENE (focus area 5): Grants partly from the ERDF for research in CO2 reduction technologies as well as model, pilot and demo activities and concept development. 50-100% of eligible cost. For SMEs 25-80%.	SMEs	x		
	Education/Research	x		
	Public	x		
	Private			
	Associations			

[1] BENE: Berlin program for sustainable development split in 5 focus areas: 1. EE in SMEs; 2. EE in public sector; 3. Smart metering; 4. Sustainable mobility; 5. R&D.

ENEO program: Grants for EE consultancy in residential buildings. EUR 500 for 1-2 dwelling buildings, max. EUR 2000 for 100+ dwelling buildings. (Max. 100% of net costs; 50% before and other 50% after implementation of suggested renovation measures)	SMEs Education/Research Public Private Associations	 x
Residential energetic renovation: Additional interest rate discounts to KfW energy efficiency house funding. Financing of EUR 100,000 for every dwelling and additional to KfW conditions 0.6% p.a. interest rate discount on the loan.	SMEs Education/Research Public Private Associations	 x
Loan for EE in collectively owned property: Subsidized loans for renovation measures implemented by Condominium associations.	SMEs Education/Research Public Private Associations	 x x
Rental building modernization: Subsidized loans for EE renovation in rental flats. Additional to KfW funding programs, loan of 100% of investment costs for measures outside the KfW funding framework. Max. EUR 100,000 per dwelling	SMEs Education/Research Public Private Associations	x x x
QUAB project: Grants for building insulation updates under the condition of employment of long term unemployed people. Depending on insulation material grants of 30-40 EUR/m^2 insulated area on buildings finalized before 1995.	SMEs Education/Research Public Private Associations	x x x

Data source: (BMWi, 2018b)

b) Mecklenburg-Vorpommern

In MV the building sector was consuming 50% of the total final energy consumption in 2008. Compared to the German average of 26% in the period 1990 until 2012 this is nearly the double of consumed energy in an average. The high energy consumption of buildings can be explained by the low industry and enterprise density in the state of MV in comparison to the German average.

In contrast, the residential building sector shows positive developments in term of energy consumption over the past 20 years. With an average energy consumption of 104 kWh/m^{2}a in the analyzed 32% of MVs total housing stock the numbers fall extensive behind comparable federal states in the north, such as Schleswig-Holstein with 177 kWh/m^{2}a or Hamburg with an average of 183 kWh/m^2 (Landtag Mecklenburg-Vorpommern, 2015, p. 32).

(1) Regulatory instruments

MV has no explicit climate protection law in place. But additional to the German EE policy framework MV developed an own energy political concept defining challenges and counteractive measures to achieve the climate goals defined at German level. The so called “Landesenergiekonzept” (LEK) was passed in 2015 and tries to combine different in the past developed concepts for specific sectors or challenges into one holistic approach with a clear goal setting. Supplementary, MV developed a climate protection action plan summarizing all goals and measures to foster CO2 mitigation in one document, which also specifies actions for the building stock decarbonization (MEID, 2016). Since there is no main legislation establishing supplementary policy instruments for higher EE in the building sector the measures defined in the concept and the action plan will be grouped to regulatory instruments. It is important to note that these measures are formulated as explicit goal setting and solution for detected challenges but are not backed up by hard law.

The climate protection goals are not exceeding the ones set at German level but some measures stated in the LEK to achieve the given targets are supplementary to the German framework and are building on regional advantages. These measures developed by MV to fulfill the German goals are summarized and explained below (MEID, 2015, p. 37).

Climate protection as part of education

As formulated in the LEK a main goal in MV is to incorporate the citizens actively into the energy transition. Therefore, early education should already aim at deepening the understanding for energy savings and the importance of EE. Furthermore, the interest of learning about EE in later life stages should be incentivized (MEID, 2015, p. 42).

Exemplary function of the public sector

Not stated in the LEK but specified in the action plan of the Ministry for Energy, Infrastructure and Digitalization in MV a major target of the EE policy environment is the role model function of the public administration. Therefore, publicly owned buildings in MV have to be supplied by CO2 neutral electricity and must have an energy management system in place. The future goal in this sphere is stated to be a publishing website for energy use data of public buildings to generate transparency and incentivize EE behavior on the citizen side. Until now the energy use of public buildings is published in energy reports every two years. Furthermore, the exchange of energy intensive appliances in publicly owned buildings is a focus of the action plan. The first directly stated goal is the exchange of public lightning infrastructure, especially in buildings, with EE LEDs to enhance energy savings (MEID, 2016, pp. 6–12).

(2) Informative instruments

Besides the climate protection education and the role model function of the public sector MV also defined the goal of intensified information tools in the LEK. Thereby, the federal government aims at increased awareness in the population for EE in the building sector and the development of EE as a strategic goal for enterprises, municipalities and public bodies. To achieve this goal the government already developed some information campaigns (MEID, 2015, p. 66).

Energy saving initiative A+

With the initiative A+ the MV government runs an information campaign to reduce energy use in the administrative buildings. Through the establishment of energy managers for every administrative property the awareness of the civil servants about their energy consumption should be increased. The information campaign is aiming at behavior changes, such as correct air ventilation or heating in the public offices (MEID, 2018a).

Consultancy for energy saving contracting

The establishment of new finance solutions to fulfill the stated goal, the role model function of the public sector, is a main focus of the MV climate protection action plan. The aim is to offer free consultancy about financial solutions, such as contracting, financed under the climate protection funding directive for municipalities, which is explained in detail in the next chapter. The informative instruments should establish an independent consultancy for public bodies about contracting models to achieve the highest possible energy savings in their buildings (MEID, 2016, p. 13).

(3) Financial instruments

		Type of funding
Financial Instrument	**Eligible entity**	Grant Loan Guarantee
Climate protection funding directive - municipality: Grants for EE investments for energy saving measures exceeding the minimum standards at German level and innovative energy saving projects. Min. EUR 20,000, 50% of investment (in exceptions up to 80%)	SMEs Education/Research Public Private Associations	 x x
Climate protection funding directive - enterprise: Grants for EE investments for energy saving measures exceeding the minimum standards at German level and innovative energy saving projects. Min. EUR 20,000, 50% of investment for EE updates	SMEs Education/Research Public Private Associations	x x

Data source: (BMWi, 2018b)

c) Baden-Württemberg

In the German federal state Baden-Württemberg (BW) the building sector is responsible for 40% of all GHG emissions and has a 35% share of the total primary energy consumption in the region. Similar to the other analyzed federal states BW has also the goal setting of climate neutral building stock until 2050 (MUKE, 2018c, 2018c, p. 1). In terms of total GHG mitigation BW just defines the short-term goal of a 25% reduction of CO2 emissions until 2020 and the long-term goal of a 90% reduction until 2050 compared to the base line CO2 amount in 1990 (Landtag Baden-Württemberg, 2013, §1).

BW is seen as a leading example for EE and decarbonization measures in the German policy environment. The energy consumption in terms of supplied square meters is declining in the trend from 1991 until 2016 in the producing industry as well as in the sector of private household heating and warm water preparation. As an example the energy used in private households declined from 66 GJ/m^2 in 2005 47 GJ/m2 in 2015 (Statistisches Landesamt BW, 2017, p. 9)

An increasing problem for higher EE in the building sector is the growing share of old buildings on the total building stock, which are mostly composed of inefficient building components and therefore have a high energy consumption. Further problems can be seen in the law for modernization costs for better living conditions §559 BGB, which allows the landlord to appropriate 11% of the costs for renovations on the rent. This leads like in Berlin to a high social repression due to increasing rent prices resulting from EE updated in residential rental buildings (MUKE, 2018c, p. 7).

(1) Regulatory instruments

BW has like Berlin a climate protection law (KSG BW) and concept, the integrated energy and climate protection concept (IEKK), defining the strategies to fulfill the goals resulting from the law established. Additionally, to the KSG the BW government established a renewable heat law (EWärmeG) to foster RES for building heating and an efficient use of the produced energy. The defined climate goals are the same as in the KSG, but the content is specialized on heat use in buildings while the KSG is concentrating on climate protection as a whole.

In the three analyzed federal states in the present report BW is unique to have established also the EWärmeG. The obligations resulting from it are backed up by law and are enforceable. Therefore, BW can be seen as frontrunner between these three regions in the establishment of a regulatory framework to decarbonize the building sector.

Exemplary function of the public sector

After the introduction of the climate goals and the general framework, such as the establishment of a climate protection concept, §7 KSG aims at the role model function of public bodies. Compared to Berlin BW wants a climate neutral administration, in term of energy used by the buildings, until 2040. This is a ten year longer implementation period as in Berlin but with a similar content.

Besides the longer time frame the content of §7 is quite similar to the EWG in Berlin. The federal government has to publish a performance report, in term of CO2 savings, every three years. Furthermore, the municipality governments should be incorporated into the strategy and make own agreements with the federal government to ensure an holistic approach in the subsidiary governing system. (Landtag Baden-Württemberg, 2013, §7).

Climate Advisory Council

§10 of the KSG states the establishment of a climate protection council within the federal government. The council should be composed of representatives from different civil associations and interest groups as well as the church scientific scholars. The main task is to advice the

government in new policies and actions based on a review of the in §9 specified monitoring reports in a yearly interval (Landtag Baden-Württemberg, 2013, §10).

Energy saving measures to fulfill RES obligation from EWärmeG

As introduced before, BW established a renewable Energy Law, additionally to the KSG. The EWärmeG §4 obliges every residential or non-residential building owner, after an exchange or a subsequent installation of a heating system, to use at least 15% of energy from RES for the heat supply in the building or reduce the energy demand by 15%. The obligation is to be fulfilled in 18 months after the installation and has to be proven to a public authority.

The law is also fostering EE updates besides the feed-in of RES into the heat supply, since the obligation can also be fulfilled by an energy demand reduction. Therefore, §7 is specifying the percentages how far the transmission heat loss (HT) values, defined in the EnEV, can be exceeded or undercut, depending on the year of the issued building permit. For example, buildings with a construction permit issued between 1995 and 2002 have to undercut the specified HT in the EnEV by minimum 20% to fulfill the obligation from §4. Consequently, the law is setting strong incentives to update the building envelope.

Furthermore, a combination of different measures can also be used to fulfill the §4 obligation. §9 specifies the possibility to establish a long-term road map for building specific EE updates in line with the 2050 goal of a climate neutral building stock to fulfill one third of the obligation. The recommendations for EE update measures consider all building specific aspects, such as the calculated costs, funding possibilities, physical building characteristics as well as urban guidelines. Further paragraphs specify more measures leading to the compliance with the §4 obligation through a variety of action combinations in the sphere of RES use and EE updates.

The EWärmeG is including residential and non-residential buildings with separated obligation specifications laid out in two divided parts of the law but referring to the same obligation in §4. Thus, the law is combining both sectors (residential and non-residential) and the two goals from the KSG (fostering RES use and EE in the building sector) in one regulation. The resulting holistic legal approach is additionally exceeding the EnEV regulation at German level (Landtag Baden-Württemberg, 2015).

(2) Informative instruments

The policy environment in BW is steady increasing the information offers for EE consultancy to foster a higher participation and knowledge in the civil population. Since energy consulting is also a possibility for the partly fulfillment of the EWärmeG obligation, new possibilities for

an extension of the consultancy market in the direction of building EE were generated and used. Hence, the informative policy instruments also were further developed in last years and new approached were established, which will be analyzed in the following (MUKE, 2018c, pp. 1–3).

Renovation road map BW

The renovation road map BW is a consultancy instrument resulting from the EWärmeG and is backed up by an own regulation (SFP VO) issued in July 2015. The instrument is listed under informative instruments because the content of the regulation is specifying the format of the road map as well as the minimum content, but the outcome is a fully informative consultancy tool for building owners. Thus, the SFP-VO is a supplementary regulation to §9 and §16 of the EWärmeG to specify scope and type of road maps for specific building types, such as residential, non-residential or complex buildings (Landesregierung Baden-Württemberg, 2015)

The environmental ministry BW established the renovation road map as an important information, motivation and consultancy tool, since it has an assessable far reach generated from the obligation in the EWärmeG. The road map is showing long term renovation actions for the individual analyzed buildings in line with the 2050 goal of a nearly climate neutral building stock. The road map is showing chronological EE update measures and solutions to foster the use of RES in buildings while considering the cost-benefit calculation and possibilities for public funding for these measures.

