RED I4HEAT

# Deliverable 3.1

## Report on Key success factors for RES-HC policies

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**ADENE**: Agencia para a Energia

**BIO**: Bioenergy Europe

**CDD**: Cooling Degree Days

**CRES**: Centre for Renewable Energy Sources and Saving Foundation

**DENA**: Deutsche Energie-Agentur Gmbh

**EGEC**: European Geothermal Energy Council

**EHP**: Euroheat & Power

**EHPA**: European Heat Pump Association

**EIHP**: Energetski Institut Hrvoje Pozar

**SHE**: Solar Heat Europe / European Solar Thermal Industry Federation

**ENC**: Energy Cities

**KAPE**: Krajowa Agencja Poszanowania Energii Spółka Akcyjna

**TRI**: Trinomics BV

# ABBREVIATION AND ACRONYMS

**CA:** Comprehensive assessment of the potential for efficient heating and cooling

**CHP**: Combined heat and power/ cogeneration

**DHC**: District heating and cooling

**DH**: District heating

**DHS**: district heating system

**EC**: European Commission

**EE**: Energy efficiency

**EED:** Energy Efficiency Directive

**EPBD**: European Performance of Buildings Directive

**EPC**: Energy Performance Certificate

**ESCO**: Energy Service Company

**HDD:** Heating Degree Days

**HP**: Heat Pump

**H&C:** heating and cooling

**STH**: solar thermal

**KSF**: Key Success Factor

**KPI**: Key Performance Indicator

**LCA**: Life-Cycle Analysis

**LHCP**: local heating and cooling plans

**NECP**: National energy and climate plan

**PESTEL**: Political, Economic, Social, Technological, Legal and Environment analysis

**RED**: Renewable Energy Directive

**REDI4HEAT**: RED implementation for heating and cooling

**RES**: Renewable Energy Sources

**RES HC**: Renewable Energy Sources for Heating and Cooling

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# 1. INTRODUCTION

## 1.1 REDI4HEAT: project context and aims

Heating & cooling (H&C) represents 50% of the energy demand in Europe and 80% of the energy consumption in households 1. The decarbonization of heating and cooling is essential to the decarbonization of the whole energy sector. Most Member States have yet to design or improve strategies for the heating and cooling sector that are ambitious and effective enough to comply with the revised Renewable Energy Directive (RED) and economically, technically and socially feasible. The purpose of REDI4HEAT is to support the implementation of the RED provisions on heating and cooling and assist Member States and local and regional governments in that process. The project will provide a better understanding of the shortcomings in current strategies and propose a set of recommendations to address them. REDI4HEAT work "Development of recommendations and tools for the deployment of Renewable Heating and Cooling (RES-HC)" will make use of the initial outputs from previous work on assessing the National Energy Climate Plans (NECPs) and current initiatives on RES-HC, to develop a set of recommendations and tools for the deployment of RES-HC. This process shall start with the identification of key success factors (**KSF**s) and key performance indicators (**KPI**s) for national heating and cooling strategies. Previous REDI4HEAT work provided the main data and information to enable work on identifying **KSF**s and assigning **KPI**s to them. These include the following documents:

- D2.1 Report: Renewable heating and cooling in the NECPs,
- D2.2 Report: Local initiatives for heat decarbonization, including the case-studies (including PESTEL analysis – Political, Economic, Social, Technological, Environmental and Legal factors for the project countries and identification of potential barriers and bottlenecks for the implementation of RES-HC policies) and,
- D2.3: Comprehensive assessment of RES-HC needs and options.

Additional documents, primarily the NECP updates and the European Commission's comments on them were also analysed.

## 1.2 EU level policies to support uptake of renewables in heating and cooling

The European Green Deal is a comprehensive package of policy initiatives designed to steer the European economy towards a sustainable and climate-neutral future. It was launched by the European Commission in December 2019. At its core, the strategy commits to achieving climate neutrality by 2050. Decarbonizing heating and cooling is a prerequisite to be able to achieve the goal of carbon-neutrality by mid-century.

The 'Fit-for-55' package aims to operationalize the goals of the European Green Deal by introducing measures aimed at significantly increasing the deployment of renewable sources and sustainable technologies by 2030 and paving a viable pathway to achieve net-zero emissions by 2050. The ambitious targets set need to be translated into actions within local and national plans. This includes almost doubling of the existing share of renewable energy in the EU energy mix with a binding target of 42,5% by 2030, and even higher ambition to reach 45%, in the framework of the Renewable Energy Directive. Key components of the 'Fit for 55' package that are most relevant for the H&C sector include the revisions to the Energy Efficiency Directive (EED), the Renewable Energy Directive (RED) and the Energy Performance of Buildings Directive (EPBD). The introduction of a new EU Emissions Trading System (ETS) for building and road fuels will also be relevant. Below we briefly review the most relevant changes based on the revision to the EED, and RED that are pertinent to the heating and cooling sector. The revised EPBD directive will increase the rate of renovation, particularly for the worst-performing buildings in each country. The EPBD directive will facilitate more targeted financing to investments in the building sector, complementing other EU instruments and fighting energy poverty by supporting vulnerable consumers. A detailed analysis on the subject is available under Deliverable 5.1 of this project: 'Report on RHC regulatory frame towards 2030'. The aim of the summary below is to provide an overview of the baseline, established by the minimum requirements set by the Directives and to which Member States must adhere. The identification of **KSF**s and **KPI**s has been made with this baseline in mind. The methodology is described in detail in the section below.

### 1.2.1 Energy Efficiency Directive

The revised EED, among other things, strengthens the provisions on heating and cooling. Two articles are especially relevant for the sector:

- **Article 25** links the national comprehensive heating and cooling assessments with the submission of the integrated National Energy and Climate Plans and introduces the requirement for municipalities above 45,000 inhabitants to carry out local heating and cooling plans.

- **Article 26** sets the criteria for efficient district heating networks, which will have to raise the share of renewable energy and waste heat in their energy supply over time, reaching 100% renewable and/or waste heat by 2050.

### 1.2.2 Renewable Energy Directive

The below articles of the Renewable Energy Directive are especially noteworthy with regards to influencing the uptake of renewables in the heating and cooling sector:

- **Article 15a** sets a new target of 49% renewable energy in the building sector by 2030. This energy should be produced on-site or nearby or taken from the grid. Member States are required to establish appropriate measures in their national regulations, building codes and support schemes to promote renewable uptake in buildings.
- The new **Article 22a** sets an indicative increase of renewables in the industrial sector of at least 1,6 percentage points as an annual average calculated for the periods 2021 - 2025 and 2026 - 2030. Waste heat and cold supplied from efficient networks might count towards this average annual increase up to a limit of 0,4 percentage points.
- In **Article 23**, the first paragraph replaces the previously indicative target with a new mandatory increase of renewables in the heating and cooling sector. Member States shall increase this share annually by at least 0,8 percentage points for the period 2021 - 2025 and by at least 1,1 percentage points as an annual average calculated for the period 2026 - 2030, starting from the share of renewable energy in the heating and cooling sector in 2020, expressed in terms of national share of gross final consumption of energy and calculated in accordance with the methodology set out in Article 7 of the same Directive. Member States may also count waste heat and cold towards the average annual increases referred to in the first subparagraph, up to a limit of 0,4 percentage points.
- In **Article 24** paragraph 4 is amended to reach an indicative of 2,2 percentage point average annual increase of renewables in district heating and cooling networks.

# 2. Methodology

## 2.1 Definition of KSF and KPI

The first step in establishing a methodology to identify key success factors (**KSF**) for the deployment of renewable energy in the heating and cooling sector was to agree on a definition of this term. Based on a literature search, **KSF** for the purposes of the task at hand we found the below definition used in the business sector[2] to be most useful.

***'Key Success Factor (KSF)** is a strategic element that supports the achievement of a specific desired outcome or objective.'*

Where, the overarching 'specific desired outcome or objective' is the increased deployment of renewable energy in the heating and cooling sector through policies, programs, financial aid and other support measures. As will be seen in the sections below, this overarching objective can be better monitored by looking at concrete sub-objectives such as the deployment of renewable energy in specific sectors like the buildings or industry sectors.

It is important to note that based on this definition, the absence of a **KSF**, does not automatically indicate that a 'specific desired outcome or objective' will not be achieved. Conversely, the implementation of a specific **KSF** does not automatically guarantee the success of a given measure. Rather, the presence of a given **KSF** indicates a higher *likelihood of success* in the uptake of renewables in the heating and cooling sector (**KSF**s are neither necessary nor sufficient elements but rather supportive).

In order to be able to measure, monitor and/or quantify a given key success factor another definition is needed: that of a key performance indicator.

***'Key Performance Indicator (KPI)** is a measurable value that allows to monitor how effective a **KSF** is in achieving a specific desired outcome or objective.'*

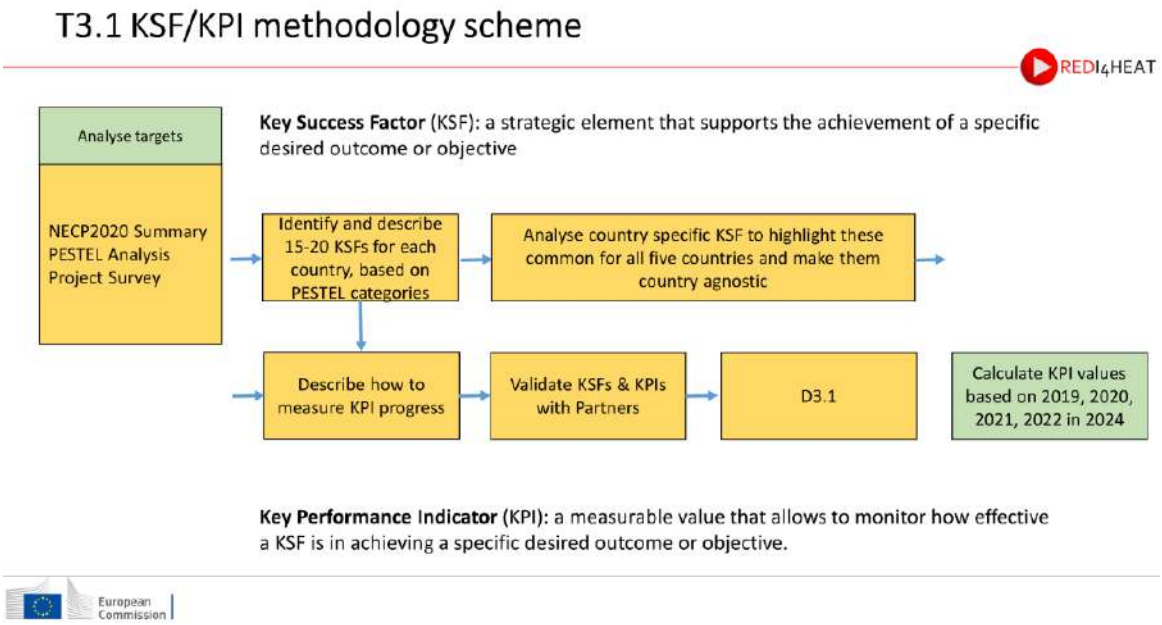
Only political KSF were looked at, such as measures, regulations and instruments. There are also other, contextual KSFs (for example - existing industry, high potential of local resources, strong willingness of people to move from fossil, etc.). Considering the new measures, reference was made to what we consider KSF. In that case, there is no history

of their impact on RES dynamics in H&C. Using the KPIs assigned to them, such a study could be conducted in following years.

## 2.2 Identification of KSF and KPI

Figure 1 provides a schematic overview of the methodology that was followed to identify Key Success Factors and the associated Key Performance Indicators for the uptake of renewable energy in the heating & cooling sector.