The estimated cost for a building owner of a one or two-family house are between EUR 800-1000. State aid for the issuance of renovation road maps is available from the regional development bank, called L-Bank BW, and is dependent on the building size and type. The subsidy can be directly applied for by the contacted energy consultant who is issuing the renovation road map (MUKE, 2015b). Further details for funding possibilities are listed under financial instruments.

Historical buildings renovation program (Zukunft Altbau)

The “Zukunft Altbau” initiative is an information and consultancy tool to foster EE updates in old buildings. Since the old building stock is a mayor emission factor due to poorly isolated building envelops, but renovations are not so easy to conduct on account of historic preservation BW developed a specialized information base for old building EE renovations. The project is an independent marketing and information campaign financed by the Ministry for environment, climate and energy. Within the initiative free consultancy is offered to owners of residential or non-residential buildings as well as all participants involved into the building or

modernization project. Additionally, the initiative offers a gallery of best practice renovation projects to motivate building owners for EE updates in old buildings as well as a free hotline for initial consultation. (Zukunft Altbau, 2018; MUKE, 2018c, p. 3)

Regional EE competence center

The federal state energy agency of BW called KEA established five local energy competence centers as central information hubs for climate protection activities. The centers offer a variety of free services in energy topics for all different actors of interest. The services range from specific expertise to the organization of information events. The centers work also as networking institutions bringing together energy service providers with regional energy agencies in workshops network meetings. Additionally, the centers support municipalities and SMEs in the implementation of systematic energy management systems (MUKE, 2015c).

Regional competitions

In addition to the consultancy activities, the federal government of BW is also tendering competitions to award best practice examples of EE updates or special efforts in the sphere of EE improvements. Through the completions, Efficiency Award: construction and modernization and Star Energy efficiency ("Effizienzpreis Bauen und Modernisieren" and "Leitstern Energieeffizienz") BW wants to show that EE renovations do not have to be expensive per se and award particular regional EE improvements. Thereby, the building of awareness and motivation towards EE improvements should be fostered and reward (MUKE, 2018a).

(3) Financial instruments

		Type of funding
Financial Instrument	**Eligible entity**	Grant Loan Guarantee
Consultancy for SMEs: Grant for business consultancy including environmental consultancy	SMEs Education/Research Public Private Associations	x
Guarantee program: granting the guarantee of 50% of financing for EE renovations on the associations buildings (max. EUR 300 000)	SMEs Education/Research Public	

	Private Associations	 x
ECOfit project: Grant for implementation of climate protection projects and workshops. EUR 400 per organization, EUR 1000 for workshops made by external service providers (80% of eligible cost, max. EUR 5000)	SMEs Education/Research Public Private Associations	x x x x
Klimopass project Grant for EE consultancy from initial until implementation phase. Around 60% of costs. Depending on implemented measures and consultancy form. (max. EUR 500 - 100 000)	SMEs Education/Research Public Private Associations	x x x x
Loan for EE in collectively owned property: Subsidized loans and additional grant for EE renovation in collectively owned property. Additional to KfW loan program 3% grant of eligible costs.	SMEs Education/Research Public Private Associations	 x x
Renovation roadmap grants: Grants for issuance of renovation roadmaps. EUR 200 for 1-2 dwelling buildings. EUR 50 for every additional dwelling. EUR 500 for 8+ dwelling buildings. (Max. 50% of total costs)	SMEs Education/Research Public Private Associations	 x
Grants for EE heat supply: Grants for: Climate protection concepts (Public). 20% of costs; Consultancy and network initiatives (SMEs, Private). 90% of costs, max EUR 90 000; Investments (SMEs, Public, Private). 20% of costs max EUR 200 000	SMEs Education/Research Public Private	x x x

	Associations		
KmS (Climate protection systematic) 2014-2020: Grants for CO2 reduction measures with funding from ERDF. 50% of eligible costs. Max. EUR 3 mio., min. EUR 200 000	SMEs Education/Research Public Private Associations	 x 	
Climate protection Plus: Grants for CO2 mitigation programs as well as structural and informative programs in non-residential buildings. 30-40% of investment costs, max. EUR 200 000, min. EUR 5000	SMEs Education/Research Public Private Associations	x x x	
Rental flat modernization: Subsidized loans for EE renovation in rental flats. Additional to KfW funding program, loan of 100% of investment costs for measures outside the KfW funding framework. Min. EUR 200 000	SMEs Education/Research Public Private Associations	x x x x	
Rental flat construction: Subsidized loans for EE new buildings. Additional to KfW funding programs loan of 100% of investment costs for measures outside the KfW funding framework. Max EUR 50 000 per dwelling	SMEs Education/Research Public Private Associations	x x x x	
Resource efficiency financing: Subsidized loan in program part C for EE in SME buildings. 100% of investment cost from KfW funding with possible addition from L-Bank and with a too high credit volume for own securities guarantee granting by the L-Bank	SMEs Education/Research Public Private Associations	x 	x

Data source: (BMWi, 2018b)

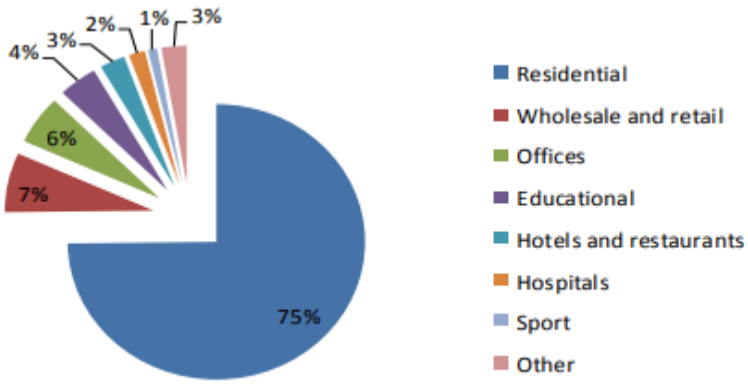
V. Policy mapping

To establish a comparable view for the variety of policy elements implemented in the different areas of implementation in the three federal states, the next step is to condense them in a lucid policy map. Therefore, the beforehand categorized policy instruments get further sub organized into the areas they apply. The selected split off is between residential and non-residential buildings and furthermore between applied to foster retrofitting measures or fostering the decarbonization of the whole building sector.

1. Justification of dimensions

At first it is important to define all buildings included in the term "building stock". In the present report the applied limitation by Europe's DG Environment will be used, which is including residential, public and commercial buildings but excluding industrial and agricultural buildings. The exclusion of industrial buildings is due to its minor representation of 1% from the entire European building stock and the high diversity of energy demand within it. The inclusion would result in too high variance which would distort the results of an impact evaluation (Herczeg *et al.*, 2014, p. 13).

Figure 7: European building stock composition (excluding industrial buildings)



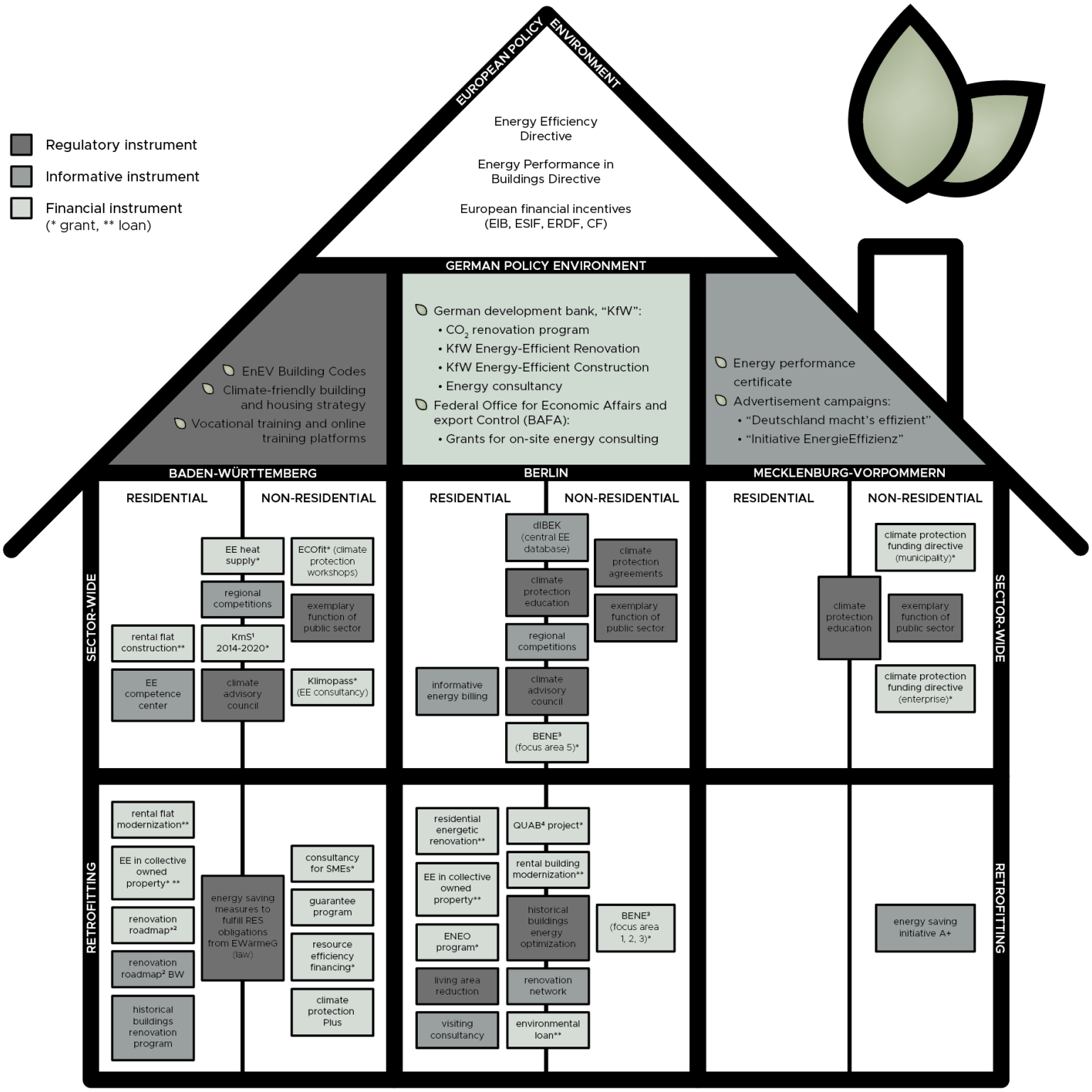
Source: (Ecofys, 2010)

Hereby, residential buildings are defined after the OECD statistical standard, that all buildings where more than half of the gross floor space is used for dwelling purposes can be defined as residential (OECD, 2001a). On the other hand, non-residential buildings are all buildings with less than half gross floor space used for dwelling purposes, such as commercial, educational, institutional and other buildings (OECD, 2001b). from this residential and non-residential

buildings 12% are estimated to be public the remaining 88% are residential (Herczeg *et al.*, 2014, p. 13).

Furthermore, the policy map will be split horizontal into the scope at which the political instruments are aiming. The chosen division is retrofitting measures, so renovation measures to foster EE in existing buildings, and instruments applying for the whole building sector, such as special subsidies for EE new buildings or monitoring activities of a state agency. The split off is selected, because the update of the old building stock is one of the most important goal settings to decarbonize the building sector but there are many additional instruments to enhance energy consumer awareness and financial incentives applied for the entire sector.

2. Policy map



1. KmS: Climate protection systematic 2014-2020, holistic funding from ERDF for CO_2 reduction measures.
2. Renovation roadmap: Step by step EE building update agenda.
3. BENE: Berlin program for sustainable development, funding partly from ERDF split in five focus areas: 1. EE in SMEs; 2. EE in the public sector; 3. Smart metering; 4. Sustainable mobility; 5. R&D.
4. QUAB: Qualification and employment funding, special grants for building envelope updates under the condition of the employment of long-term unemployed people to fulfill project.

VI. Discussion of results

a) Similarities and Differences

As first step it is important to point out the main similarities and differences in additionally to the regulations set at state level applied instruments in the three German federal. As it is visible in the policy map also the amount of implemented policies varies highly between the three selected regions. While MV has 6 separated policy tools established additional to the German framework, Berlin (19) and BW (19) have nearly triple the amount of applied policies. The reasons for this high alteration will get examined afterwards.