*Figure 1 Overview of the methodology to identify **KSF**s and **KPI**s for the uptake of RES in H&C sector*




The identification of key success factors is focused on five representative Member States based on the countries participating in the REDI4HEAT project. These countries are Greece, Croatia, Portugal, Germany and Poland. The participation of National Agencies from these five countries in the project provides the opportunity to ensure that the results are based on accessing the extensive knowledge and expertise on the situation in these countries and that the results can be robustly validated by the National Agencies. In addition, the five countries of focus provide good coverage of different underlying conditions in terms of climate, geography and resources across Europe.

### 2.2.1 Identification of KSF

The first step in the methodology was the collection of information. The primary source of information to identify the key success factors were the National Energy and Climate

Plans (NECPs). The fact that all Member States are required to submit NECPs provides a uniform source of information. The National Agencies of the five Member States of focus were asked to fill out a template on the Political, Economic, Social, Technological, Legal and Environmental (PESTEL) elements found in the NECPs. The PESTEL analysis was developed jointly by consortium members involved in Task 2.2 and Task 3.1 (present task).

By 30 June 2023, Member States were due to submit their draft updated NECPs in line with article 14 of the Governance Regulation. At the time of the data collection (May – September 2023), not all five Member States of focus had submitted their final updated NECPs. However, when available, the National Agencies were asked to use the updated versions of the NECPs to complete the PESTEL analysis[3]. The PESTEL analyses for all five countries are available under deliverable D2.1.

The key success factors were identified from the data submitted under the PESTEL analysis and, where applicable, additional sources of information were used. Based on the data submitted, the team identified all measures, policies, financial mechanisms that could contribute directly or indirectly to the uptake of renewables in the heating and cooling sector. The **KSF**s identified were classed as either:

- **direct** – in the case where the identified elements can have a direct influence on the deployment of renewable energy in the H&C sector. Factors related to the electrification of the heating sector are classified as 'direct', independent of the energy used to produce the electricity.
- **indirect** - in the cases where the key success factor is focused on areas indirectly relevant to renewable uptake such as improvements in the efficiency of the building envelope or other energy efficiency measures. For example, programs that support thermal retrofits in buildings usually include the replacement of fossil-based heat sources by renewable-based ones in their scope. While the action is indirect, given the large scale of impact of these programs on the national building stock, the impact on renewables uptake is also significant. Likewise, factors aimed at addressing energy poverty are often focused on addressing energy efficiency aspects first while indirectly contributing to increased RES uptake. Thus, they are classified as indirect.

Furthermore, the **KSF**s identified were categorized as either supporting the greening of district heating and cooling, supporting the deployment of renewables in single or multi-

family buildings, supporting the deployment of renewables in public buildings or addressing the uptake of renewables for heating and cooling in industry. Commercial buildings were not separated because NECPs do not pay special attention to this area. In addition, a category of 'other' was added which includes all key success factors which support the uptake of renewables in H&C but do not fall directly into any of the other areas.

### 2.2.2 Grouping of KSF

To arrive at 'universal' key success factors with wider applicability, the key success factors found in individual countries were grouped into broader groups. For example, the 'Thermal Upgrading Tax Credit for single family houses' program in Poland and the 'Programa de Apoio a Edifícios mais Sustentáveis' (PAES) in Portugal where both grouped under 'Incentives for renewables in H&C including taxation (e.g. deduction), via building renovation'. The former program provides deduction of expenses from the tax base, including for purchasing heat pumps, solar thermal, and PV installation. The latter funds the acquisition or replacement and installation of renewable heating and cooling systems and hot water production systems (class A+ and higher). It also applies to the acquisition of PV systems and other production units/systems for self-consumption, with and without storage.

### 2.2.3 Assigning KPI

For each Key Success Factor identified a Key Performance Indicator was assigned. As defined, **KPI**s are quantifiable indicators that allow for the objective evaluation of the Key Success Factors. Given that **KSF**s where identified both from the NECPs submitted in the past as well as the updated versions, the key performance indicators suggested to monitor the Key Success Factors are either **backward-looking** (focused on policies, measures, programs that have already been implemented and thus, where data/statistics should already exist) or **forward-looking** (focused on policies, measures or programs which have been announced, are considered desirable, but have not yet been implemented and for which data/statistics are not yet available).

For certain Key Success Factors more than one Key Performance Indicator can be used. For example, to measure a Key Success Factor related to the implementation of building codes, Key Performance Indicators can focus on either the number of new buildings complying with the building codes or the percentage of buildings with a specific share of

RES. In these cases, we list the different **KPI**s possible. Often, the most suitable choice of **KPI** will depend on the specific considerations of the given local authority, especially regarding data availability.

Assigning **KPI**s to **KSF**s is of particular importance because it allows for the quantitative assessment of the real impact of the **KSF**. This in turn, allows for the monitoring of the extent to which a given **KSF** is appropriate to achieve the desired objectives and to make adjustments in case the objectives are not being reached. Notably, there are **KSF**s for which quantitative **KPI**s are not appropriate. This can be the case, for example, regarding influencing public perceptions and opinions. **KSF**s that target public perception and opinions are challenging to quantify but can be important in supporting the deployment of renewables in heating and cooling.

Annex 3 'Methods for selecting most appropriate Key Performance Indicators' contains information on how the most relevant KPIs can be selected from a range of possible ones based on a ranking system of their attributes. Given, that in the following chapters we do not make use of this ranking, the description has been moved to an Annex.

## 2.3 Reading Guide

The full assessment of all **Key Success Factors** identified for the five Member States as well as their associated **Key Performance Indicators** is available in an excel format as an annex to this report. Below we provide an example on how to navigate the excel document.

In the excel repository we have included all **KSF**s identified. For each country we created a separate tab. Each **KSF** was assigned a name, tag (identification) and a description. As described above, similar **KSF**s were grouped into categories (**KSF** group). For each **KSF**, a corresponding **KPI** was proposed including a **KPI** name and the description of the **KPI**. In addition, if applicable, the **KSF** was connected to a corresponding objective or target. The 'base-level' of the target (baseline/starting point) is included if applicable and available. In addition, the target is specified, and it is indicated whether it is binding or non-binding. The excel includes a column in which the PESTEL category under which the **KSF** falls under is identified. Finally, the source from which the **KSF** was identified is included.

*Table 1 Information available on KSFs and KPIs in Database*

| Tag | KSF group | KSF name | KSF description | Target base level | Target: non-biding | KPI name | KPI measure | Source | PESTEL category |
|---|---|---|---|---|---|---|---|---|---|
| Single and multi-family buildings | | | | | | | | | |
| KSF1 | Promote RES | Promote replacement of inefficient H&C systems by RES based ones | Encourage the replacement of outdated H&C tech by more efficient and renewable energy systems. | N/A | Increase % RES supply for heating Increase EE | Replacement of inefficient systems | No. of (fossil-based) heating systems replaced by new RES ones between 2020 -2030 | New NECP PESTEL | Technology |

# 3. KSF and KPI for promoting renewable energy uptake in heating and cooling

The results of the identification of **KSF**s and their associated **KPI**s, carried out in accordance with the methodology described earlier, are presented in the accompanying excel. However, it is worthwhile to pay attention to the differences between the individual countries, manifested, among other things, in a different approach to **KSF**s classified in the same areas (e.g. District Heating, Single and multifamily buildings...) or in a different identification of **KPI**s for **KSF**s from the same group (e.g. conditions/restrictions on financing of inefficient DHC, ban on fossil-based systems, etc.). The purpose of describing the particularities of each of the five chosen Member States in detail is to provide a clear picture of the situation in each country.

## 3.1 KSF and KPI identified in Germany

### 3.1.1 Particularities of the German context

#### *3.1.1.1* Climate, geography, natural resources

Since measurements began in 1881, 14 of the 19 warmest years in Germany were after the turn of the last millennium; the two warmest years were 2022 and 2018. Over the past few decades, a decrease in the number of heating degree days (HDD) in Germany (2750 HDD in 2022)[4] can be observed and an increase in the number of cooling degree days (35 CDD in 2022). Weather conditions affect the availability of renewable energy generated by solar PV and wind technologies. Thus, they also have an impact on the amount of energy storage technologies that will be required in the future. These considerations can impact directly or indirectly the availability of renewables for the heating and cooling sector given that electrification is an important element for decarbonizing the sector. In southern Germany, for example, wind power generation is very low (because of geographical and political reasons). New power lines are therefore being built to transport wind energy from north to south, and long-term storage systems will play an increasingly important role.

#### *3.1.1.2* Building Stock, infrastructure, societal aspects

Heating and cooling represent more than half of Germany's energy consumption and around 80% of heating demand is currently met using fossil fuels such as gas and oil, which are sourced from abroad in 95% of the cases. In 2021, there were 19.4 million residential buildings in Germany. The number of residential buildings, non-residential buildings, dwelling units and living space per person recorded an increase, as suggested by the data from the beginning of 2022 compared to the previous year. The number of social housing units has decreased continuously since 2006 from 2.1 million units to 1.1 million in 2019[5].

Germany is a Federal Republic and therefore the implementation of a heating and cooling transition depends on the effective cooperation between local, regional, and national government levels. A Heat Planning and Decarbonization of Heat Networks Act (WPG) is mandatory from the first of January 2024. Due to the phase-out of coal-fired power generation, most of district heating produced by coal cogeneration plants will disappear by 2030. Heat pumps are expected to play an essential role in the German renewable heat mix. The public awareness and acceptance of a German energy transition is overall high but there is a dominant public discussion on heat pumps, oil and gas dependence and the new building regulations.

## 3.1.2 KSF and KPI identified in Germany

### *3.1.2.1* District Heating

By connecting buildings to the district heating network and increasing the load on the district heating system, Germany further improves its efficiency. At the same time, it reduces the number of individual heat sources, such as gas boilers in existing buildings and heat pumps in new ones. Altogether, this leads to more control over the decarbonization process and efficiency of the heating system. Germany is a large country with developed district heating and cooling (125000 GWh/a), although it accounts for only 13% of the final energy consumption in the residential sector and 10% of the total final energy amount for H&C in 2018[6]. Considering the important place of DHC and the impact it may have in decarbonization routes, Germany has set up several relevant measures that should be considered as **KSF**s. One important **KSF** is setting up targets. One key target is to connect 100,000 buildings per year to the district heating network starting in 2028. Another target is to have 50% of all buildings powered by the DHC by 2030. For Germany's district heating branch, this means considering changing heat volume needs for H&C when modernizing and building energy-efficient district heating systems.

District heating must always consider local conditions such as the availability of fuels, the density of buildings and their nature, or the possibility of using waste heat from nearby plants. The transformation and development of Germany's heating sector, assuming a steady and ambitious increase in the share of renewable energy (to 30% by 2030), is a major challenge. Heat sources used to date, such as coal- and gas-fired district heating plants (and related cogeneration solutions), cannot be replaced by one or two new standard solutions (like large heat pump or biomass boiler) but a multi-source plant will be usually needed, depending on local availability of RES. Thus, the potential development of district heating is now conditioned not only by local growth in demand for heating and cooling, but also by the ability to feed the heat network with renewable energy sources.

Given the described context, we have identified the **KSF**s which **support the development of RES in district heating**. Their effectiveness will depend on the pace of implementation of **support schemes limited only to the use of renewable fuels and waste heat**. Polices are moving in the direction of transforming district heating by **conversion of inefficient systems to energy efficient ones** following the requirements in the Energy Efficiency Directive, **promotion of renewables** (which is indispensable for achieving efficient systems) and strong **support for combined heat and power** (CHP).