Exemplary function of the public sector and climate advisory council

The only established policy instrument in every of the three federal states is the exemplary function of the public sector. This is not surprising because public bodies are the easiest sphere to implement new EE enhancing policies and to test outcomes due to easy monitoring. Nevertheless, the performance of the monitoring varies vastly from state to state as well as the actual contents of the role model function.

BW is tracking the outcome of the implemented measures in public buildings in a yearly energy report where the 2017 edition is only specializing on the performance of publicly owned buildings. The report states that the 2020 goal of a 40% reduction of CO2 emissions was already reached in 2015 with a total CO2 emission reduction of 45% compared to 1990. But, the ministry refers to the possibility of increasing emission values due to changing weather conditions and the already full accounting of the switch to eco-electricity of all public property in the 2015 balance sheet, which had a major impact on the high emission reduction but will not have in future balancing of energy accounts (Finance Ministry, 2017, p. 11).

Berlin on the other hand, has no steady monitoring report of either the impacts of general policy tools or the measures applied in the public real estate, since the senate has not been publishing the energy report since 2006. Even though the obligation of energy reporting by the senate is enshrined in the EWG there is no central tracking of policy impacts on CO2 or energy demand impacts (VerfGH Berlin, 2014). Some districts fulfill the obligation to publish yearly reports but the form and content is not standardized, which makes it difficult to condense the results. The statistical office is offering an overview of sectoral CO2 reductions and energy uses but is not specifically separating the building sector which makes a strict distinction again not possible (Berlin Senate, 2018a).

MV has the role model position of the public sector not enshrined in the climate protection concept. The approach is to publish exemplary actions by public bodies, such as the introduction of energy management systems, on the online information platform. Also here the impacts or the results of the measures are not tracked systematically and an impact evaluation is not possible (MEID, 2016).

Moreover, Berlin and BW have an established climate advisory council within the federal government. The council is an established institution to monitor the progress in the regulatory sphere and give further political recommendations based on the monitoring reports. Since there is no central climate protection law in MV there is also no institutional need for its monitoring.

Climate protection as part of education

Berlin has the inclusion of climate protection education into the school system enshrined in the EWG and also refers to this plan in the BEK 2030. MV on the other hand has no law but the goal to establish school education concerned with the results of climate change and ways to prevent them is stressed in the LEK. The impacts of the measure are also not traceable until now since the implementation in both federal states is still ongoing and did not produce any outputs until now

Climate protection agreements

An important instrument, and unique to the other two model regions, in Berlins EE policy mix are climate protection agreements (CPA) with local enterprises and associations. Hereby, enterprises commit to a CO2 reduction target within a volunteer agreement between the local government and a network of mostly semi-private partners. First established with a network of 14 partners in 1997 with an implementation period until 2002, some agreements got extended and new ones established, so that today there are still 11 partners participating (Berlin Senate, 2018b).

The CPAs cover many semi-private buildings such as swimming pools, the zoo, universities but also the IT service center Berlin. In most cases the reduction targets stated in the CPA were fulfilled or even undercut. The reduction goals in the CPAs are in line with the climate targets from the EWG and therefore are one of Berlins most important tools to incorporate semi-private owned buildings into the EE updates of the public sector. The agreements are signed for a 10-year period which is also enshrined in §10 EWG (House of Representatives, 2018, 2017).

Energy saving measures to fulfill RES obligation from EWärmeG

A unique policy element established in BW is the regional EWärmeG as described beforehand. None of the other model regions developed an own law to foster RES use in regional heating supply. The law builds on the obligations resulting from the renewable energy law at German level but has stricter obligations and furthermore also tackles the existing building stock and not only new buildings. The obligation applies for nearly all buildings with some exceptions, such as forbidden retrofitting measures due to a historical building status or disproportionate costs. The obligation arises for an exchange of a heating system and is thereby directly linked to anyway needed retrofitting measures, which leads to a reduction of upfront costs for EE updates (MUKE, 2015a, p. 16).

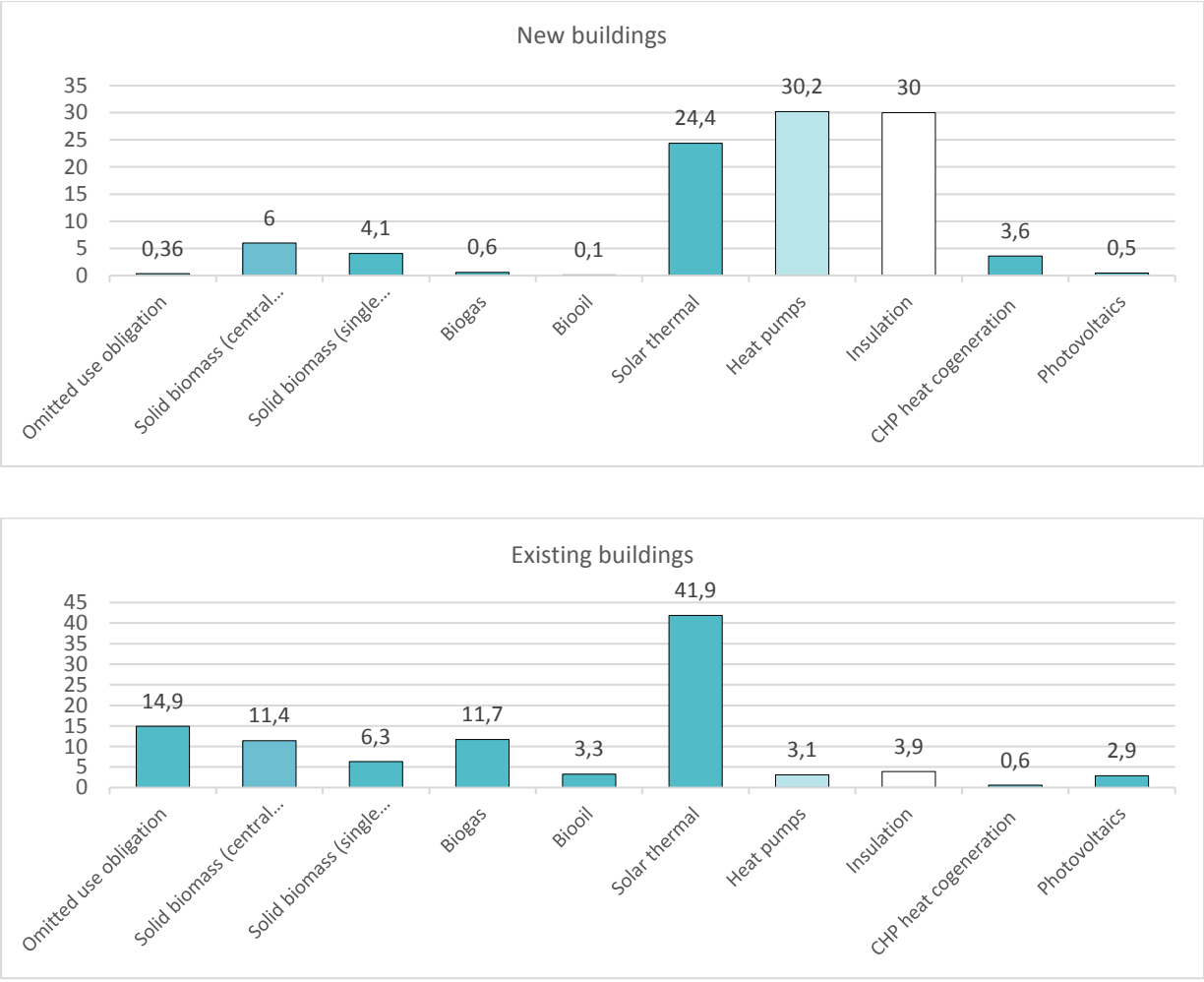
The §4 obligation can be fulfilled in many different combinations of measures and originally aims at the inclusion of RES into the regional heat supply. In July 2011 the environmental ministry tendered an evaluation concerning the progress of the EWärmeG. To this time incorporating still new and existing buildings. The Evaluation was conducted on data from participation rates, calculated CO2 mitigation scores and surveys with concerned constructors and building owners. The results about used fulfillment options are summarized in Figure 6. In first three-year period of the law 30.2% of all new building constructors used heat pumps to fulfill the obligation. 30% used building envelope updates exceeding the building code standards and 25% installed a solar thermic plant to reach the 20% RES obligation. In the existing building stock most obliged owners, 40.9%, used a solar thermic installation to reach the 10% heat from RES. 15% used biogas and oil, 17.7% Biomass and only 3.9% decided to fulfill the obligation by updating the building insolation (La Croix *et al.*, 2011, p. 43)

The measure was calculated to have an impact in terms of CO2 savings amounting to 46600 t CO2 comparable to a yearly decarbonization of 0,3 % of the entire private household sector. 26800 t CO2 savings in the existing building stock and 19800 t CO2 savings in new buildings were detected. On a building average this results in 1,3 t CO2 saved per building per year in the existing stock and a 16% CO2 reduction compared to 2008. Due to a higher obligation 2t CO2 reduction per building in the new building sector and 35% CO2 savings compared to 2008 (La Croix *et al.*, 2011, pp. 44–47).

In 2015 the EWärmeG got renewed which was already decided in 2013. The goal of the novel was to concentrate only on existing buildings since new buildings were incorporated in the national law at German level and in this sector BW was not aiming at tighter obligations. The 2015 EWärmeG called then for a 15% instead of 10% inclusion of RES into the building heat

supply, which got obligatory after changing the central heating system in a building. Furthermore, the use of biooil got excluded as fulfillment option and obligations for biogas were tightened. Also, the renovation roadmap scheme was added as a 5% fulfillment option. Thereby, official energy consultants issue a step by step renovation concept which then has to be fulfilled in a given time period by the building owner (Lpb, 2018).

Figure 8: Shares of used fulfillment options for EWärmeG obligations in new and existing buildings



Data source: (La Croix *et al.*, 2011, pp. 43–44)

The 2015 version is still in place but did not get deeply evaluated so far. For the new act there are no datasets for CO2 mitigation or participation rates available. Interestingly, the law at German level has still no inclusion of the existing building stock while it took the concept for new buildings in a quite fast and similar way from the BW EWärmeG into the EEWärmeG at national level.

<u>Energetic optimization of historical buildings</u>

Specializing policy elements to foster EE retrofitting in old buildings is an important aspect to decarbonize the building sector in Germany and therefore implemented in BW as informative instrument and in Berlin as regulatory policy. The program in BW is also aiming at a higher renovation rate in old buildings but over an informative approach while Berlin enshrined the priority of EE updates in historical buildings in the BEK 2030 concept as key priority. Old buildings have a major impact on Germanys energy consumption in total. Figure 8 shows the magnitude of building categories grouped after their construction date in m^2 and the energy consumption of the different age groups. Resulting in the outcome that the buildings built before the introduction of the first building code are consuming the most energy and simultaneously building the biggest age group in terms of m^2.

In Berlin the measure is more specializing on historical listed buildings while in BW the program "Zukunft Altbau" is aiming at a general modernization of old buildings. In Berlin this goal is incorporated in the informative tool "renovation networks" where the focus is also put on historical buildings and available information on their energetic optimization possibilities (Berlin Senate, 2017, p. 74).