Article 26 of the EED which defines energy efficient DHC, without providing specific ways to apply it, will become a strong driver to invest in efficiency (i.e. RES & WHR). There are several options for the concrete implementation of this article, from very soft (awareness, highlighting the risk of stranded assets), soft (guidelines for financial institutions), to hard (requiring financial institutions to include conditionality to financing e.g. refuse financing, or provide less favourable conditions if efficiency criteria are not met). One **KSF** to increase the share of renewable energy in district heating can be to force the construction or refurbishment of efficient district heating systems by **blocking the possibility of external financing for less efficient networks**. At the local level, a special solution is needed - **co-financing of DHS refurbishment as a condition for EU funding**. The performance measure (**KPI**) of this **KSF** consists in following up the number of efficient systems and the amount of heating and cooling provided by such systems.

Renewable heat sources that are feasible for use in German district heating include high-capacity heat pumps, solar thermal installations, geothermal sources, and co-generation units powered by renewable fuels such as hydrogen, synthetic fuels, bioenergy or biogas. Ensuring the introduction of such solutions into the district heating branch is an important way to increase the share of renewables in this area. A group of **Key Success Factors** has been identified, consisting of in **properly configured financial support programs**. This means that the scope of support of individual programs is not too general and focuses on selected technologies, but one can benefit from a couple of programs in parallel. In this case, the performance of this group of **KSF**s will be measured (**KPI**) by examining the amount of energy produced by the renewable energy sources mentioned earlier.

#### *3.1.2.2* Single and multifamily buildings

In the case of Germany, the issue of mandating that buildings use heating systems powered by at least 65% renewable sources starting in 2024[7] is relevant. This is a workable compromise which, given that it does not require achieving a target of 100% renewable energy, will allow for faster modernization of systems and the introduction of RES with high total installed capacity. Increasing the share of renewable energy in powering buildings requires the parallel use of obligations (sticks) and encouraging (carrots) activities. We have identified Key Success Factors falling under both categories. **KSF**s related to **obligations on the increase in the energy efficiency of buildings** (energy consumption indicators) in connection with regulations specifying permitted modernization methods (e.g. **banning the use of solid fuel boilers**) belong to the first category (sticks). In the second group, we have **KSF** based on encouraging activities such

as **co-financing programs for renewable heating sources in buildings or tax reliefs**. There is pressure in Germany from those powering buildings with heat pumps to introduce solutions that **reduce the tariff on electricity used to power heat pumps**. Such action, guaranteed by the government over a long-term period, can be a success factor increasing the share of renewable heat sources in buildings based on heat pumps. However, it is important to caution that the current demand for heat pumps is due, in part, to insufficient investor knowledge of the real-world efficiencies of air-to-water heat pumps (often coupled to solar PV) in the geographic zones of Germany, which affects design assumptions and results in an incorrect assessment of future operating costs.

Proper planning of the modernization of existing buildings through consulting, using renewable sources is an important way to increase the share of renewable energy in heating and cooling of buildings and avoid errors in the selection of heat pumps mentioned above. Similarly, ensuring the availability of trained installers is a prerequisite for modernizing building systems. **Programs supporting the use of consultants' services and installer training like the federal funding for efficient buildings (BEG)** are **KSFs** whose performance can be measured (**KPI**) by the number of consulting services and the number of licenses issued to installers.

#### *3.1.2.3* Public buildings energy efficiency

Based on the Energy Efficiency Directive (EED), Member States must ensure that the final energy consumption of all public institutions is reduced by at least 1.9% each year compared with 2021. The obligation to renovate at least 3% of the total area of heated or cooled buildings has been extended: new provisions apply to buildings owned by all public institutions. On November 18, 2023, the new Energy Efficiency Act came into force to transpose the new EED requirements into national law. It obliges public authorities, energy-intensive companies, and data centres to save more energy in order to permanently reduce Germany's energy consumption. The federal government is to save 45 TWh/year of final energy by 2030, the federal states 3 TWh/year. The federal government, federal states and local authorities will introduce energy and environmental management systems. They must save 2% of final energy each year.

The success factors (**KSF**) previously identified around single-family and multi-family buildings, such as requirements for the modernization and construction of facilities and **the ban on the use of fossil fuel heating and cooling sources**, also apply in the area of public buildings. For public authorities we identify additional, key success factors (**KSF**)

related to supporting the use of Energy Performance Contracting as a model for increasing the share of renewable energy in powering buildings. In this area for Germany, we identify **KSF** in the form of **free consulting for EPC projects**[8], which is resulting in a stimulus toward an increase in the number of projects with guaranteed effects on public buildings. The implementation of RES in these retrofits is stimulated by increasingly demanding regulations limiting final energy consumption, mentioned before. This success factor should be strengthened with an additional **KSF**, such as co**-financing program for EPC projects**, as this will make it possible to mobilize a large number of projects and significantly increase the share of renewable energy in public buildings.

#### *3.1.2.4* RES in industry

In the industrial sector national final energy demand is approximately 736 TWh/year. Heating and cooling applications account for around 76% of final energy demand in industry[9]. Demand for process heating is particularly relevant in the industrial sector. Within the German industry process heat amounts to approx. 496 TWh/year and therefore accounts for almost 90% of final energy demand for heating and cooling. Process heating refers to all applications that provide the temperatures needed for processes, such as steam generators or industrial furnaces. In the industrial sector a smaller share of final energy consumption (approx. 41 TWh/yr) can be attributed to space heating. Cooling applications play a more minor role. The share of renewable energy for heating in German industry is not large. Due to the priority of production continuity, stable energy sources are preferred, e.g. gas cogeneration, which will be replaced by hydrogen in the future. The second important element is the development of energy storage facilities. Moreover, the industrial approach to energy issues includes a typical energy system of the entire plant, considering the already mentioned priority of production continuity and technological security.

A **KSF**, that has been identified in Germany is **the measure to provide free consulting for SMEs**, accelerating enterprise modernization decisions that consider the use of RES with a view to both lowering exploitation costs and meeting environmental regulations and ESG reporting.

#### *3.1.2.5* Other

An important element, influencing the acceleration of the introduction of RES in H&C for cities, is the universality and **standardization of planning for a comprehensive energy**

**transformation of an urban area**, with the assumption of a rapid elimination of the use of fossil fuel-generated energy. So far, in the case of Germany, the barrier here has been the need for individual decisions by each state (rather than the federal government).

# 3.2 KSF and KPI identified in Poland

## 3.2.1 Particularities of the Polish context

### *3.2.1.1* Climate, geography, natural resources

Polish climatic conditions make heating the dominant part of the H&C area. In Poland, the average value of the heating index from 1979 to 2020 was 3513 heating degree-days (HDD). During this period, the country's heating demand fell by 23.5%. The average cooling index was 15 degree-days [10]. Poland has average solar radiation and good conditions for biomass production (mainly agricultural biomass). Low winter temperatures limit some RES technologies and complicate technical solutions. The occurrence of geothermal energy is associated with waters with temperatures not usually exceeding 90°C, and in occasional cases slightly exceeding 100°C.

### *3.2.1.2* Building Stock, infrastructure, societal aspects

The national building stock consists of over 14.2 million buildings[11], over 40% of which are single-family dwellings. The data shows a wide variation in the energy efficiency of buildings. The share of RES in the Polish heating sector should be 28.4% by 2030.

Installed capacity (thermal) was 53 GW in 2022. During 2022, district heating plants sold more than 357,000 TJ of heat. Since 2002, the length of the district heating network has increased from 17,312 km to 22,578.4 km. In turn, the length of the network per company has increased from about 23.8 km to 62.89 km. The total volume of thermal capacity installed at licensed heat generators fell from about 71 GW to about 53 GW in the 2002-2022 period. The share of cogeneration in total heat production was 62.1% in 2022.

Since 2002, the share of coal fuels in heat production has decreased by 15.2 percentage points (from 81.7% to 66.2% in 2022). The gross profitability of the district heating industry was minus 22% in 2022[12].

Two specific areas of interest in terms of RES application in district heating can be distinguished. One is district heating, which includes District Heating Enterprises[13] where the influence of residents on the solutions used is very small; modernization decisions are made based on economic and regulatory considerations. The second area is local energy sources in single- and multi-family buildings. On the one hand, residents benefit from a number of programs that support, in the investment part, the transition to renewable

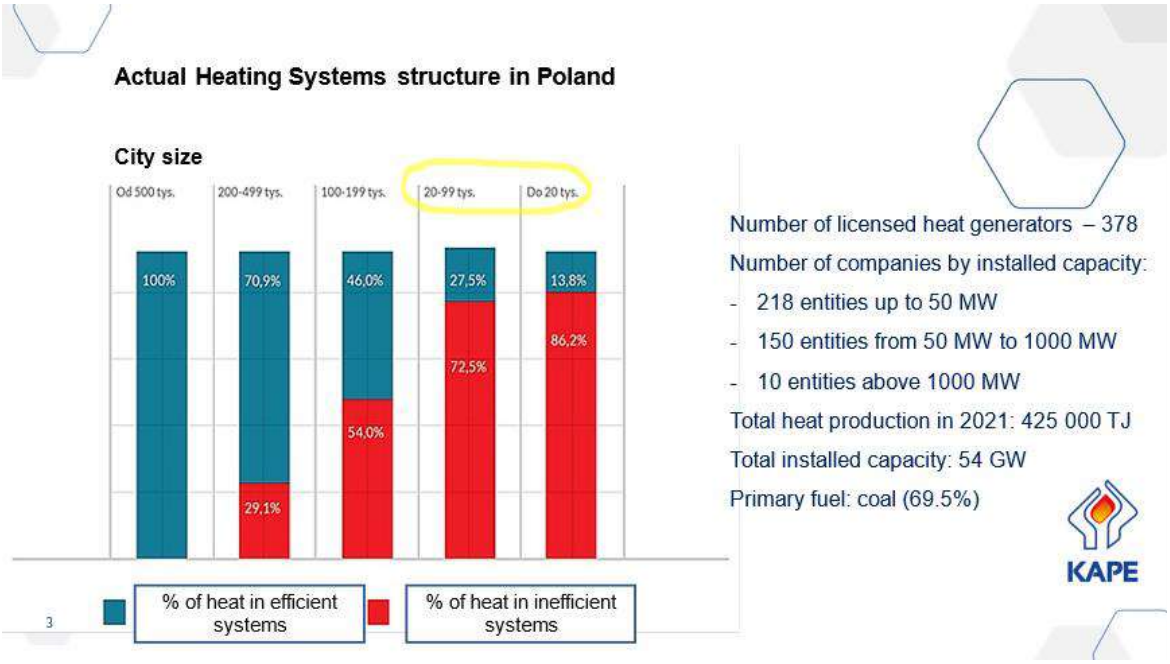
sources, but on the other hand they raise concerns about the cost of operating these sources. For example, expectations are being formulated to develop a special electricity tariff for residents who use heat pumps for heating. Up to 21.4% of households are affected by energy poverty, but estimates vary from close to 10 to over 20%[14]. Poland lacks a comprehensive, unified strategy to tackle energy poverty, but the government aims to reduce energy poverty to 6% by 2030[15].

## 3.2.2 KSF and KPI identified in Poland

### *3.2.2.1* District Heating

Poland is a country with a highly developed district heating. The basic data is shown in the figure below. The biggest modernization challenge is for small district heating companies, especially those serving cities with fewer than 100,000 residents. These enterprises have coal-fired sources or gas-fired cogeneration. The share of renewable sources is small. The primary direction that, with the large amount of heat supplied, will significantly affect decarbonization and efficiency on a national scale is the modernization of inefficient district heating systems. There are several hundred district heating systems in Poland and most of them do not meet the definition of an efficient system according to the Energy Efficiency Directive. It should also be remembered that while the current systems were built with reference to local conditions, their modernization must further consider the local availability of renewable energy sources. Thus, the potential development of district heating is now conditioned not only by local growth in demand for heating and cooling, but a prerequisite is the ability to feed the heat network from a renewable energy source, ultimately 100%. Efficient district heating systems produce energy from renewable sources. By connecting buildings to the district heating network and increasing the load on the district heating system, Poland further improves its efficiency. At the same time, the number of individual heat sources is being reduced, such as gas (or even coal) boilers in existing buildings and heat pumps in new buildings. In the case of Poland, the goal is to increase the share of dwellings powered by DHC in cities from the current 60% to 70% in 2030.

*Figure 2 Heating System structure in Poland*




In identifying the **KSFs**, it is necessary to address the various direct and indirect measures affecting the dynamization of the process of achieving the parameters of energy-efficient systems by district heating companies. This is impossible to achieve without the use of renewable energy sources. One of the **KSF**s with a strong effect of mandating the modernization to efficient systems is the **threat of non-financing, both from public and private funds** to district heating companies that do not implement this type of transformation. Renewable heat sources that are feasible for use in the Polish district heating include high-capacity heat pumps, solar thermal installations, geothermal sources and cogeneration units powered by renewable fuels such as hydrogen, synthetic fuels, bioenergy or biogas. A group of success factors (**KSF**), in the form of **properly configured financial support programs** has been identified. This ensures that the support provided by each program is specific and focused on selected technologies. By utilizing multiple technologies, one should be able to benefit from multiple programs simultaneously. The performance measure (**KPI**) of this **KSF** consists in following the number of efficient systems and the amount of heat and cooling provided by such systems from RES. For programs that directly support the installation of energy sources based on renewable technologies, the **KPI** examines the increase in the number of such devices in successive years or the amount of energy they produce.

#### *3.2.2.2* Single family and multifamily buildings

Poland is characterized by two great challenges – one for single family buildings and a second for multifamily buildings - when it comes to the transformation of building heating. For single-family buildings, the heating source is still mostly (especially in rural areas) a coal-fired boiler[16]. The total number of single-family buildings is 3 million out of 5,5 million buildings. Although the modernization of sources has been taking place for many years, mainly gas boilers have been installed. For a few years now, heat pumps have been installed, usually coupled with solar PV installations. In most parts of Poland, the installation should also be equipped with a source supporting an air source heat pump for periods of very low temperatures. **KSF**s can be identified that will significantly accelerate the number of heat pumps installed in single-family homes, responding to owners' demands.

In Poland, there is pressure from those heating buildings with heat pumps to restore **the possibility of billing prosumer electricity on an annual basis** ("grid storage") or **to introduce solutions that reduce the tariff for electricity used by heat pumps**. However, the owners' demands are controversial (for example, due to the use of a previous investment subsidy or technical limitations of the electricity infrastructure) and are largely due to the lack of sufficient knowledge among investors about the real efficiencies of air-to-water heat pumps (and the efficiency of cooperating PVs) in the geographical zone of Poland, resulting in an incorrect assessment of future operating costs. In a situation where there are millions of single-family homes with coal-fired boilers, very important **KSF**, which applies to all types of buildings, is the **ban on the use of fossil fuel boilers**, especially solid fuels (including in existing buildings), introduced by local governments in 15 of the 17 provinces through the so-called Anti-Smog Resolutions. In this case, another identified essential **KSF** is a **program to subsidize the purchase of RES for heating single-family homes**. The primary program is the Clean Air Program[17] (2018-2029), which has already received approx. 800,000 applications. To date, subsidies of a couple of billion zlotys have been paid out. The obvious **KPI** here is to measure in consecutive years the number of buildings powered by renewable sources. An additional **KSF** measure that drives the conversion of heating sources in buildings are **national regulations, in this case the Technical Guidelines 2017 and 2021**.

Upgrading heat sources in multifamily buildings is a separate challenge. The owners of multi-family buildings in Poland are housing cooperatives (up to 200 buildings in a single cooperative) and communities of residents (several buildings in one). This is a huge stock

of over 550 thousand buildings[18]. There are two areas here - buildings that are fed or can be connected to the district heating network, and those that must have an individual heat source. The previous section outlined the **KSF** issues in district heating, but an important aspect, among other things, due to the use of renewable energy sources, is the modernization towards lowering the supply temperature of the installation and, consequently, also in the district heating network. An important **KSF** here is **financial support for thermal upgrading of buildings in terms of insulation and replacement of heat sources and installations**. The main multi-year program for this is the Thermomodernization and Renovation Fund.

#### *3.2.2.3* Public buildings energy efficiency

Based on the Energy Efficiency Directive, Member States must ensure that the final energy consumption of all public institutions is reduced by at least 1.9% each year compared with 2021. Additionally, public institutions are now required to renovate at least 3% of the total area of heated or cooled buildings. These new provisions apply to buildings owned by all public institutions (420 thousand[19]). The success factors identified in the area of single-family and multi-family buildings also apply to public buildings. These factors (**KSFs**) include requirements for **modernization and construction of facilities**, as well as a **ban on the use of solid fossil fuel heating and cooling sources**. In the case of public buildings, the primary **KSF** is to **facilitate the preparation of retrofit projects by public entities**, particularly **under the Energy Performance Contracting (EPC) formula**. In Poland, an important element is the Energy Performance Contracting Plus subsidy program[20]. It allows the organization of EPC projects, in which the entire cost of the project can be covered during the contract period from the sum of the energy cost savings and the grant (up to 49%). RES and EPC facilitation are an eligible cost.

#### *3.2.2.4* RES in industry

Renewable energy accounts for a small share of heating in the Polish industry. Stable energy sources, such as gas cogeneration, are preferred due to the priority of production continuity. However, these sources will eventually be replaced by hydrogen. Another important aspect is the development of energy storage facilities. In addition, the industrial approach to energy issues considers the entire plant's energy system, prioritizing production continuity and technological security. Apart from ETS-type schemes, there is another important system called White Certificates that rewards investments resulting in energy savings. It is recommended, that **KSF**s such as corporate energy audits, combined

with **the White Certificate system**, must be strongly supported by **subsidy programs for investments in renewable sources**, resulting from the audits. Funds obtained from energy efficiency improvements are not sufficient here. In the industry sector, a **KSF** strongly dynamizing the use of RES, especially in small and medium-sized enterprises (SMEs), is the **subsidization of high-efficiency CHP, powered exclusively by waste heat or renewable fuels.** The technological development of RES, which reduces the cost of using low-temperature thermal energy sources and stores, is making the use of waste heat in industry increasingly attractive.

#### *3.2.2.5* Other

Here we identify **KSF** in the form of an obligation scheme, in Poland it is a system of efficiency certificates, the so-called **White Certificates**[21], which has been in operation for years. In the case of industrial plants, a significant volume of certificates awarded is due to the application of RES.

An important **KSF**, influencing the acceleration of the introduction of RES in H&C in the case of cities, is the **universality and standardization of planning for the comprehensive energy transformation of the urban area**, with the assumption of the rapid elimination of the use of energy generated from fossil fuels. An additional **KSF** supporting this process is the **subsidization of high-efficiency CHP projects powered by urban biogas**.

## 3.3 KSF and KPI identified in Croatia

### 3.3.1 Particularities of the Croatian context

#### *3.3.1.1* Climate, geography, natural resources

Croatia is divided into two climate zones – coastal and continental. The average number of heating degree days for Croatia in 2022 was 2114 HDD and the number of cooling degree days 210 CDD[22]. Three main energy sources for heating (and cooling) purposes in Croatia are solid fuels (traditional biomass), fossil fuels and electricity. Solid fuels are mainly used in continental climate, while electricity is used in coastal climate. Fossil fuels are used either for centralized systems, or in cities in continental part (natural gas). Overall estimated potential of geothermal energy in Croatia exceeds one GW. In the final consumption of energy for heating and cooling, RES share achieved in 2021 was 38.0% however, this share is largely contributed by traditional biomass. The target for 2030 is 47.1%.

#### *3.3.1.2* Building Stock, infrastructure, societal aspects

Traditionally, rural areas/family houses rely on firewood for heating purposes, while urban areas/multiapartment buildings use either natural gas or centralized heating systems. Coastal part of Croatia, with relatively mild winter and strongly relying economically on the seasonal tourist sector mostly uses electricity for heating, via air heat pumps. Approximately 70% of the electricity consumed for heating and cooling in the coastal part of Croatia is produced by compression heat pumps, while 30% is produced by the standard electric resistance heating system. The use of firewood (49.84%) prevails in Croatia's household sector, followed by natural gas (23.48%) and electricity (12.44%). Around 80% of the total district heating systems heat delivery is in the City of Zagreb, where 90% of the total DH demand is covered by national DH company. Almost 20% of households in the Republic of Croatia probably spend significantly more than 10% of total personal consumption expenditure on energy (energy poverty threshold) but Croatia has not yet assessed the number of households that are in energy poverty but plans to develop a "Program for elimination of energy poverty" which will define it, assess its scope and propose measures[23].

## 3.3.2 KSFs and KPIs identified in Croatia

### *3.3.2.1* District Heating

In Croatia, the development of infrastructure for district heating and cooling networks should be accelerated and directed towards efficient and flexible exploitation of a wider range of renewable heat and cold sources to increase the use of energy from renewable sources. At the same time, it is necessary to determine urban zones with potential to develop district heating. Decarbonization of Croatian district heating requires upgrading all existing systems to meet Article 26 of the EED which defines Energy Efficient DHC. The success factor (**KSF**) here will be **programs that subsidize EED-compliant retrofits**. District heating systems will be upgraded by using renewable energy sources instead of the current fossil fuel ones. In the case of Croatia, the most important technologies that will enable to increase RES share in heating and cooling production are shallow and deep geothermal, biomass, waste heat, solar energy and hydropower. The figure below shows the heating modernization scenarios. High-efficiency cogeneration is an important element here, but it will be a challenge to maintain the given heat production volume only with renewable fuels.

*Figure 3 Total annual energy delivered at the entry point to the distribution network of DH systems in Croatia*[24]

| Total annual energy delivered at the entry point to the distribution network of district heating systems [GWh/a] | | | | | |
|---|---|---|---|---|---|
| Name of energy product/technology | 2019 | BAU – 2030 | BAU – 2050 | SIM – 2030 | SIM – 2050 |
| DHS – natural gas boilers | 1 326.77 | 1 250.00 | 1 050.00 | 661.90 | 200.00 |
| DHS – fuel oil boilers | 34.70 | 31.53 | 0.00 | 0.00 | 0.00 |
| DHS – biomass boilers | 3.76 | 5.00 | 10.00 | 7.00 | 13.34 |
| DHS – natural gas – high-efficiency cogeneration | 38.51 | 101.99 | 136.99 | 250.00 | 237.39 |
| DHS – biomass – high-efficiency cogeneration | 105.51 | 131.89 | 225.37 | 150.00 | 256.28 |
| DHS – natural gas – cogeneration | 197.80 | 190.00 | 140.00 | 0.00 | 0.00 |
| DHS – geothermal energy | 113.94 | 170.00 | 250.00 | 422.27 | 477.14 |
| DHS – solar energy | 2.05 | 4.00 | 10.00 | 24.80 | 33.49 |
| DHS – heat pumps – electrically driven | 0.00 | 0.00 | 0.00 | 14.20 | 24.15 |
| DHS – heat pumps – RES from the environment | 0.00 | 0.00 | 0.00 | 48.30 | 82.10 |
| DHS – industrial waste heat | 0.00 | 0.00 | 0.00 | 15.00 | 22.67 |
| DHS – thermal waste treatment heat | 0.00 | 0.00 | 0.00 | 130.00 | 195.76 |
| **TOTAL** | **1 823.04** | **1 884.41** | **1 822.36** | **1 723.47** | **1 542.31** |
| BAU – business-as-usual scenario, SIM – scenario with integrated measures | | | | | |

It is therefore necessary to update the list of renewable energy sources that district heating and cooling enterprises should increasingly accept. The integration of thermal energy storage as a source of flexibility, greater energy efficiency and more cost-effective

operation is here a necessary condition. There is always the question of what RES can be effectively used on a significant scale, in the transformation of a particular country's DHC. In the case of Croatia, an important **KSF** is the **development of geothermal energy sources** (422 GWh planned in 2030). The effects of implementation will be measured (**KPI**) by the percentage of geothermal energy in the total amount of energy in the heating and cooling sector. A measure that is recommended and will significantly influence the increase of RES participation in H&C is **the utilization of waste heat from industrial plants, energy-from-waste, using renewable energy sources such as biomass and solar collectors**. A specific **KSF** is the **upgrading of the Construction Act**, where the construction of a geothermal well, a seasonal tank and a heat pump will be defined as one integrated system. This will speed up the investment process and reduce its cost.