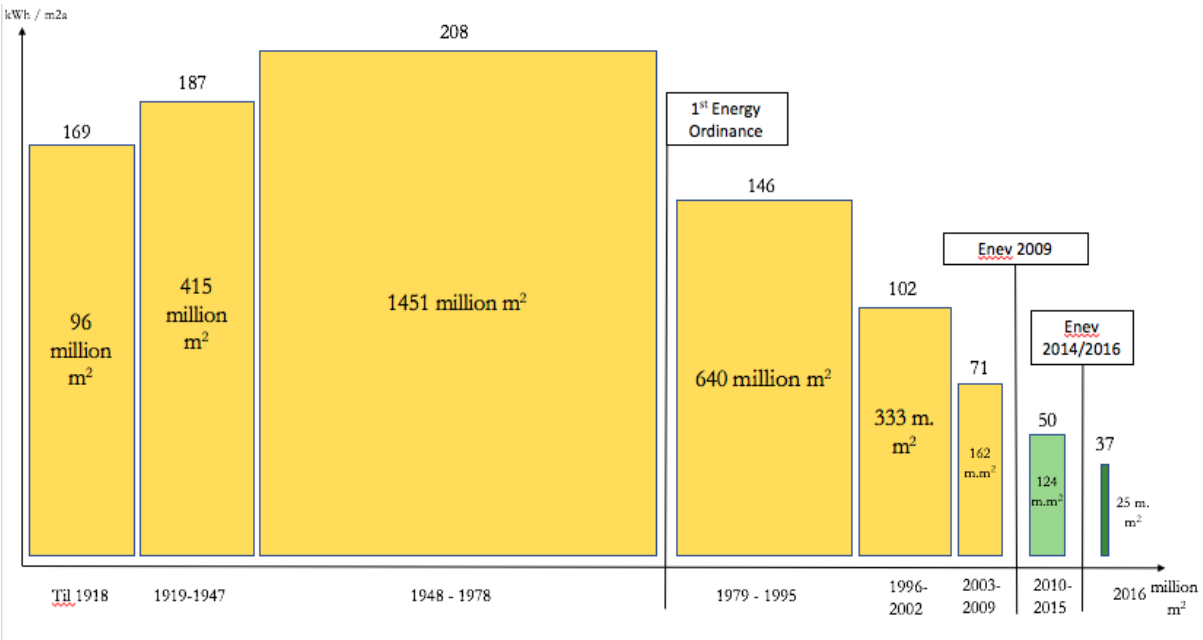


Figure 9:Energy consumption of the building stock by time classes:

Source: (Julie Emmrich, 2018)

Figure 8 illustrates the importance of EE renovations in the historical building stock. Buildings from 1948 – 1978 have a magnitude of $1451m^2$ and consume 208 kWh/m^2a. This means that

more than one third of the building stock is from this time period and has the highest average energy consumption compared to buildings from all other time periods.

Informative energy billing

A further unique implemented policy is the establishment of informative electricity, hot water and heating billing for all households in Berlin. The instrument aims at a detailed consumption split off and appropriated costs to each energy consuming unit. Interestingly, the 2012 Energy Efficiency Directive is obliging all MS to incorporate this policy tool in the national framework. Article 10 (2012/27/EU) is binding all MS to introduce and informative energy billing until the end of 2014, for all households without an installed smart metering system, to ensure household energy consumption information. Moreover, Article 11 is calling for a cost free implementation for the households (Energy Efficiency Directive, 2012, Article 10-11). While Germany is still in the implementation phase of the measure Berlin took a role model function in this sphere and incorporated the measure into the BEK 2030 strategy. The further goal is to incorporate the policy into the climate protection agreements with the biggest building owner associations in Berlin.

The projected impact of the policy implementation suggested by the Berlin Senate is amounting to a total of 15% energy consumption reduction in private households. Resulting in a yearly reduction of 1.5 to 3% due to the informative feedback about personal energy consumption patterns. The data should be furthermore included into the central information databank dIBEK to generate an higher impact due to publicly available private energy consumption patterns (Berlin Senate, 2017, p. 109).

Other regulatory/informative instruments

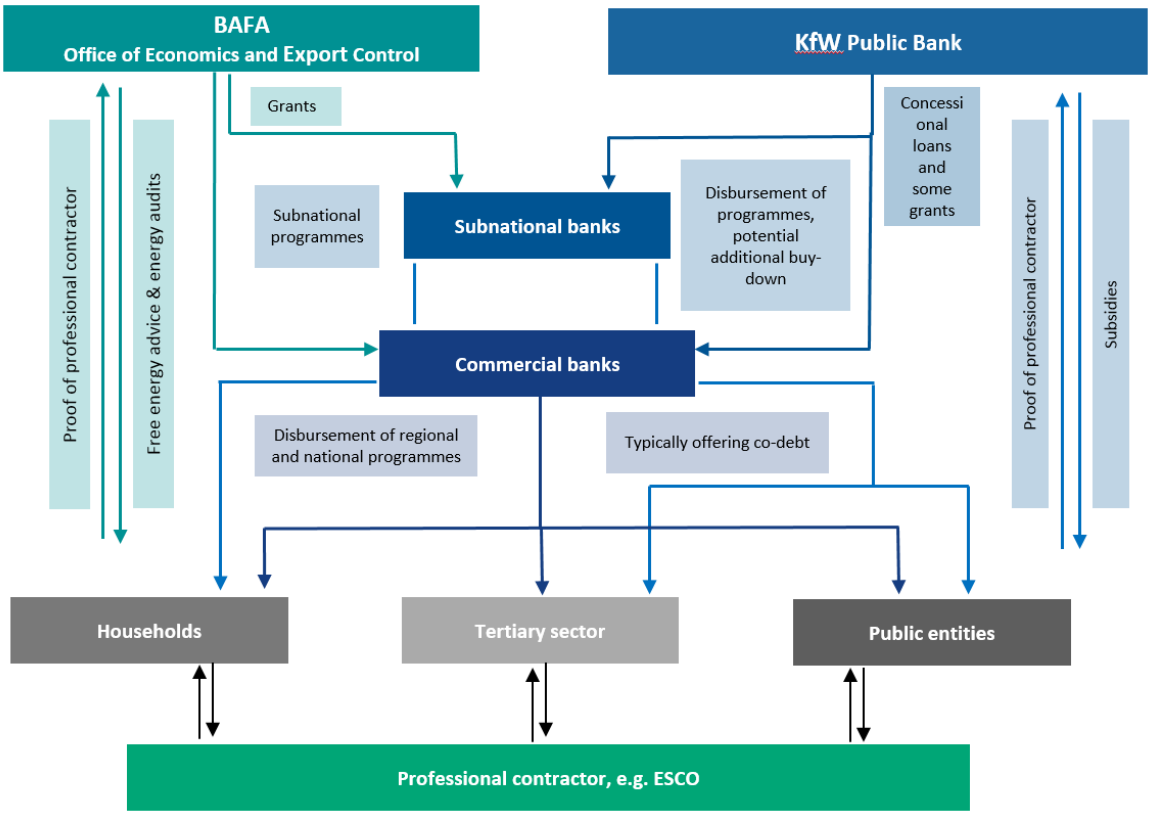
As shown in the policy map there are further applied policies in every state, but the reach, detail and coverage of the policies are rather specific, small or just applicable in especially this federal policy environment. An example for the applicability is the living area reduction in Berlin, aiming at a balanced distribution of living space among the different districts. This is specifically important for a densely crowded city state while it has a rather minor impact on bigger and less densely populated states as MV and BW.

The other applied informative tools are besides their rather detailed focus hard to compare in terms of impact since these tools are freely available to the public and thereby hard to evaluate. Examples are the regional competence centers, competitions, a central energy information database, or renovation networks. The participation in consultancy programs and thereby also

informative policy tools will be established over the comparison of financial incentives in the following, which are also often aiming at offering free information to the public.

Financial instruments

Figure 10: Institutional actors for climate finance in the building sector



Source: (Julie Emmrich, 2018)

Figure 9 shows the general institutional landscape climate finance in the German building sector. The two main sources of funding for subnational development banks is the BAFA or the KfW. From there the regional development banks develop their own programs as shown in the policy map. To establish an overview over the applied financial instruments in the different selected federal states this section condenses the detailed tables from the section about the regional policy environment into one comparable table x. Hereby, the eligible entities for the financial instruments are displayed by numbers of eligible sectors with a maximum number of 5 resulting from the beforehand established tables. The section “Focus area” is added to show how specific the instruments are targeting EE update areas. The category “EE updates” is used to describe a holistic instrument not focusing on one specific area which is for example often the case in interest rate discounted loans.

State	Financial Instrument	Type of funding	Eligible entities	Focus area
Berlin	QUAB project:	Grant	3	Building envelope
	BENE (focus area 1 and 2):	Grant	2	EE updates
	BENE (focus area 3):	Grant	3	Energy management system
	BENE (focus area 5):	Grant	3	R&D
	ENEO program:	Grant	1	Consultancy
	Residential energetic renovation:	Loan	1	EE updates
	Loan for EE in collectively owned property:	Loan	2	EE updates
	Rental building modernization:	Loan	3	EE updates
	Environmental loan:	Loan	2	EE updates
BW	Consultancy for SMEs:	Grant	1	Consultancy
	Resource efficiency financing:	Grant/ Guarantee	1	EE updates
	ECOfit project:	Grant	4	R&D
	Klimopass project	Grant	4	Consultancy

	Loan for EE in collectively owned property:	Grant/Loan	1	EE updates
	Renovation roadmap grants:	Grant	1	Consultancy
	Grants for EE heat supply:	Grant	3	Consultancy/Investments
	KmS 2014-2020:	Grant	1	EE updates
	Climate protection Plus:	Grant	3	EE updates
	Rental flat modernization:	Loan	4	EE updates
	Rental flat construction:	Loan	4	EE construction
	Guarantee program:	Guarantee	1	EE updates
MV	Climate protection funding directive - municipality:	Grant	2	EE updates
	Climate protection funding directive - enterprise:	Grant	2	EE updates

Data source: (BMWi, 2018b)

What gets at first obvious, as already shown in the policy map, is BWs variety of financial instruments. Compared to Berlin and MV, BW has the most financial instruments established to foster a decarbonization of the building sector. When summarizing the BENE program in Ber-

lin into one financial instrument Berlin has 7 instruments while BW implemented 12. But these numbers are difficult to compare, since credit volume, interest rate discounts and overall offered budget are hard to separate. Therefore, the sphere of "Focus area" is added into the table to fast compare how specific the instruments are applied for a certain outcome.

Most similar are the policy environments of Berlin and BW. The BENE program in Berlin and the KmS grants in BW are both resulting from the ERDF funding scheme and have the highest total credit volume in both states. While the program in Berlin is split in several focus areas and is covering all sectors besides private households in BW it is just applicable for the public sector. Furthermore, BENE is targeting specific problem areas such as the promotion of smart metering, but focus area one and two are generally aiming at a CO2 reduction of 60t resulting from EUR 1 mio. funding similar to the goal setting in BW just with a more detailed focus.

Moreover, both states have established a financial incentive to foster decarbonization strategies in collectively owned property. Additional, Berlin and BW have financial instruments in form from interest rate discounted loans to foster the EE in residential rental buildings. Berlin has two loan programs both aiming at the private sector with additional discount rates to the KfW loan program, while BW has one program for the EE renovation of existing buildings and one targeting new building constructions with a similar framework as Berlin.

At last the guarantee program in BW is to mention, since guarantees are not included in Berlins financial policy environment. In Berlin two special instruments are the environmental loan which is directly linked to percentage energy savings resulting from the investment and the QUAB project which tries to incorporate long-term unemployed people into the EE update process and specifically targets the old building stock simultaneously.

Noteworthy is the renovation road map grand established in BW since the instrument is directly targeting a specific established informative tool. Thereby, the financial environment directly helps to foster awareness about possible EE updates and specifically the increase in issued renovation road maps which is an important policy tool in BW. Also in Berlin grants for EE consultancy for the private sector are offered through the ENEO program but BW therefore has a second instrument, the Klimopass program, which is furthermore targeting a bigger variety of entities.

MV has two big financial programs in addition to the KfW funding scheme established. One is targeting municipalities to establish further EE updates in the public sector and the other one is targeting SMEs. Both are aiming at a variety of decarbonization measures including the

building sector and EE but also all other sectors. The grants are also eligible for investment planning and planning studies. Problematic is the fact that there are no specific instruments targeting the private sector in addition to the KfW funding scheme (BMWi, 2018b).

b) Multilevel reinforcement and federalism

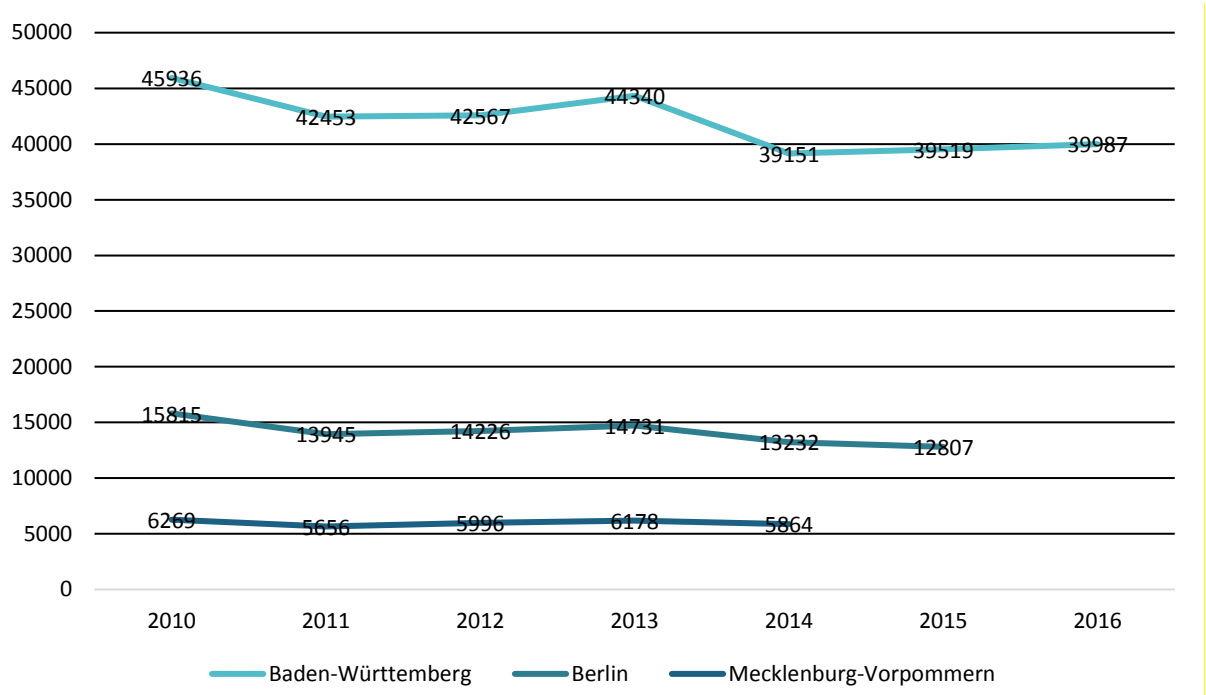
These different outcomes in policy implementation are grounded in the federalist governance system applied in Germany. In contrast to a hierarchical state structure, the theoretical foundation for the political implementation of EE policy is the multilevel governance context considering institutional interaction of national, supranational and subnational bodies with own obligations. Federalism is building on shared authority with same goal setting and complementary actions (Hooghe and Marks, 2003). This should serve as the basis for multi-level reinforcement of climate mitigation policies. There are indeed several processes resulting in a reinforced diffusion of climate friendly policies. Reinforcement can be triggered through technologies developed by lead- implementers and also from lessons learned by early adopters and furthermore by vertical and horizontal learning processes triggered by the multi-level governance environment (Jänicke, 2014, p. 37).

In this case BW would be taking a pioneer role in EE policy implementation and through the reinforcement cycle spillover effects should be generated to other states. This could be seen in the example of Berlin where the Senate established a quite new but progressive energy law and concept following the example of beforehand established regional energy programs. Furthermore, Berlin developed also new regulations, such as the living area reduction, from which then other stated could draw on learned lessons by Berlin.

Besides the reinforcement of climate friendly policies, the state competition also leads to a steady increasing heterogeneity of applied policies in the different German regions. This can lead to a mismatch with the German or European goal setting due to regional specific interests and challenges. Combined with a mutual difference of historical path dependency, especially between the former east and west, there is the risk of increasing inefficiency and costs if regional regulations are not coordinated into a coherent and multilateral beneficial direction instead of self-interest goal settings (Ohlhorst, 2015, pp. 304–305).

There can be further reasons detected for the variety in policy instruments. Figure 10 shows the emissions generated by private household energy consumption for the past years from 2010.

Figure 11: CO2 emissions from final energy consumption of households, tertiary sector and other consumers (excluding industry and transport) in 1000t (polluter balance)



Data source: (LAK, 2018)

BW has by far the highest emissions from households' final energy consumption, more than triple the amount of Berlin and nearly seven times the emissions of MV. It is important to note that BW is also one of the biggest federal states while MV is one of the smallest. Therefore, these numbers are hard to compare but put the policy implementation in a different perspective. Obviously MV has a lower incentive for progressive EE policies if on an emission scale the impact of higher EE in the building sector would be rather small at German level. It must be noted that the statistic is also including other polluters but it can be assumed that most of the CO2 emissions result from buildings energy consumption. This assumption had to be made since there is no data for per m^2 energy consumption or CO2 emissions at federal state level available.

Besides smaller incentives for additional EE in MV due to a low impact at German level of additional energy savings, constrains resulting from economic, social, environmental and financial differences play an important role in regional EE planning (Raimondi *et al.*, 2012, pp. 8–13). Due to varying regional advantages and disadvantages the institutional setting is also diverse from state to state. The departments responsible for energy policy in different federal states are totally different structured. With more divisions responsible for energy related topics in some states and merged departments where energy efficiency is no single division but a shared competence in other states. In the three representative states Berlin has a shared de-

partment for energy, digitalization and innovation with one division responsible for energy related topics (Berlin Senate, 2018c). MV has also a shared department for energy and land development with three divisions responsible for energy questions (MEID, 2018b). BW in return has a specialized department for energy related issues with five subdivisions from which one is especially for EE in the building sector (MUKE, 2018b).

From these institutional differences diverse resulting policy outcomes are expectable. An entire division specialized on EE in the building sector will produce more detailed and complex EE supportive policies then one division responsible for EE but also two other focus areas with less people, as in Berlin. Therefore, the different political outcomes discovered in the policy map are also grounded in institutional development differences. If there is a learning potential resulting from the differenced will be discussed in the next paragraphs by testing the transferability of extracted best practice examples of applied policies.

c) Best practice and transferability

From the discovered decarbonization policies applied in the three federal states the selection will be condensed into best practice examples of implemented policies. Best practice referees here to the policies where afterwards the replicability potential to other regions will be tested. Due to the limitations of the report the transferability will not be tested for all applied policies.

The selection will be based on three indicators:

- Does the applied policy tackle a major barrier to EE improvements in the building sector?
- How focused is the policy? Does it reach out to more than one specific target group but has not a too far reach over all target groups in the sector?
- Is the policy already implemented?

The first indicator refers to the analyzed barriers in the literature review. If the policy is not addressing a specific barrier it will not be taken as a best practice example. A similar process will be applied to the focus. If the policy is too specific and just addresses a really small target group the following transferability test is not relevant due to low mitigation potential. Furthermore, the policy has to be already implemented since a hypothetical transferability test is groundless.

Excluded because the instrument is not tackling a major barrier to EE improvements:
Regional completions (B, BW), exemplary function of public sector (B, MV, BW), climate advisory council (B, BW).

Excluded instruments due to an unspecific focus:
EE competence center (BW), Renovation network (B), Visiting consultancy (B).

Excluded instruments because not already implemented in praxis:
climate protection education (B, MV), informative billing (B), central EE database (B), living area reduction (B).

After the selection of best practice decarbonization instruments in the building sector the horizontal transferability of these policies is to be tested. The replicability of policy elements is important to be tested in these circumstances to evaluate a learning potential between the different regions. If horizontal transferability of additional policies in BW to MV is not a given for some instruments this could result from different challenges towards EE improvements due to regional differences. But if none of the policies is transferable this could result in a failure of multilevel reinforcement and the justification basis of multilateral benefits in federalism.

As developed in the methodology, the four spheres should serve as a basis to evaluate the transferability of a policy element to another region:

- Similarity of Stakeholder interests.
- Magnitude of issue in regional framework.
- Similarity of addressed target group characteristics.
- Degree of additionality.

If these indicators are similar in the different regions the policy element should be transferable since then it can be excluded that the policy is just targeting a regional specific barrier or target group but a general problem to EE improvements from which other regions could learn. Therefore, the four spheres will be tested systematically with the extracted best practice examples to develop an overview of horizontal learning possibilities in the multi-level policy environment.

(1) Renovation roadmap (BW)

The instrument of the renovation roadmaps issued in BW was chosen because:

- It tackles multiple barriers to EE improvements in the building sector. A main problem is the circumstance specific need for information about cost effective technologies to enhance a buildings energy performance. The roadmap offers a step for step plan about reaching different levels of EE in a building and thereby gives the building owner a comprehensive overview about positive long-term effects of energetic renovations under the restriction of personal preferences and circumstances. Moreover, it is connected to a grant offered by the L-bank for roadmaps issued in the private sector and thereby tackles the financing barrier as well. Also, it can be used to partly fulfill the EWärmeG obligations and thereby has an enhanced motivation factor through the connection to the regulatory sphere (MUKE, 2015b, pp. 1–5).
- The renovation road map is especially targeting users obliged by the EWärmeG, after exchanging the central heating system, to incorporate 15% of RES into their heat supply or execute alternative measures such as building envelop updates or the renovation roadmap. The instrument is targeting users, who are already engaged in the EE discourse and therefore it is expectable that many building owners will fulfill measures proposed in the roadmap, even without a penalty for noncompliance to the renovation plan (MUKE, 2015b, pp. 1–2).
- The instrument is already implemented and backed up by an own regulation since 2015 establishing a legal framework for the content and goals of the roadmap (Landesregierung Baden-Württemberg, 2015).

Transferability

The renovation roadmap BW already got partly transferred to the German level. In the Energy efficiency strategy for buildings developed by the BMWi the plan to develop a standardized German consultancy tool, called renovation roadmap, was already enshrined (BMWi, 2015, p. 72). The software based tool is available for all building energy inspectors since May 2017 and is part of the BAFA on site consultancy funding (BMWi, 2018a). But the regional renovation roadmap in BW is established already since 2015 and is different in detail and policy support. While the German renovation plan is an attempt to standardize EE consultancy at German level in BW the roadmap is also used fulfill the obligations from the EWärmeG which leads to a high motivation by users to first get a consultancy and then also take proposed measures into action. Out of these reasons a test of transferability of regional specific renovation roadmaps additional to the software tool established at German level is valuable and will be tested in the following.

The interests of affected stakeholders stay the same in the different German federal states. The policy is in any case affects mainly building owners who are exchanging their heating system or plan an energetic renovation and energy efficiency consultancies and inspectors who are eligible to issue the renovation roadmap. The first group will tend to have a diverse interest into the roadmap dependent on personal cost resulting from the issuing and the fact that EE updates are not a main topic for many. While inspectors will have a bigger interest caused by a probably higher demand for the roadmaps. In a wider sense it affects all parties engaged with building updates but the core stakeholders share the same interests in any federal state.

The magnitude of issue in regional context is also similar since all federal states have the need for a better informative and consultancy offer in the sphere of EE in the building sector. In terms of the obligation from the EWärmeG the issue with the renovation roadmap as a fulfillment option gives a higher importance to the tool in BW than in other German federal states, since the German wide roadmap is not mandatory in any case. Therefore, the magnitude of the issue is also dependent on an obligation to issue a roadmap.

The addressed target groups are the same in all different federal states since actually all building owners are addressed. In BW the tool is just further targeted and focused due to the connection to the EWärmeG.

The degree of additionality is furthermore the same in the German federal environment, since none of the states have a standardized consultancy tool based on regional regulations besides the renovation roadmap at German level established. In the light of that the degree of additionality is the same but can be evaluated as rather small if not connected to a regional regulation obliging the roadmap in any sense.

In conclusion it can be said that the tool is transferrable horizontally but the additionality generated by it without an obliging regulation backing up the roadmap is rather small. Since there is already a tool developed at German level the lessons learned from the BW tool should be incorporated at German level and implemented with a leeway for regions to incorporate regional specifications.

(2) Historical buildings renovation program (BW)

The informative tool established in BW is best-practice example, since:

- It aims at solving the problem with distorted information about possibilities for funding and available technologies especially for old buildings which are the major CO2 emitters in the building sector.

- It is directly targeted on owner of old/historical buildings. This is an important target group since these buildings are a majority in the building stock and are built before the introduction of the building codes and therefore have the highest potential for CO2 reductions through retrofits (BMWi, 2014).
- The program is run by the federal state energy agency of BW called KEA and gets funding from the MUKE.

Transferability

The affected stakeholder by the policy are the same in all federal states since the instrument is implemented by the federal state energy agency which is existing in all regions and which shares the same interest. The development and composition of the agencies may vary but formally the implementing parties are similar to one another.