A **KSF** on the road to 100% RES participation in heat production is establishing **the priority of connecting buildings to the energy efficient district heating network**. By connecting buildings to heating network and increasing the load on the district heating system, Croatia further improves its efficiency. At the same time, the number of individual heat sources will be reduced, such as gas boilers in existing buildings. These measures, all together lead to more control over the decarbonization process and efficiency.

#### *3.3.2.2* Single and multifamily buildings

In the building area, we identify two groups of success factors that support the advancement of RES introduction. These are **KSF**s related to incentives (carrots) and **KSF**s that are obligations (sticks). Measures for the household sector include the replacement of fossil fuels with renewable energy sources by the introduction, in case of Croatia, of heat pumps as well as the use of solar energy for heating and domestic hot water preparation. **KSF**s package includes dedicated programs: **financial program to support appliance replacement, Energy Renovation Program for multi-apartment buildings and Energy Renovation Program for single family houses. KSF** which additionally supports the mentioned programs are **tax credits for those investing in RES-based heating equipment**. The use of funds from these programs requires **meeting technical parameters under increasingly restrictive mandatory building standards and guidelines**. The introduction of these regulations is a success factor (**KSF**) significantly influencing the increase in the share of renewable energy used to heat and cool buildings. To evaluate the performance of **KSF**s in the area of buildings, **KPI**s are suggested based on examining in successive years the increase in the share of H&C energy

in the power supply of buildings or the installed RES capacity for H&C (like solar thermal target - 15% of total heat in 2030).

Identified **KSF** in the form of subsidy programs most often have an indirect effect on RES implementation, as these solutions consider various additional conditions. In the case of Croatia, these include, for example: program for **renovation of multi-apartment buildings undamaged by earthquakes**, program for **renovation of multi-apartment buildings damaged by earthquakes**[25], and/or **financial support to citizens at risk of energy poverty**. One example is promoting the use of renewable energy sources and energy efficiency through the funds of the Environmental Protection and Energy Efficiency Fund. RES projects for which the Fund for Environmental Protection and Energy Efficiency allocates funds include solar, wind, biomass, and energy from small hydroelectric plants and geothermal energy. The **KSF** reinforcing factor mentioned above is the strategy to achieve the average final energy consumption in the residential sector of 30 kWh/m$^2$ for newly built and renovated buildings, **as this is not achievable without RES**[26].

#### *3.3.2.3* Public buildings energy efficiency

Member States will reduce the final energy consumption of all public institutions by at least 1.9% per year compared to the 2021 consumption. Moreover, public institutions are required to renovate at least 3% of the total area of heated or cooled buildings, with new provisions applying to buildings owned by public institutions.

Decarbonization of the heating systems in the public sector and RES introduction is in Croatia supported by a **KSF** which is the **obligation to replace heating systems that use solid and liquid fossil fuels by 2024** and another success factors **KSF**, which is the **co-financing for replacing natural gas boilers with new systems that uses RES** and electrification of heating systems using **heat pumps with mandatory supply of electricity from photovoltaic systems on the building**. The following **KSF** identified here, specifically powerful in case of public entities is **the modernization co-financing (grants) of public buildings in Energy Performance Contracting model**. The target of the above **KSF**s is to retrofit 350,000 m$^2$ of public building space over the period 2021-2030. Assessment of the impact of the **KSF**s can be done through either a **KPI** examining the amount of retrofitted space or an increase in the share of power from RES in the following years.

### *3.3.2.4* RES in industry

The total amount of energy supplied in Croatia for heating and cooling in the industry sector in 2019, is as follows (GWh):

*Table 2 Total amount of energy supplied in Croatia for heating and cooling in the industry sector in 2019*[27]

| Use | Energy supplied [GWh] |
|---|---|
| **Heating in the production process** | 5 772.19 |
| **Space heating and DHW preparation** | 579.75 |
| **Cooling in the production process** | 270.31 |
| **Space cooling** | 111.72 |
| **TOTAL** | **6 733.98** |

The total value of energy used for heating and cooling accounts for 75% of all energy supplied to industry. Heat for industrial infrastructure is partly supplied from the city's district heating networks, but this does not exceed 8% of industrial demand for H&C purposes. The share of renewable energy is very small, for example, the share of high-efficiency cogeneration powered by renewable fuels was 0.76% in 2019. In this regard, the implementation of RES for heat and cooling production is related to the success factors discussed in the area of district heating.

Increased use of renewable energy sources is an important goal, as defined in the NECP. Overall, the share of RES in 2019 according to the Comprehensive Assessment, is as follows:

*Table 3 Overview of the energy delivered for heating/cooling purposes to the industrial sector in 2019[28]*

| DELIVERED ENERGY PROVIDED ON-SITE | | | Unit | Value |
|---|---|---|---|---|
| INDUSTRY | Sources of fossil fuels | Boilers used for heating only | GWh/a | 2 711.81[9] |
| | | Other technologies | GWh/a | 731.67 |
| | | High-efficiency cogeneration | GWh/a | 2 013.01[10] |
| | RES energy | Boilers used for heating only | GWh/a | 293.01[11] |
| | | High-efficiency cogeneration | GWh/a | 0.00 |
| | | Heat pumps | GWh/a | 0.00 |
| | | Other technologies | GWh/a | 489.67 |
| **DELIVERED ENERGY PROVIDED OFF-SITE** | | | | |
| INDUSTRY | Sources of fossil fuels | Waste heat | GWh/a | 0.00 |
| | | High-efficiency cogeneration | GWh/a | 36.25[12] |
| | | Other technologies | GWh/a | 454.64[13] |
| | RES energy | Waste heat | GWh/a | 0.00 |
| | | High-efficiency cogeneration | GWh/a | 3.75 |
| | | Other technologies | GWh/a | 0.16 |
| **TOTAL** | | | | **6 733.98** |

The above data clearly shows that a significant amount of heat is produced by gas-fired cogeneration plants, so a major challenge is the gradual transformation of these plants to run on renewable fuels. The main recommended measures for on-site heat and cooling production are:

- **Financial programs to support the use of high-capacity industrial heat pumps and biomass boiler plants**.
- **Financial programs to support the modernization or construction of new cogeneration facilities, powered by renewable fuels** (synthetic gas, hydrogen, biogas).

Most of the energy, used in industry for heating and cooling (85%) involves technological applications, so RES application planning and selection of success factors must take into account, among other things, the required parameters and issues of continuity of energy supply in relation to production cycles.

#### *3.3.2.5* Other

There is a significant problem concerning energy poverty in Croatia. Therefore, it is necessary to develop the program for elimination of energy poverty. The government has therefore adopted a strategy consisting of measures to reduce the cost of energy for residents in the energy poverty zone which implies **subsidizing the introduction of RES into heating systems**, hence the **KSF** identified in this area. An example is the energy poverty reduction pilot program based on the installing of renewable energy sources in residential buildings in assisted areas and areas of special state concern for the period up to 2025.

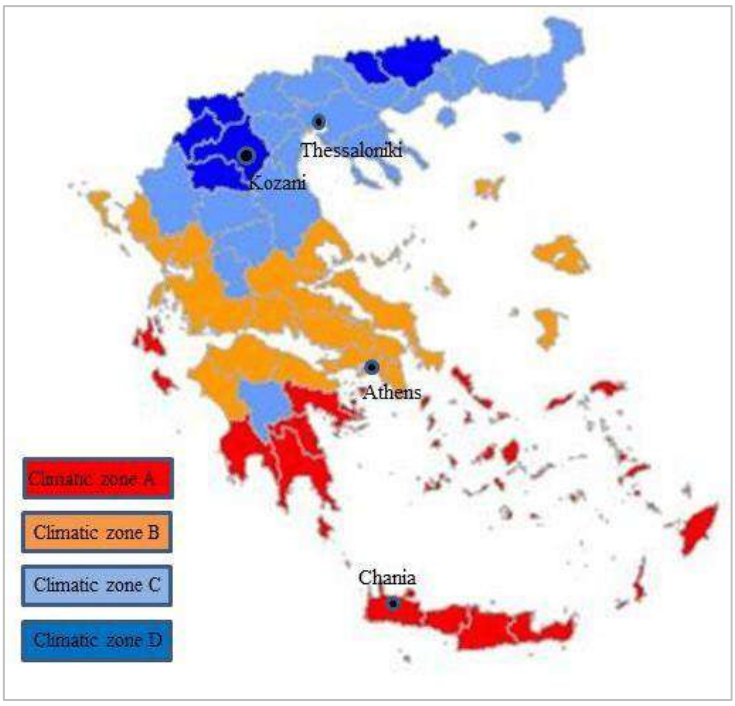
# 3.4 KSF and KPI identified in Greece

## 3.4.1 Particularities of the Greek context

### *3.4.1.1* Climate, geography, natural resources

The climate in Greece is predominantly Mediterranean. However, due to its geography, the country has a wide range of micro-climates and local variations. The residential heating period in Greece, varies according to the four climatic zones and in average, lasts approximately from October to April, being shorter in southern Greece. The four climatic zones in Greece are illustrated by the figure below.[29]

*Figure 4 Climatic zones in Greece*




Data from the period between 2006 and 2017 shows that residential heating in Greece has relayed mainly on oil and petroleum products (43.02%), renewable and wastes (36.18%, incl. solar thermal and biomass) and secondarily, on gas (13.61%), electricity (4.79%), derived heat (2.23%) and solid fuels (0.17%). The energy consumption profile has significantly changed over the last decade in Greece in favour of biomass (27.07 PJ in 2006 compared to 35.67 PJ in 2017) and gas consumption (5.22 PJ in 2006 compared to 13.03 PJ in 2017. These changes can be attributed to two main factors: a) the lift of the ban on biomass usage for space heating (in force since 1993) in 2011 and b) the economic crisis, that sharply decreased the fossil fuel consumption for space heating. Today, space

heating occupies the greatest share of the total energy consumed in the residential sector with 56.2%, whereas space cooling is only 4.3%.[30]

Regarding cooling, forecasts predict that Greece will face increasing temperatures throughout the 21st century[31] and therefore, the cooling loads are expected to rise. Increased temperatures are also expected to cause electricity supply risks by reducing the efficiency of thermal power plants[32] and increasing cooling water consumption. Further, rapid rises in peak electricity demand for cooling during extreme heat events may prompt network failures, as recently happened in 2017 and 2021. In July 2023, a long-lasting, heatwave struck the country with record breaking temperatures. As a result of this heatwave, devastating fires burned forests in southern Rhodes and Laconia.

Climate adaptation in Greece is defined in the Greece's National Adaptation Strategy that was adopted in 2016. The Strategy defines the goals, priorities and measures for climate adaptation and is implemented through 13 Regional Adaptation Action Plans.

Another particularity of Greece is the large number of islands; Greece has around 227 inhabited islands. Most of those islands are electrically interconnected to the mainland, but there are 29 islands non-interconnected. These are Crete and Rhodes, with a peak load of over 100MW each, 8 islands of peak load 10-100MW and 19 smaller islands with peak load less than 10MW.[33] Greece is currently carrying out interconnection plans, notably for Crete, which is the most populous island in the Mediterranean, and several islands of the Cyclades.[34]

#### *3.4.1.2* Building Stock, infrastructure, societal aspects

Most of the buildings in Greece were constructed prior to 1980[35], with practically no thermal protection systems, such as insulation and double glazing. According to a recent Greek Energy Market Report[36], 42% of the total building stock is constructed before 1970 and as a consequence, buildings present poor energy performance, with almost 67% of the households being classified in the lowest energy performance categories. Meanwhile, the increase in living space per person has also contributed to increase the energy demand per person. The energy saving potential of district heating and cooling networks is not exploited. Finally, the high penetration of air-conditioning use combined with the frequently occurring heat waves in recent years has further increased the energy consumption in the building sector and the country's peak electrical power loads. For the

above reasons, the building sector is responsible for roughly one third of total $CO_2$ emissions and around 36% of total energy consumption in Greece.

In Greece, the social protection system is weak. Despite recent progress, income inequality remains higher than the eurozone average. Greece's urban/rural income gap is considerably higher than the eurozone average and has been increasing since 2017.[37] Spending on social assistance is one of the lowest in the Eurozone. The coverage and targeting of social protection are relatively poor. These societal conditions, combined with the old energy-inefficient building stock have led to particularly high levels of energy poverty. More specifically, in the two most important energy poverty indicators, the arrears on utility bills, and inability to keep home adequately warm indicator, Greece ranks first.[38]

## 3.4.2 KSF for increased deployment of renewables in H&C in Greece

### *3.4.2.1* Single and multi-family apartment buildings

Many of the **KSFs** for the uptake of RES in the heating and cooling sector in Greece focus on single and multi-family buildings. This is consistent with the large share of buildings in Greece which were constructed prior to 1980 and often lack thermal protection systems, such as insulation and double glazing.

One of the identified **key success factors is an obligation** put in place to achieve a **60% share of renewable energy for water heating in new buildings**. This share should be covered by solar thermal or any other renewable source more efficient than solar thermal. Greece has a strong solar thermal industry in place, with a market that is over 40 years old. In 2023, Greece was among the top 5 countries by installed capacity per 1,000 inhabitants. Given how strong the solar thermal industry is in Greece, it makes sense to incentivize the installation of solar thermal technologies.

Furthermore, with a **clear target** in place for the share of renewables in water heating provides **certainty to stakeholders**, planners, builders, installers, developers, and owners, regarding the required obligations. It also allows policy makers to have more clarity for planning and developing additional policies on how to achieve their decarbonisation targets by setting foreseeable expectations on emissions saved through this measure. Thus, this obligation addresses **multiple aspects at the same time**: the uptake of renewables for heating and incentivizing domestic production of solar thermal technologies. The latter, in turn, is expected to result in job retention/creating in a sector that is already strongly competitive.

Like various other countries, Greece has placed a **ban on fossil equipment**, a measure that has been identified as a **key success factor (KSF)**. Specifically, Greece has decided that the installation of oil boilers will no longer be allowed from 2025, and from 2030, oil for heating will have to contain at least 30% by volume of renewable liquid fuels.[39] Heating oil represents about half of the total energy consumed for space heating and has the highest penetration in the Greek market.[40] For example, together with natural gas boilers, heating oil boilers ate the most utilized space heating systems in Athens. Thus, the

measure to ban oil boilers is largely impactful. Furthermore, it also provides certainty and a clear direction for builders, planners, and other relevant stakeholders.

Financial support in the form of either **fiscal incentives (e.g. income tax deductions) or interest-free loans and grants have been identified as constituting key success factors (KSF)**. From 2019 on, Greece has offered income tax deduction in the value of 10% of the total qualifying project costs for investments in heating and cooling systems that use solar thermal, biogas, biomass, geothermal energy or heat pumps. In addition, the programs 'Saving at home' and "Energy Saving for young people"[41] provide interest-free loans and grants for the installation of renewables and energy efficiency measures and renovations. In particular, the 'Saving at home' program is based on an integrated approach that aims to address several relevant dimensions, the **replacement of fossil-based heating systems by renewable-based ones can support these goals**:

- reducing the energy needs of buildings and subsequently the greenhouse gas emissions that contribute to climate change;
- reducing energy expenditures for citizens and at the same time, improving living conditions, indoor comfort and health and safety of the building occupants; and
- improving the air quality and ceasing the environmental degradation.

For the 'Saving at home' program, the yearly rounds from 2018 to 2020 received a total of 94,094 applications and provided grants worth 1.3 billion€ and loans for 113 million€. The 2021 round of the program had a budget of 1.14 million€, a maximum eligible intervention of 28,000€ and **targeted support for vulnerable households**. The 2022 round of the program had a record high of 87,578 applicants.[42] The 2023 first round had 31,549 applications with a total budget of 422 million€.[43] Nowadays, a second round of the 2023 program is still online with a budget of 110 million€, addressing only vulnerable citizens. The total investment of all "Saving at home" rounds is expected to contribute to the energy savings by 213 ktoe per year and to the energy renovation of at least 105,000 residences by 2025.[44]

Based on the 2016 Development Law, subsidies and tax breaks are also available for investments in solar thermal, biogas, biomass, geothermal and heat pumps (air, water and ground-source) built by private enterprises.

Finally, Greece exploits the heat pumps as one of the key technologies to decarbonize its heating and cooling sector. Since the retail price of electricity is an important consideration for choosing heat pumps, a special **heating allowance for electricity** has been introduced by the Greek government. This allowance does not only support energy vulnerable consumers, but it also guides them to the selection of heat pump instead of any other technology. This allowance has been identified as a **key success factor (KSF)**. Eligibility for this aid requires specific income and property criteria and excludes recipients of other heating allowances for oil, natural gas and other fuels, as well those under the Social Tariffs. In the 2023 program, there were 763,307 beneficiaries with a total allowance of 175 million€.

#### *3.4.2.2* Public Buildings

Based on the updated NECP, the energy intensity of the public buildings in Greece is well above the EU27 average, since 2017. Thus, **renovation programs** especially targeted at public buildings are an important factor for the decarbonisation of heating and cooling. As such, the 'Electra' program which runs in the period 2022-2026 is designed to support the energy update and the deployment of renewable technologies in the public buildings. It finances the renovation of the whole building, aimed to improve energy efficiency and at reaching class B and reduction of energy demand by 30% with the **mandatory appointment of an energy manager**. In particular, the mandatory appointment of energy manager for optimizing energy use of public buildings has been identified as a **key success factor (KSF)** that will contribute to the successful deployment of more renewables for heating and cooling of public buildings. Financed interventions include replacing windows, modernising heating and cooling systems and installing renewables and electricity storage. The programme encourages the participation of energy service companies to perform the renovation works. The programme is funded with 500 million€ by the Deposit and Load Fund of the European Investment Bank, 170 million€ from the EU Recovery and Resilience Facility and 250 million€ from private investments. The programme addresses public buildings of the lowest energy classes, between C and H, that have not yet undergone radical renovation.

Additional funds for public buildings are also available in the 2016 Development Law.

#### 3.4.2.3 Industry

In Greece, the SMEs represent an important element of the Greek 'non-financial business economy'. In 2020, they accounted for 83.0% of overall employment and 56.7% of overall value added, substantially more than the EU averages.

Industry is an important source of greenhouse gas emissions for Greece. In comparison with other EU27 Member States, Greek industry uses more electricity and oil and less gas and RES. [45] Thus, addressing the electricity mix through increasing the share of renewables in the power sector is a relevant measure to support the decarbonisation of the industrial sector. As in the case of buildings, electrification is the path to decarbonisation, since it involves indirect deployment of renewable energy. Recent data from 2021 indicate that the largest energy consuming industrial sectors are non-metallic minerals, chemical and petrochemical and non-ferrous metals, each accounting for 19% of industrial consumption. Less energy consuming sectors are food and tobacco (14%), agriculture/forestry (9%), construction (7%), iron and steel (4%), mining and quarrying (3%), machinery (3%), and paper (2%)[46]. Many of these sectors do not even require high temperature heat, which enables them to utilise solar thermal technology or heat pumps for covering their needs.[47]

Industrial policy measures today focus more on energy efficiency and less on heat decarbonization. However, there are certain measures that can also incentivize the deployment of renewables for heating and cooling in industry. As such, the program 'Energy Saving at Enterprises' **consists of interest-free loans and grants for the installation of renewables and energy efficiency measures for SMEs**. The program has a budget of 700 million€ and aims at supporting 25,000 companies of which 3,400 are new. It provides a subsidy of 40% for each investment. The minimum amount of the subsidy is 30,000€ and maximum 1 million€.[48]

In addition, measures to introduce hydrogen as fuel and/or feedstock and the development of Carbon Capture and Storage value chain are addressed in the updated NECP.

#### 3.4.2.4 District Heating and Cooling

Greece does not have a well-developed district heating and cooling infrastructure. Large scale development of new networks is not foreseen from a logistical and economic perspective.

However, the exploitation of the existing, albeit limited, DHC networks, is being promoted. In the updated draft NECP, the use of lo**cal DHC networks within industrial districts that exploit waste heat** is encouraged. Furthermore, Priority 2 of the Just Transition Found foresees new renewable energy projects to be integrated in the existing district heating networks in the Kozani, Ptolemaida, Amintaio, Florina and Megalopoli (lignite phase out regions). The target for 2029 is to add or improve 3.5 km of DHC pipeline.[49] Even with limited DHC infrastructure, a more ambitious goal regarding the length of DHC network to be added/improved could have been established. Nonetheless, setting up a concrete commitment under the NECP with a **clear goal on the length of DHC to be added** is important and has been identified as a **key success factor (KSF)**.

In addition to the commitments established in the updated NECP, additional DHC projects are being developed in Greece through programs such as the EU's Horizon 2020. An example of this is the geothermal-based DHC project in the Anthelia-Aristino region. This geothermal district heating network project is expected to provide heat for municipal buildings, social housing and greenhouses with a total thermal power estimated at 10 MW.[50] The provision of renewable heat for social housing is important as it addresses issues of social protections of vulnerable consumers which, as highlighted in the section above, needs more attention.

"High-efficiency cogeneration, district heating and cooling" is also mentioned as one of the areas to be developed under the draft Common Provisions Regulation.

Given the limited DHC infrastructure, the actions taken by Greece, are aimed at maximizing the benefits and leveraging the current conditions strategically.

#### *3.4.2.5* Other

**Public information campaigns are an important success factor for Greece.** Since the publication of the Greek EPBD, many public awareness campaigns, communication campaigns, and general publicity through the media have happened. This is reflected in the wide deployment of RES in heating and cooling and the annual sales of heat pumps and solar thermal systems.