The magnitude of the issue is slightly dependent on the federal state. This is due to the building stock composition differences from one region to the other. But overall, all old buildings have a low renovation rate and high emissions per square meter and are therefore a problem to be tackled with same importance in all German federal states.

The characteristics of the with the policy addressed target group are also similar in the different regions. Since the target group is owners of old buildings with a low renovation rate the addressed target group has similar characteristics.

The degree of additionality depends on the execution of the information and marketing campaign. If the same money is invested to generate a high reach in all regions the additionality would be similar. In all regions old buildings bare the same problematic to EE improvements in the build environment and all federal states share the goal to solve that problem.

To summarize the tested spheres, it can be said that the information campaign to foster EE updates in old buildings can be perfectly transferred to other regions in Germany. The generated impact in other regions mainly depends on the budget spend on the campaign. The interest in running a marketing campaign also depends on the composition of the building stock in the other regions.

(3) EWärmeG (BW)

The regional established renewable heat act for existing buildings in BW is a best practice example for CO2 mitigation policies applied in the building sector because:

- It tackles the institutional barrier to EE improvements by obliging all house owners to act but offer a variety of measures to fulfill the obligation. Thereby, considering the fragmentated market and interest structure of the decision-making process. Through the attachment of the obligation to the exchange of the central heating system the instrument also considers the barrier of high upfront costs. The connection of the obligation to anyway conducted renovation measures (MUKE, 2014). Moreover, the regulation is incorporating also other instruments, such as the renovation roadmap, trying to combine established informative tools to solve the distorted information problem in the EE policy environment.
- The target group of the instrument are building owners who need to exchange a heating system. Therefore, it can be broadly applied but is targeting from a big cohort just the building owners who are in need or interested in an energetic renovation.
- The first version of the EWärmeG was already implemented in 2008. The obligation for new buildings resulting from the 2008 version became national law in 2009. From then the law got renewed in 2010, just concentrating on existing buildings and tightened and renewed in 2015, which is the current version of the regulation until now (Lpb, 2018).

Transferability

Also this regulation from BW got partly transferred to the national level in 2009 with an obligation to incorporate 20% of heat from RES into the supply of new buildings. After this the EWärmeG was specializing on the existing building stock in BW and left the regulation for new buildings up to the national legislator. The transferability test in this section is only referring to the EWärmeG from 2015 and thereby only on obligations for existing buildings which can be also fulfilled by a combination of EE updates instead of the feed-in of RES into the heat supply (Lpb, 2018).

The by the regulation affected stakeholder can be defined similar in all regions in Germany and also in Europe. The construction companies and energy service providers will have a big interest into the regulation due to an increased renovation rate. The policy makers also have a high interest in increasing the renovation rate of the old building stock due to the shortcomings in this sphere. The building owners will also have a rather diverse opinion about the regulation but probably in a similar distribution in all regions. Therefore, it can be said that the interests of the by the policy affected stakeholders share the same interests into the policy in all German federal states.

The magnitude of the issue is high in the entire EE policy environment. Since new buildings follow strict obligations resulting already from the European directives the existing building

stock has the highest potential for further energy savings. Therefore, greening the existing building stock from major importance in the EU and its regions (Ma *et al.*, 2012).

The characteristics of the target group are a little bit dependent on the region. The regulation addresses all building owners having to exchange a heating system and thereby people who are already planning on a renovation measure the support of the policy relies also on financial aspects. Through the tie of the obligation to anyway conducted building update the upfront costs for a EE renovation are decreasing but the total costs are anyway higher than for the originally planned measure. But §19 is defining exceptional cases, such as the financial or building specific situation, where the obligation is not to fulfill. Therefore, it can be said that the target group characteristics may vary from region to region but the implementation of the regulation is taking that differences into consideration (Landtag Baden-Württemberg, 2015, §19).

The degree of additionality is the same in all federal states since the law is adding the sphere for existing buildings to the national law for new buildings and BW is the only state having this supplementary regulation implemented.

In conclusion it can be said that the regulation is transferable horizontal to other federal states. This learning process would be also important to establish further regulations attempting to green the existing building stock where a major potential for energy savings can be realized. The biggest obstacle for this process are political agendas, since the regulation would have to be implemented by different parties and thereby progressive environmental laws are more likely to get passed by a strong green federal government, as it was the case in BW. In theory the regulation would be good transferable to other states but there are also many applicability barriers to consider. A step by step implementation approach considering constant user feed-back and evaluations could be the chosen way.

(4) Historical buildings energy optimization (B)

The program similar to the informative tool established in BW for historical buildings is a best practice for EE in the building sector, since:

- It also aims at solving an institutional barrier. The barrier results from listed historical buildings with restrictions on renovation work but the need to update the energy per-formance of that historical building stock Therefore, it is also a part of the EnEV at German level to which the Berlin measure is supplementary. Furthermore, the aim to combine maintenance work on historical building structure to the conduction of EE

updates breaks the barrier to get a renovation permit for listed buildings in the first place (Berlin Senate, 2017, p. 70).

- The target group are owners of listed historical buildings. It is an important target group in regions with many historical buildings from which many are furthermore listed as monuments and as described above also evaluated as important at German level.
- It is established in the BEK 2030 strategy and was already 2013 a part of a big project study (Berlin Senate, 2013).

Transferability

The interests of affected stakeholders by the policy can be defined as similar from region to region in the case of listed historical building updates. But the interests are not complementary in the sense that the policy maker and public want to maintain historical building structures, but simultaneously have a high interest in updating the buildings in terms of EE. How these counteractive interests are balances then depends on the federal state.

The magnitude of the issue is also dependent on the federal state since some regions have a higher density of historical buildings then others. In the states with many listed buildings this is a major topic for advanced EE policies.

The characteristics of the target group also varies from region to region. Exact numbers are not available but the Bavarian historical preservation ministry published a summary of listed historical monuments per federal state in 2002. The list is not specific and complete but gives insights about the structural distribution of listed historical buildings in Germany (denkmalnetz bayer) . From the list it gets obvious that the distribution of historical buildings and their ownership structure is highly state dependent. Some states have 90% public ownership of listed historical buildings others have high private shares in ownership instead.

Since the ownership and distribution structure is so state dependent but exact numbers are not available a statement concerning the additionality in the different regions is not possible. The additionality of the policy element is region specific and could be calculated by the regional ministries.

From the tested dimensions it can be concluded that a policy aiming at EE updated in historical listed buildings has to be implemented with regional specific attributes and therefore a transferability of a general policy element is not possible.

(5) Climate protection agreements (B)

The in Berlin established CPAs between the Senate and big economic stakeholders in the building sector, such as the housing industry, energy service providers and energy producers can be seen as a best practice example because:

- It mitigates the interest conflict between the economic stakeholders and the policy makers through multilateral agreements on volunteer basis, in which specific mutual measures from both sides to reach the climate goals are declared in detail and thereby get obligatory. Furthermore, the CAPs take specific interests and conflicts into account, since each agreement is individual in goal setting and set of measure instead of a one-fits-all approach.
- The target group are big companies in the private sphere related to housing or energy service in a broader sense and therefore one of the most important target groups for EE in the building sector.
- The first CPAs were signed in 1997 between 14 partners and the state of Berlin. From then onwards the agreements got renewed with 10 of the partners in 2002and then further partners joined and some agreements ended in the meanwhile (Berlin Senate, 2018b).

Transferability

Climate protection agreements are a long-developed tool in berlin and one of the main pillars for EE improvements in the city state. While there are many CPAs at international level between states berlin is unique with agreements between a federal state and the private economy to achieve multilateral goal settings.

In terms of stakeholder interest, the regional states are not different to one another in the sphere of big private enterprises and associations. Most private economically stakeholders share the same interest in profit maximization. Therefore, the agreements are obligatory on both sides. While the state of Berlin is directing climate investments to the CPA partners, the obliged enterprises commit to achieve beforehand established CO2 reduction goals and further climate targets with a specified measure catalog. This interest structure can be balanced in this way in all German regions.

The magnitude of the issue to incorporate big private enterprises such as the housing industry into the energy transition is high in all states.

The characteristics of the target group on the other hand depend on the federal state environment. While in Berlin there is a high industry density and in terms of the building sector an oligopoly structure of the housing industry, other states have much more fragmentated market structures. Therefore, the characteristics of the target groups would be similar in more densely populated federal states while they would be quite different in rathe rural states, such as MV.

The degree of additionality depends, as in the last paragraph on the size and influence of the with the CPA targeted interest group. In Berlin the degree of additionality of a CPA with one housing association can be defined as big while in MV one association has a rather small impact and an agreement with all housing associations would be a desirable goal.

In conclusion CPAs are a desirable policy tool to incentivize higher EE in big private enterprises especially with a less fragmentated housing industry structure. They can be transferred into other regions but the negotiations can have different outcomes in different federal states. Nevertheless, volunteer agreements have a positive impact in any case to archive climate protection goals when the targeted enterprises are selected after the highest possible impact of influence. Other states can build on lessons learned from Berlin since the agreements got multiple time renegotiated and outcomes can be evaluated.

VII. Conclusion

1. Summary

The building sector in Germany is one of the sectors with the highest generated GHG emissions. The current unsustainable use of energy has major impacts on the environment and climate. Employing further EE in the building sector is therefore an important step to lower the energy use in buildings and thereby the primary energy demand. To achieve this goal setting the political framework must be efficient in incentivizing EE decisions for building updates and retrofits.

Due to the German federalist policy system and the European multi-level governance framework regions play an increasing important role in developing further policy elements built upon regional challenges and advantages. Therefore, this report collected and analyzed the additional regional applied policies in the three representative federal states Berlin, Mecklenburg-Vorpommern and Baden-Württemberg. Thus, condensing them into an informative policy map to visualize similarities and differences in regional EE policy implementation.

One of the most crucial observations in the policy map is big difference in the amount and composition of additionally applied policies to foster a regional building sector decarbonization. MV has 6 separated policy tools established additional to the German framework, while Berlin and BW have 19 supplementary policy tools. Furthermore, the composition of applied policies also varies highly between the three regions. While BW established three regulatory tools and MV two, Berlin has six. Financially BW offers incentives through 12 separated programs while Berlin established seven additional to the German funding scheme and MV has two general programs resulting from ERDF funding.

The big differences in policy implementation under the same national framework can be explained by varying economic, social, environmental and financial contains in every federal state. Moreover, they are grounded in the federalist governance system relying on multi-level reinforcement through learning processes between regions. Thereby, regions with a less employed policies, such as MV should employ policies from lead federal sates, such as BW, which are proven effective. An Example therefore can be seen in Berlin which developed a rather new and progressive EE policy agenda also incorporating policies from BW.

Problems in this process are seen in a lack of coordination on specific national targets reached by complementary federal state policy development. The increasing heterogeneity resulting

from regional specific interest can lead to a mismatch of regional and national goal setting. A coordinated evaluation process of regional EE policies in terms of impact and effectiveness could be a solution to this problem.

Policy	Stakeholder interests	Magnitude of issue	Target group characteristics	Additionality	Conclusion
Renovation roadmap	✓	--	✓	--	Transferable, but minor impact
Historical building renovation	✓	--	✓	✓	Transferable, but impact depends on invested budget
EWärmeG	✓	✓	--	✓	Transferable, but political barriers to implementation
Listed historical buildings EE	✓	/	/	/	Not transferable
Climate protection agreements	✓	✓	--	--	Transferable, but outcomes are dependent on negotiations with private sector

✓ = Similarity is given; -- = Similarity is given in some regions; / Similarity is not given

Source. Author

In terms of horizontal transferability, it can be said that many of the extracted best-practice policy examples have the potential to be applied in other German regions and specifically also in MV. It has to be noted that some policies offer rather small additional value in other regions due to specific regional challenges in the federal states for which they are applied. An example is the renovation roadmap in BW which adds a higher value in combination with the EWärmeG but without this specific regulation the similar tool employed at German level is also sufficient for the other federal states.

Other tools from informative nature, such as the historical building initiative in BW, are easy to transfer and it can be built on lessons learned where they are implemented to generate the highest impact. Therefore, an exchange of expertise about informative policies and generated outcomes at regional level is a valuable field of action. Regulations with a high impact such as

the EWärmeG are rather difficult to transfer directly due to political barriers but a step for step approach for more progressive policies targeting the existing building stock is an important future development and therefore highly recommendable.