# 3.5 KSF and KPI identified in Portugal

## 3.5.1 Particularities of the Portuguese context

### *3.5.1.1* Climate, geography, natural resources

Portugal is a warm country with a Mediterranean climate, some areas have a milder climate due to the Atlantic Ocean, for example, the Algarve. In Portugal, an upward temperature trend is projected to occur throughout the 21st century, such that the country's average annual temperature in 2100 under a high-GHG emission scenario could be up to 4°C higher than during 1971-2000. This temperature increase is expected to be especially pronounced during the summer. More very hot days (daily maximum temperature above 35°C) and tropical nights (daily minimum above 20°C) are projected, and heat waves are anticipated to last longer, especially in the northern countryside, raising the risk of forest fires.

These temperature changes will likely affect Portugal's energy supply, particularly of electricity. According to the National Climate Change Adaptation Strategy's energy sector report, rising temperatures and more frequent heatwaves could reduce thermal power plant generation efficiency and availability as well as power grid efficiency and maximum transmission. More frequent extreme heat events could also interrupt thermal power generation by raising the temperature of cooling water.

Forecasted changes in precipitation may also affect the energy sector. For instance, the Mediterranean drought of 2017 limited Portugal's hydropower production capacity by lowering the water level and raising competition over water use.

Portugal is one of the few Member States that stands out in the renewable heating and cooling sector, as to have already reached its 2030 targets. The target established for 2030 corresponds to 38% of renewables in heating and cooling, but it has been surpassed already. In 2020, the percentage of renewables in the mix represented 42% of the total.

Regarding different technologies for H&C, biomass and heat from cogeneration correspond to approximately 60% of the supply from renewables. Energy supplied from heat pumps and solar thermal are expected to represent about 30% and 7%, respectively, in 2030. Whereas the estimation for renewable gases corresponds to 6 % share of the RES

supply by 2030. Overall, 64 % of the total bioenergy (biomass, heat from co-generation and renewable gases) is expected to be used in the H&C sector until 2030.

#### *3.5.1.2* Building Stock, infrastructure, societal aspects

Based on data from the energy certificates issued between 2014 and 2020 (~1.3 million certificates which only represent a fraction of the national housing stock), the number of dwellings built in relation to energy performance requirements for the housing sector show that only 12.3% of accommodations qualify as very efficient (A or A+ rating), and around 70% of certified dwellings are rated with an efficiency class C or lower.

Regarding indoor temperature comfort, the perception that winter is short and mild and that it has been colder in the past contribute to a devaluation of low temperatures at home, encouraging the use of low-cost measures to tackle the cold and thus holding back investment in equipment and building renovation, that improves thermal comfort. On the other hand, the perception that heat waves tend to become more frequent and severe due to climate change leads the population to purchase equipment that helps tackle heat at home. However, due to family's low income and the decision to purchase low price models, favours the demand for cheaper solutions, which do not require renovation works at home, nor the need for technical advice.

According to the EU Survey on Income and Living Conditions, in 2019, Portugal had the fourth highest rate of inability to maintain dwellings adequately warm during the winter (18.9%) of all Member States.[51] A different survey (PCS/Quercus, 2017) also reported difficulty in maintaining an adequate temperature in Portuguese homes, particularly in the heating season. Of all respondents, about 74% consider their housing cold during the winter, 24% of the people consider their houses hot during the summer, and only 1% report that their housing is at a temperature that provides in both seasons.

This sort of tolerance to thermal discomfort is reinforced by the social view that each person has an important role towards energy efficiency/rational use of energy at home. In this socio-cultural context, many citizens prefer not to take advantage of energy services and therefore don't incur in expenses that they cannot pay or that they consider to be high.

## 3.5.2 KSF and KPI identified in Portugal

### *3.5.2.1* District Heating

District Heating is not well developed in Portugal. Furthermore, a study shows that the potential for urban heating and cooling networks in Portugal is low or almost zero.[52] The main obstacles to the adoption of urban heating and cooling networks identified were: a very low building density in interior areas with more climate extremes and, in contrast, a mild climate in coastal areas that support denser urban areas. Other economic, sociocultural, and practical barriers were also identified. It was concluded that, unlike most other EU countries, Portugal is not expected to obtain significant improvements in energy efficiency through the adoption of district heating and cooling network solutions.

However, opportunities for urban heating networks have been found for certain specific situations in which there are geothermal or industrial waste heat sources close to the urban area (Chaves, Amadora, Parque das Nações). Furthermore, it has been investigated, and it appears possible, although not strictly economically viable in itself, to adopt heat and cold networks in historic and tourist districts, to reduce the impact on the urban landscape of intrusive heating and cooling solutions, namely air conditioning devices.

In accordance with the above assessment no success factors were identified for the development of DHC in Portugal. Based on assessing the updated NECP, the technology is not expected to play a significant role in the decarbonisation of the H&C in the country.

### *3.5.2.2* Single and Multi-Apartment Buildings

The **KSF** to support the uptake of renewables in the H&C sector in Portugal relay on programs to **incentivize renewable-based heating solutions together with energy efficiency**. **Financial incentives (grants) for RES-heating can be accessed through 'Programa de Apoio a Edifícios mais Sustentáveis'**. The program covers space heating and/or cooling and domestic hot water systems that use renewable energy (energy class 'A+' or higher). It also covers the installation of PV systems and other renewable energy production equipment for self-consumption with or without storage. Technologies in the scope of the program include heat pumps, solar thermal systems, biomass boilers and stores and PV systems. The **"Vale Eficiência"** is a similar program but specially designed and targeted at vulnerable consumers, who also benefit from social electricity tariffs. A **dedicated program for vulnerable consumers** is expected to better help address the needs of energy-poor households and has been identified as another **key success factor**.

Measures to promote the **replacement of inefficient H&C systems by renewable-based ones** are listed in the updated draft NECP but a description of what specifically such measures will entail is not available. However, given that the ownership and use of decentralised, low-efficiency heating systems such as fireplaces and electric oil heaters are widespread in Portugal[53] this is an important area to target. Based on this, we believe that such measures can constitute a **key success factor** in supporting further uptake of renewables in H&C in Portugal.

Portugal has also achieved a high level of electrification. In 2019, electricity covered 25% of total final energy demand and 56% of building energy demand.[54] Portugal plans to further **promote the electrification of the building energy demand through support for heat pumps** and this can be seen as a **KSF.** Portugal has committed to develop a National Action Plan to accelerate the uptake of heat pumps in Portugal in buildings and industry, with the framework of the EU Heat Pumps Action Plan. In this regard, the (private and public) buildings sector intersects with industry when it comes to the promotion of heat pumps. The timeframe for this measure is 2020-2030.[55]

**Fiscal measures** are also proposed to support energy efficiency and renewable energy uptake in buildings, and they will constitute **key success factors**. In the updated NECP, Portugal has committed to introduce tax incentives for energy efficiency and the introduction of renewable energy and a **more favourable tax regime for renewable energy buildings** (e.g.: create tax incentives, such as reducing IMI, for nearly zero-energy buildings (NZEB)).

Finally, special electricity tariffs for vulnerable families are proposed as a factor to support electrification solutions in energy poor households.

#### *3.5.2.3* Public and Commercial buildings

The **KSF** identified in the public and commercial buildings sector are similar to those designed to support the uptake of renewables in the private buildings sector. The program '**Programa de Apoio à Renovação e Aumento do Desempenho Energético dos Edifícios de Serviços'** appears very similar in scope to 'Programa de Apoio a Edifícios mais Sustentáveis' with the differentiating factor being the target sector. A comparison on how these programs perform with respect to one another using the proposed **KPI**s could provide interesting results. As in the case of the private buildings, Portugal aims to promote electrification in the public buildings sector. 'The Prosumer" program focuses on state housing buildings but also includes privately owned ones hence also bridging the scope between these two buildings sectors.

#### *3.5.2.4* Industry

As mentioned above, Portugal has committed to drafting a National Action Plan to accelerate the **uptake of heat pumps including in the industry** sector – this has been identified as a **key success factor**.

In the updated NECP, Portugal has included a program to **promote high-efficiency cogeneration based on renewable energy sources in industry**. High-efficiency cogeneration systems that take advantage of renewable resources should be added, making it possible to improve the cost of production, making industry more competitive and contributing to the achievement of energy and climate targets. This should also include retrofitting cogeneration units for operation also with renewable gases.

In its updated NECP, Portugal mentioned programs aimed at promoting the **uptake of more efficient technologies and increasing awareness regarding efficient use of heating and cooling systems in industry.** However, no further details are available on how concretely this is to be achieved.

#### *3.5.2.5* Other

As mentioned in the section on underlying conditions in Portugal, the country is among the highest reporting thermal discomfort by its citizens. It has the fourth highest rate of citizens reporting inability to maintain dwellings adequately warm during the winter (17.5 %).[56] Thus, it is appropriate that the updated NECP contains many **measures aimed at addressing energy poverty**. A recent study shows that, at least in European countries, increased renewable energy can significantly reduce energy poverty.[57] The NECP promises the delivery of a national, long-term strategy as well as local strategies to combat energy poverty. Furthermore, there is mention of promoting more structural programmes, actions and support mechanisms to combat energy poverty, such as incentives for changes in consumption patterns, targeted interventions for investments in energy efficiency, renovation of buildings and programmes aimed at the integration of renewable energy. These support mechanisms will be developed together with municipalities in order to better suit reality and promote closer proximity to energy poor consumers.

In addition, Portugal, has placed emphasis on **promoting trainings and skills required for the decarbonization, including through the uptake of renewables, of the heating and cooling sector.** Importantly, these programs promote the synergies between energy efficiency gains and renewable energy uptake.

# 4. DISCUSSION

## 4.1 Discussion on KSF identified

In this chapter the analysis undertaken for each one of the five Member States is brought together and integrated to assess similarities and differences between the countries. Most importantly, similar key success factors observed across countries are grouped together to extract more general lessons with wider applicability across all EU27.

### 4.1.1 KSF and KPI - commonalities and differences between the five Member States

When analysing all five Member States, similarities between two groups of countries: Germany (DE), Poland (PL) and Croatia (HR) on the one hand, and Greece (GR) and Portugal (PT) on the other, can be observed. In these two groups, similarities in the **KSF**s can be attributed mainly to two considerations: i) a certain climatic similarity and ii) the degree of development of district heating. In the first three countries, it is not possible to operate buildings in winter without the use of heating (however, the average demand rate kWh/m$^2$ per year is much lower in Croatia than in Germany or Poland). The high degree of development of district heating in Germany and Poland, for example, is due to the corresponding level of the indicator defined as power density per unit area - the cold climate and intensive urban development make the construction and operation of district heating networks economically justified. In Croatia, it is largely a matter of using geothermal sources with high temperatures sufficient to supply thermal networks without the need for reheating. In the case of Greece and Portugal, the low degree of power density per unit area does not justify the development of thermal networks beyond single areas in some cities. Another difference between the two groups is the use of RES for hot water production. While in Greece and Portugal solar thermal systems are capable of meeting demand throughout the year, in Poland, Germany and Croatia they are, except during the summer, systems supporting other heat sources.

From the analysis of **KSFs** in the five Member States several commonalities can be observed. Although the specific design of successful policies or other measures (key success factors) in each country differs, the broader mechanisms used to promote renewable H&C in different sectors can be largely classified under the umbrella of a few broader groups.

The common groupings of key success factors identified in each country are discussed in the following sections. Annex 2 presents a table containing the groups of common key success factors

observed across the five Member States per each of the sectors analysed. The finding that most of the **KSF**s identified in the five countries can be classified into common groups gives rise to the claim that it will be possible to apply the REDI4HEAT results to other Member States.