Policies targeting listed historical buildings, such as the energy optimization of listed buildings in Berlin, are difficult to employ in other states because of the big variety in numbers of listed historical building from one region to another. On the other hand, the climate protection agreements established in Berlin are difficult to transfer, due to a different stakeholder structure in different federal states, but aiming at volunteer agreements with the private economy is highly recommendable to extend the influence in this sector. Therefore, the policy cannot be directly transfers but is an important goal setting also for other federal states, which can build on the experiences in Berlin.

2. Recommendations

To foster multilateral beneficial regional policies to decarbonize the building stock some recommendations for further development can be given.

Establish systematic monitoring

To have a better overview about regionally applied policies a duty monitoring also at federal state level could be a good solution. Furthermore, continuous monitoring is resulting in a more systematic development of regional EE policies and can be better aligned with the climate goal setting at German and European level.

Exchange platform for monitoring results

Establishing an institutional platform for regional knowledge exchange for decarbonization policies in the building sector could help to foster better spillover effects between federal states. Presenting monitoring reports and evaluation of regional policies could foster a multilateral beneficial development of regional EE policies.

Coordination of regional policies

Based on an established monitoring and knowledge exchange a better coordination of applied policies to reach a common goal under the restrictions of regional advantages and challenges could be developed. This could decrease the heterogeneity of regionally applied policies and foster a faster climate goal achievement.

Evaluation of monitoring

In depth evaluations of impacts resulting from applied policies and based on monitoring results are needed to give further insights about beneficial and non-beneficial policy implementation. Furthermore, evaluations based on quantitative data are important to give further policy recommendations.

Transparency of monitoring

An increased transparency of available data regarding applied policies is central to foster civil participation and further research in this field. In the sphere of financial incentive, publishing data about participation rates for different programs and funding volume available in every federal state is important to generate an overview of instruments and their importance.

3. Future research

Full landscape

To build upon the conducted research in the present report a policy map for the entire German federal state landscape can be developed. This would establish a comprehensive overview of the entire policy environment and could help to give further policy recommendations.

Transferability study backed by quantitative data

Due to the data limitations discovered in the present research concerning the impacts of regional applied policies in terms of CO2 savings or cost-benefit analysis further research in the sphere of EE policy transferability could establish better learning mechanisms. Therefore, research using quantitative data combined with the established qualitative approach could be conducted in this field

Transferability pilots

To realize the potential of transferability studies pilot projects could be used to back up discovered transferability potentials of policies. Trying to replicate a policy in another region using a pilot project would generate further insights into this topic.

Transferability of financial instruments

Due limited data offered by the regional development banks about additionally employed financial incentives, further research is needed to discover the replication potential of financial instruments. With available data about all programs run by different federal state development banks a comparison of instruments is possible and transferability study based on quanti-

tative data could be conducted. The insights generated would be from big importance to establish effective financial support to foster EE improvements.

VIII. Bibliography

ACEEE (2016), "Summer Study on Energy Efficency in Buildings: From Components to Systems, From Buildings to Communities. Energy Efficiency and Climate Change Policy: U.S. & Beyond", 9. Energy Efficiency Policies in the German Energy Transition, 9-1 - 9-13.

Allouhi, A., El Fouih, Y., Kousksou, T., Jamil, A., Zeraouli, Y. and Mourad, Y. (2015), "Energy consumption and efficiency in buildings: current status and future trends", *Journal of Cleaner production*, Vol. 109, pp. 118–130.

Bergek, A. and Norrman, C. (2008), "Incubator best practice: A framework", *Technovation*, Vol. 28 No. 1-2.

Berlin Senate (2013), "Senatsverwaltung für Stadtentwicklung und Umwelt. Studie Energetische Perspektive denkmalgeschützter Wohnungsbauten", available at: https://www.stadtentwicklung.berlin.de/staedtebau/baukultur/iba/download/studien/IBA-Studie_denkmalgeschuetze_Wohnungsbauten.pdf (accessed 9 July 2018).

Berlin Senate (2016), *Berliner Energiewendegesetz: EWG Bln*.

Berlin Senate (2017), *Berliner Energie- und Klimaschutzprogramm 2030 (BEK 2030): Für ein klimaneutrales Berlin*, Umsetzungszeitraum 2017 bis 2021, Konsolidierte Fassung.

Berlin Senate (2018a), "Senatsverwaltung für Umwelt, Verkehr und Klimaschutz. Klimaschutzpolitik in Berlin: Die Erfolge der Klimaschutzpolitik", available at: http://www.berlin.de/senuvk/klimaschutz/politik/de/erfolge.shtml (accessed 5 June 2018).

Berlin Senate (2018b), "Senatsverwaltung für Umwelt, Verkehr und Klimaschutz. Klimaschutz-vereinbarungen des Landes Berlin", available at: https://www.berlin.de/senuvk/klimaschutz/aktiv/vereinbarung/index.shtml (accessed 7 June 2018).

Berlin Senate (2018c), "Senatsverwaltung für Wirtschaft, Energie und Betriebe Abteilung III - Energie, Digitalisierung, Innovation", available at: https://www.berlin.de/sen/web/ueber-uns/leitung-und-organisation/abteilungen/abt-iii/ (accessed 6 July 2018).

BMWi (2014), *Bunesministerium für Wirtschaft und Energie [Federal Ministry for Economic Affairs and Energy]: Sanierungsbedarf im Gebäudebestand*.

BMWi (2015), *Bunesministerium für Wirtschaft und Energie [Federal Ministry for Economic Affairs and Energy]: Energieeffizienzstrategie Gebäude*, III. Maßnahmen und weitere Optionen zur Steigerung der Energieeffizienz und des Anteils Erneuerbarer Energien im Gebäudebestand, Berlin.

BMWi (2017), "Bunesministerium für Wirtschaft und Energie [Federal Ministry for Economic Affairs and Energy]. Energieeffizienz in Zahlen".

BMWi (2018a), "Bunesministerium für Wirtschaft und Energie [Federal Ministry for Economic Affairs and Energy]. Energieeffizienzstrategie Gebäude", Der individuelle Sanierungsfahrplan, available at: https://www.bmwi.de/Redaktion/DE/Artikel/Energie/energieeffizienzstrategie-gebaeude.html (accessed 10 July 2018).

BMWi (2018b), “Bunesministerium für Wirtschaft und Energie [Federal Ministry for Economic Affairs and Energy]. Förderdatenbank”, available at: http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html (accessed 13 June 2018).

Brown, M.A., Chandler, J., Lapsa, M.V. and Sovacool, B.K. (2007), “Carbon lock-in: Barriers to deploying climate change mitigation technologies. Oak Ridge National Laboratory”, *ORNL/TM-2007/124 (Revised November 2008). http://www. ornl. gov/sci/eere/publica tions. shtml*.

Buffett, C., Ciliska, D. and Thomas, H. (2007), “Can I Use This Evidence in my Program Decision? Assessing Applicability and Transferability of Evidence”.

Bürger, V. (2011), *Einsparquote für Deutschland? Machbarkeit und Eignung eines Quotenansatzes zur Erschließung nachfrageseitiger Energieeffizienzpotenziale*.

Corrales, M.E., Puerta, J.M., Medieta, M.P., Morales, C. and Suarez, D. (2014), *Background Paper: Energy Sector*.

Covary, T. and Averesch, U. (2013), “Overview and assessment of the energy efficiency and energy conservation policies and initiatives of the Republic of South Africa. ECEEE Summer Study - Rethink, Renew, Restart”, pp. 591–600.

denkmalnetz bayer, “Denkmalzahlen. Deutsches Nationalkomitee für Denkmalschutz; Erstellungsdatum unbekannt (nach 2002, vor 2009)”, Denkmalschutz und Denkmalpflege in Deutschland, available at: https://www.denkmalrechtbayern.de/wp-content/uploads/2015/06/1-3-3-Denkmalzahlen_DNK_Stand_2002-5-S.pdf.

Ecofys (2010), “Bio Intelligence Service. Study to support the impact assessment for the EU energy saving action plan”, *Study to support the impact assessment for the EU energy saving action plan*.

Energy Efficiency Directive (2012), “Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32”, *Official Journal, L*, Vol. 315, pp. 1–56.

EPBD Recast (2010), “Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)”, *Official Journal of the European Union*, Vol. 18 No. 06, p. 2010.

European Commission (2002), “Directive 2002/91/EC on Energy Performance of Building Directive”, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:l27042&from=DE.

European Commission (2010), “Europe 2020: a strategy for smart, sustainable and inclusive growth”, *Working paper {COM (2010) 2020}*.

European Commission (2011), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Energy Efficiency Plan 2011*, Brussels.

European Commission (2015), “Regional Policy. Priorities for 2014-2020”, available at: http://ec.europa.eu/regional_policy/en/policy/how/priorities.

European Commission (2016), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of regions and the European Investment Bank, Clean Energy For All Europeans: COM(2016) 860 final*.

European Commission (2017a), "Policies, information and services. Energy Efficiency", Buildings, available at: https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings (accessed 27 March 2018).

European Commission (2017b), "Policies, information and services. Energy Efficiency", Financing energy efficiency, available at: https://ec.europa.eu/energy/en/topics/energy-efficiency/financing-energy-efficiency (accessed 11 April 2018).

Finance Ministry (2017), *Ministerium für Finanzen: Energiebericht 2017*.

GBPN (2017), "Policy Comperative Tool Database. Germany", available at: http://www.gbpn.org/databases-tools/bc-detail-pages/germany#undefined (accessed 20 March 2018).

Girod, B., Stucki, T. and Woerter, M. (2017), "How do policies for efficient energy use in the household sector induce energy-efficiency innovation? An evaluation of European countries", *Energy Policy*, Vol. 103, pp. 223–237.

Henger, R.M., Runst, P. and Voigtländer, M. (2017), *Energiewende im Gebäudesektor: Handlungsempfehlungen für mehr Investitionen in den Klimaschutz*.

Herczeg, M., McKinnon, D., Milios, L., Bakas, I., Klaassens, E., Svatikova, K. and Widerberg, O. (2014), "Resource efficiency in the building sector", *Final report. Prepared for European Commission by ECORYS and Copenhagen Resource Institute, Rotterdam, the Netherlands*.

Hooghe, L. and Marks, G. (2003), "Unraveling the central state, but how? Types of multi-level governance", *American political science review*, Vol. 97 No. 2, pp. 233–243.

House of Representatives (2017), "Schriftliche Anfrage des Abgeordneten Georg P. Kössler (GRÜNE). Drucksache 18 / 10 300", Welche Erfolge verzeichnen die bisherigen Klimaschutzvereinbarungen Berlins?, available at: http://pardok.parlament-berlin.de/starweb/adis/citat/VT/18/SchrAnfr/s18-10300.pdf (accessed 7 June 2018).

House of Representatives (2018), "Schriftliche Anfrage des Abgeordneten Georg P. Kössler (GRÜNE). Drucksache 18 / 14 807", Klimaschutzvereinbarungen des Landes Berlin, available at: http://pardok.parlament-berlin.de/starweb/adis/citat/VT/18/SchrAnfr/s18-14807.pdf (accessed 7 June 2018).

IEA (2017), "Energy Efficency. Market Report Series".

Jänicke, M. (2014), "Multi-level reinforcement in climate governance", in *Im Hürdenlauf zur Energiewende*, Springer, pp. 35–47.

Julie Emmrich (2018), *Tracking Climate financein the German Building Sector: A Landscape offinanceflows forbuilding decarbonisation in 2016*, forthcoming thesis at IIIEE; Lund University; ISSN 1401-9191, Sweden.

KfW (2018), "Merkblatt Energieeffizient Bauen", available at: https://www.kfw.de/PDF/Download-Center/Förderprogramme-(Inlandsförderung)/PDF-Dokumente/6000003464_M_153_EEB_2018_04.pdf (accessed 17 April 2018).

Koeppel, S. and Ürge-Vorsatz, D. (2007), *Assessment of policy instruments for reducing greenhouse gas emissions from buildings*, Report for the UNEP-Sustainable Buildings and Construction Initiative, Central European University.

La Croix, M. de, Macek, M. and Schmauz, S. (2011), "Klimaschutz in Baden-Württemberg. 3 Jahre Erneuerbare-Wärme-Gesetz Baden-Württemberg", *Statistisches Monatsheft Baden-Württemberg*, Vol. 9.

LAK (2018), "Länderarbeitskreis Energiebilanzen [federal state energy balance working group]. CO2-Emissionen aus dem Endenergieverbrauch (Verursacherbilanz) *) ohne internationalen Luftverkehr in 1000t (Stand 4.6.18)", available at: http://www.lak-energiebilanzen.de/co2-emissionen-aus-dem-endenergieverbrauch-verursacherbilanz-ohne-internationalen-luftverkehr-in-1000t-2013/ (accessed 5 July 2018).

Landesregierung Baden-Württemberg (2015), *Verordnung der Landesregierung zum gebäudeindividuellen energetischen Sanierungsfahrplan Baden-Württemberg (Sanierungsfahrplan-Verordnung): SFP-VO*.

Landtag Baden-Württemberg (2013), *Klimaschutzgesetz Baden-Württemberg (KSG BW)*.

Landtag Baden-Württemberg (2015), *Gesetz zur Nutzung erneuerbarer Wärmeenergie in Baden-Württemberg (Erneuerbare-Wärme-Gesetz–EWärmeG)*.

Landtag Mecklenburg-Vorpommern (2015), "Unterrichtung durch die Landesregierung: Energiepolitische Konzeption für Mecklenburg-Vorpommern. Drucksache 6/3724, 20.02.2015", available at: http://www.dokumentation.landtag-mv.de/Parldok/dokument/35742/energiepolitische-konzeption-für-mecklenburg-vorpommern.pdf (accessed 13 July 2018).

Lpb (2018), "Landeszentrale für politische bildung Baden-Würtemberg [Federal office for political education BW]. Erneuerbare-Wärme-Gesetz Baden-Württemberg (EWärmeG)", available at: https://www.lpb-bw.de/ewaermeg.html (accessed 29 June 2018).

Ma, Z., Cooper, P., Daly, D. and Ledo, L. (2012), "Existing building retrofits. Methodology and state-of-the-art", *Energy and Buildings*, Vol. 55, pp. 889–902.

MEID (2015), *Ministerium für Energie, Infrastruktur und Digitalisierung [Ministry for Energy, Infrastructure and Digitalization]: Energiepolitische Konzeption für Mecklenburg-Vorpommern; Gesamtkonzeption für eine integrierete Energie- und Klimaschutzpolitik der Landesregierung*.

MEID (2016), "Ministerium für Energie, Infrastruktur und Digitalisierung [Ministry for Energy, Infrastructure and Digitalization]. Aktionsplan Klimaschutz Mecklenburg-Vorpommern 2016; Teil B - Klimaschutzaktionen", available at: https://www.regierung-mv.de/Landesregierung/em/Service/Publikationen/?id=4874&processor=veroeff (accessed 17 May 2018).

MEID (2018a), "Ministerium für Energie, Infrastruktur und Digitalisierung [Ministry for Energy, Infrastructure and Digitalization]. Aktionsplan Klimaschutz Mecklenburg-Vorpommern; Energieeinsparung und Energieeffizienz in der öffentlichen Verwaltung", Energiesparen am Arbeitsplatz, available at: http://www.klimaschutzaktionen-mv.de/Energiesparen/Öffentliche-Verwaltung/Energiesparen-am-Arbeitsplatz/ (accessed 24 May 2018).

MEID (2018b), "Ministerium für Energie, Infrastruktur und Digitalisierung [Ministry for Energy, Infrastructure and Digitalization]. Organigramm", available at: https://www.regierung-mv.de/Landesregierung/em/Ministerium/Organigramm/ (accessed 6 July 2018).

Michelsen, C. and Ritter, N. (2017), "Energieeffizienz: Regulierung für Wohngebäude wirkt", *DIW-Wochenbericht*, Vol. 84 No. 38, pp. 787–790.

Mosselman, M., Prince, Y. and Kemp, R. (2004), "Review of the methodologies to measure effectiveness of state aid to SMEs", *Final report to the European Commission*, pp. 1–114.

MUKE (2014), *Ministerium für Umwelt, Klima und Energiewirtschaft [Ministry for environment, climate and energy]: Entwurf: Gesetz zur Nutzung erneuerbarer Wärmeenergie in Baden-Württemberg (Erneuerbare-Wärme-Gesetz - EWärmeG)*, Vorblatt, Baden-Württemberg.

MUKE (2015a), "Ministerium für Umwelt, Klima und Energiewirtschaft [Ministry for environment, climate and energy]. Erster Monitoring-Kurzbericht 2014", Klimaschutzgesetz, available at: https://um.baden-wuerttemberg.de/fileadmin/redaktion/m-um/intern/Dateien/Dokumente/2_Presse_und_Service/Publikationen/Klima/Klimaschutz_Monitoring-Kurzbericht_2014.pdf (accessed 12 June 2018).

MUKE (2015b), *Ministerium für Umwelt, Klima und Energiewirtschaft [Ministry for environment, climate and energy]: Begründung Sanierungsfahrplan*, Baden-Württemberg.

MUKE (2015c), *Ministerium für Umwelt, Klima und Energiewirtschaft [Ministry for environment, climate and energy]: Regionale Kompetenzstellen des Netzwerks Energieeffizienz*, Baden-Württemberg.

MUKE (2018a), "Ministerium für Umwelt, Klima und Energiewirtschaft [Ministry for environment, climate and energy]. Informieren, Beraten und Fördern", available at: https://um.baden-wuerttemberg.de/de/energie/informieren-beraten-foerdern/ (accessed 24 May 2018).

MUKE (2018b), "Ministerium für Umwelt, Klima und Energiewirtschaft [Ministry for environment, climate and energy]. Organisation des Ministeriums für Umwelt, Klima und Energiewirtschaft Baden-Württemberg", available at: https://um.baden-wuerttemberg.de/fileadmin/redaktion/m-um/intern/Dateien/Dokumente/1_Ministerium/Aufgaben_und_Organisation/Organisationsplan.pdf (accessed 6 July 2018).

MUKE (2018c), *Ministerium für Umwelt, Klima und Energiewirtschaft [Ministry for environment, climate and energy]: Stellungnahme: Mehr Energieefizienz in Gebäuden*, Drucksache 16 / 3057, Baden-Württemberg.

MURE (2018a), "ODYSSEE-MURE Energy Efficiency Policy and Measures Database. Mésures d'Utilisation Rationnelle de l'Energie", GER9: detailed meassure description, available at: http://www.measures-odyssee-mure.eu/public/mure_pdf/household/GER9.PDF.

MURE (2018b), "ODYSSEE-MURE Energy Efficiency Policy and Measures Database. Mésures d'Utilisation Rationnelle de l'Energie", GER97: detailed meassure description, available at: http://www.measures-odyssee-mure.eu/public/mure_pdf/household/GER97.PDF.

MURE (2018c), "ODYSSEE-MURE Energy Efficiency Policy and Measures Database. Mésures d'Utilisation Rationnelle de l'Energie", GER94: detailed meassure description, available at: http://www.measures-odyssee-mure.eu/public/mure_pdf/household/GER94.PDF.

MURE (2018d), "ODYSSEE-MURE Energy Efficiency Policy and Measures Database. Mésures d'Utilisation Rationnelle de l'Energie", GER43: detailed meassure description, available at: http://www.measures-odyssee-mure.eu/public/mure_pdf/tertiary/GER43.PDF.

MURE (2018e), "ODYSSEE-MURE Energy Efficiency Policy and Measures Database. Mésures d'Utilisation Rationnelle de l'Energie", GER32: detailed meassure description, available at: http://www.measures-odyssee-mure.eu/public/mure_pdf/tertiary/GER32.PDF.

MURE (2018f), "ODYSSEE-MURE Energy Efficiency Policy and Measures Database. Mésures d'Utilisation Rationnelle de l'Energie", GER67: detailed meassure description, available at: http://www.measures-odyssee-mure.eu/public/mure_pdf/household/GER67.PDF.

MURE (2018g), "ODYSSEE-MURE Energy Efficiency Policy and Measures Database. Mésures d'Utilisation Rationnelle de l'Energie", GER33: detailed meassure description, available at: http://www.measures-odyssee-mure.eu/public/mure_pdf/tertiary/GER33.PDF.

MURE (2018h), "ODYSSEE-MURE Energy Efficiency Policy and Measures Database. Mésures d'Utilisation Rationnelle de l'Energie", available at: http://www.odyssee-mure.eu/project.html.

MURE (2018i), "ODYSSEE-MURE Energy Efficiency Policy and Measures Database. Mésures d'Utilisation Rationnelle de l'Energie", GER49: detailed meassure description, available at: http://www.measures-odyssee-mure.eu/public/mure_pdf/tertiary/GER49.PDF.

NEEAP (2017), *National Energy Efficiency Action Plan for the Federal Republic of Germany: pursuant to Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency*.

Nejat, P., Jomehzadeh, F., Taheri, M.M., Gohari, M. and Abd. Majid, M.Z. (2015), "A global review of energy consumption, CO 2 emissions and policy in the residential sector (with an overview of the top ten CO 2 emitting countries)", *Renewable and Sustainable Energy Reviews*, Vol. 43, pp. 843–862.

Neuhoff, K., Amecke, H., Novikova, A. and Stelmakh, K. (2011), "Energetische Sanierung: Handlungsbedarf auf vielen Ebenen", *DIW Wochenbericht*, Vol. 78 No. 34, pp. 2–12.

OECD (2001a), "Glossary of statistical terms. Non-residential buildings", available at: https://stats.oecd.org/glossary/detail.asp?ID=1833 (accessed 4 June 2018).

OECD (2001b), "Glossary of statistical terms. residential buildings", available at: https://stats.oecd.org/glossary/detail.asp?ID=2326 (accessed 4 June 2018).

Ohlhorst, D. (2015), "Germany's energy transition policy between national targets and decentralized responsibilities", *Journal of Integrative Environmental Sciences*, Vol. 12 No. 4, pp. 303–322.

Pehnt, M., Sterner, M. and Gerhardt, N. (2012), "Fahrplan Energiewende", *IFEU, Fraunhofer IBP, OTH Regensburg Google Scholar*.

Raimondi, A., Chesani, F. and Woods, T. (2012), *"Impacts, constraints, objectives and implementation strategies in Regional Planning: General Aspects: Deliverable D2.2*, Bologna.

Reul, L.K. and Michaels, H.G. (2012), "Mapping Energy Efficiency for Community-Level Engagement".

Ringel, M. (2016), "Energy efficiency policy governance in a multi-level administration structure—evidence from Germany", *Energy Efficiency*, Vol. 10 No. 3, pp. 753–776.

Ringel, M., Schlomann, B., Krail, M. and Rohde, C. (2016), "Towards a green economy in Germany? The role of energy efficiency policies", *Applied energy*, Vol. 179, pp. 1293–1303.

Sarkar, A. and Singh, J. (2010), "Financing energy efficiency in developing countries—lessons learned and remaining challenges", *Energy Policy*, Vol. 38 No. 10, pp. 5560–5571.

Schönball, R. (2018), "Senat eröffnet Tauschbörse für Wohnungen", *Der Tagesspiegel,* 22 January, available at: https://www.tagesspiegel.de/berlin/hohe-mieten-in-berlin-senat-eroeffnet-tauschboerse-fuer-wohnungen/20871484.html (accessed 16 May 2018).

Statistisches Landesamt BW (2017), *Energiebericht kompakt 2017*.

Steininger, B.I., Nadler, C., Franke, M. and Pommeranz, C. (2017), "Evaluierung des Energieausweises".

Tews, K. (2011), "Stromeffizienztarife für Verbraucher in Deutschland? Vom Sinn, der Machbarkeit und den Alternativen einer progressiven Tarifsteuerung".

VerfGH Berlin (2014): *VerfGH 134/12*.

Williams, C.C. and Dzhekova, R. (2014), "Evaluating the cross-national transferability of policies: a conceptual framework", *Journal of Developmental Entrepreneurship*, Vol. 19 No. 04.

Zukunft Altbau (2018), “Das Programm Zukunft Altbau”, available at: https://www.zukunftaltbau.de/ueber-uns/ (accessed 24 May 2018).

Contact persons

Dr. Aleksandra Novikova

Wissenschaftliche Referentin des IKEM

aleksandra.novikvoa@ikem.de

+49 (0)30 4081870 12