### 4.1.2 KSF for increasing renewables in District Heating and Cooling

To facilitate readability, for each sector discussed, we include a table with the **KSF**s groups presented above for the sector. Table 4 shows the groups of common **key success factors** identified across the five Member States. with regards to District Heating

*Table 4 Classification of common KSFs in relation to five Member States in the DHC sector*

| Key Success Factor groupings | PL | DE | HR | EL | PT |
|---|---|---|---|---|---|
| **Restrictions on financing of non-efficient DHC** | Bank will not credit DHC projects not meeting minimum EE criteria | Bank will not credit DHC projects not meeting minimum EE criteria | Bank will not credit DHC projects not meeting minimum EE criteria | / | / |
| **Connection to DHC supplied by RES or meeting EE standards** | Priority connection when RES supply | / | Priority connection when RES supply | / | / |
| **Support to high efficiency DHC (def. on RES)** | Financial support for high efficiency DHC | Financial support for high efficiency DHC | / | / | / |
| **Promotion of RES in DHC** | RES technology deployment (HP, Geo, STH, biogas) | RES technology deployment (HP, Geo, STH) | RES technology deployment (HP) | Implementation of geothermal DHC through co-financing | / |

In countries with existing district heating and cooling infrastructure like in Poland, Germany, and Croatia, some of the common KSFs areas observed are:

1. **Financial penalties, risk of diminished access or even complete restriction to financing if DHC networks do not fulfil the EED definition of energy efficiency standards**. The energy efficiency standards cannot be met if renewable energy sources are not used. This **KSF** group is especially important for Poland given that the country has Europe's second largest district heating market with approximately 400 district heating networks supplying heat to around 16.5 million residents. 80% of the network is still powered using hard coal. Of course, it is crucial for other countries, where district heating

already incurs high environmental costs from the use of hard coal, so the inability to finance the longer stages of the transformation could mean the threat of closure of fossil based DHC networks. In Germany, too, modernization of district heating is not possible without sustained public financing. Likewise in Croatia. In addition to restricted access to non-efficient DHC, facilitating the access to finance to efficient and highly efficient DHC should be considered by authorities to strengthen the effect by coupling discouragement and promotion. For example, by agreeing to part-finance from EU programs and part-finance from national funds, provided that the modernization is completed by the deadline.

2. **Prioritise the connection of end-users (incl. buildings) to DHC networks against the installation of individual heating systems**. The effective **KSF** is to administratively require the priority for the use of an energy-efficient district heating network before considering the use of alternative individual heating systems. If other sources of supply are considered, it is mandatory to demonstrate that these are better solutions than a connection to a close DHC (vav environmental, economic and technical aspects). The objective is primarily about reducing the use of individual heat sources in buildings in cities when a DH network exists and can afford the connection, as the district heating network provides better opportunities for the use of RES, which ensure professional control of heat supply parameters. An additional argument is often the fact that existing thermal networks, fed by RES, have large reserves of capacity which allow new connections of buildings (due to the steady reduction in heat consumption of buildings after retrofitting), so in addition, the social cost of heat supply using DHC is much lower than in the case of new individual solutions. In addition, DHC also provides an opportunity for RES sources in the form of low-temperature waste heat or biogas cogeneration.

3. **Support schemes and other measures for increasing the Energy Efficiency of DHC.** Financial support for increasing the energy efficiency of existing district heating networks is very effective in supporting the decarbonisation of DHC. These can be paired with financial-penalties for non-compliance with EED efficiency requirements for maximize synergies between sticks (penalties) and carrot (incentives) – type of measures.

4. Finally, **support for renewable energy technologies to supply District Heating networks is also important**. This type of support can be observed in four out of the five countries analysed. The specific technologies supported will depend on the country's natural resources, manufacturing capacity, climatic conditions etc. A combination of different programmes with specific design for individual technologies is often desirable

as support for different technologies requires different design parameters suitable for the particular technology.

In the countries with limited district heating networks (GR, PT), support is given to local strategic projects (such as geothermal water), but it is not expected that small local DHS can contribute significantly to GHG reduction targets under the NECP.

## 4.1.3 KSF for increasing renewables in buildings

In this section, the **KSF**s groups identified for increasing the uptake of renewables in buildings are discussed. The section is divided into a sub-section focusing on residential (single and multi-family) buildings and another one focusing on public buildings. This structure allows for distinguishing between the differences in the two, as well as appreciating the similarities.

### *4.1.3.1 Single and multi-family buildings*

Table 5 presents the KSF groupings identified across the five Member States in the single and multi-family building sector.

*Table 5 Classification of common KSFs in relation to five Member States in the residential buildings sector*

| Key Success Factor groupings | PL | DE | HR | EL | PT |
|---|---|---|---|---|---|
| Building codes (limiting annual primary energy use) for new construction (& deep renovation), incl. RES % obligation | Technical Guidelines - Level of energy performance requires RES | Building Energy Act - Obligation of % RES | Technical Guidelines - Level of energy performance requires RES | Obligations on % of RES for water heat in buildings - new buildings | / |
| Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation | Incentives for RES with EE (incl. tax credit single fam buildings) | Incentives for RES with EE (CO2 building renovation pgm + tax credit) | Incentives for RES with EE (Ener renovation pgm for multi and single fam buildings) | Income tax deduction for RES H&C systems (STH, biogas, bioenergy, Geo, HP) | Programme (RRP) for EE & RES |
| Promotion of RES in buildings | / | RES technology deployment (HP, STH) | RES technology deployment (HP, STH) | / | Promotion of acquisition and renewal of H&C systems (STH, HP, biomass) |

| | | | | | |
|---|---|---|---|---|---|
| Electricity tariff for HP | Lower electricity prices for supplying heat pumps | Lower electricity prices for supplying heat pumps | / | / | / |
| Banning fossil based systems | Anti-smog programme (ban coal boilers) | Ban of fossil equipment | / | Installation of oil boilers will no longer be allowed from 2025 | / |
| Consulting - providing guidance | / | Thermomodernization consulting for residential buildings owners | / | / | / |
| Facilitate access to finance | / | / | / | Interest-free loans and grants for RES and EE in homes | / |

The KSFs identified across the five Member States in the residential buildings sector can be grouped into several broader groups. These groups can further be distinguished by classifying the **KSF**s into indirect and direct ones. Direct **KSF**s are the ones that have an immediate impact on the uptake of renewable energy in the sector. On the other hand, indirect **KSF**s focus on energy efficiency aspects which will have an indirect effect on supporting renewable energy deployment in residential buildings. Below we offer some of the key observations resulting from the analysis of the identified **KSF**s groups in the single and multi-family buildings sector.

1. Enforcing **building codes and obligations for minimum RES share** in H&C of buildings. The countries analysed have either technical guidelines (PL, HR) or obligations for a minimum share of RES in buildings, in the case of Germany, enforced by the Building Energy Act. In the case of Greece, the minimum share of RES pertains to water heating in new buildings.
2. Different types of **incentives for RES implementation together with building energy efficiency** modernization:
    a. Grant programs (Thermomodernization bonus in PL, financial support under $CO_2$ Building Modernisation Programme in DE, 'Programa de Apoio a Edifícios mais Sustentáveis (PAES), 'Vale Eficiência' (PT);
    b. Tax credits (Thermal Upgrading Tax Credit PL and in DE according to § 35c Income Tax).

    The choice of which financial incentive to use will depend on several factors which are discussed in other studies.[58]

3. Programs focused on the **promotion of specific renewable based technology deployment** (DE, HR, PT). In addition to mixed support programs combining RES deployment with building modernization, programs to specifically support a given renewable-based heating technology are helpful. If possible, support for technologies with a strong local manufacturing base, like solar thermal in Greece, should be favoured to maximize the benefits not only in relation to GHG emission reductions but also support for local jobs.

4. Programs for **replacement of inefficient RE heating tech** (PT). An analysis of the generally held believes and perceptions in a given country and region is important in determining the effectiveness of such programs. As seen in the case of Portugal, many of its citizens have a high tolerance to thermal discomfort, preference for purchasing cheaper albeit less efficient technologies. It is important to highlight, that in general, extending the lifetime of equipment is environmentally desirable. Thus, the early replacement of existing equipment should only be encouraged if substantial emission reduction can be demonstrated considering a life-cycle analysis (LCA). Furthermore, more efficient H&C equipment often requires that the building insulation standards are high enough to achieve maximum efficiency.[59] Thus, combining these types of programs with energy efficiency requirements of the building enveloped is suggested.

5. **Banning of fossil-based heat equipment** (coal, oil but not necessarily gas) (PL, DE). Bans on fossil equipment have become more widespread among Member States [60] as it becomes evident that this type of equipment is incompatible with climate targets.

6. **Electrification of heating and cooling** by promoting the procurement and use of heat pumps for AQS and ambient air heating and cooling in buildings (PT).

In addition to existing **KSF**s, a recommendation which was frequently encountered during the analysis was that in colder countries (PL, DE) special lower tariff for electricity consumed in heating systems with heat pumps should be considered. Discussions on this topic are taking place in both countries mentioned. However, one can see three main problems here. The first is public resistance due to the privileging of one group operating RES sources. The second is the need for a separate measurement of power consumption to power the heat pump. The third stems from the logic of possibly subsidizing the operation of a heat pump only if it operates at designed COP (and not as a kind of electric boiler), and this is very difficult because of technical reasons.

#### 4.1.3.2 *Public buildings*

Table 6 shows the **KSF**s grouped into common themes for the public buildings sector.

*Table 6 Classification of common KSFs in relation to five Member States in the public buildings sector*

| Key Success Factor grouping | PL | DE | HR | EL | PT |
|---|---|---|---|---|---|
| Incentive programmes for RES in H&C, incl. with target (e.g. EPC level), via building renovation | National program EPC+ (funding up to 49% of investment cost) | / | Energy renovation programme for public buildings (not necessarily RES) | "ELECTRA" (public buildings) to improve EE and reach class B & "SAVE" for local authorities program | Program aimed at supporting the renovation and energy performance |
| Facilitate Energy Performance Contracts (ESCO) | / | Funding EP Contracts for municipality non-residential buildings | / | / | / |
| Consulting - providing guidance | / | Thermomodernization consulting for municipalities | / | / | / |
| Prosumer program | / | / | / | / | Prosumer program (re habilitation) |
| Combine EE & RES renovation | / | / | / | / | Promote uptake of easy wins, EE and/or RES solutions |

In this area, the EED imposes quantitative targets, the implementation of which is most often the responsibility of local authorities, and building retrofits introducing RES are carried out based on public procedures for selecting contractors. Hence, **KSF**'s strengths are consulting on the technical and formal preparation of projects, and supporting models that guarantee local authorities to achieve an outcome, such as EPC/ESCO. Thus, we note significant differences between key success factors in 'private' versus public buildings:

1. Public buildings energy modernization can be based on more ambitious targets because ongoing control over improvement measures and energy consumption is more effective.
2. There is greater certainty of including RES in the thermo-modernization project due to the participation of consultants and EED requirements for public institutions.

3. Inappropriate financial model can result in increased public debt and negatively affect other financial indicators of the city. For this reason, too, the **KSF** associated with consulting is very important.

### 4.1.4 Key Success Factors for uptake of renewable energy in industrial heating and cooling

Table 7 shows the KSF groups identified in the industry sector.

*Table 7 Classification of common KSFs in relation to five Member States in the industry sector*

| Key Success Factor groupings | PL | DE | HR | EL | PT |
|---|---|---|---|---|---|
| High efficiency cogeneration (Industry) financial support | High-efficiency CHP, sourced with WH, RES, gas, synthetic gas or H2 | High-efficiency CHP, sourced with WH, RES, gas, synthetic gas or H2 | / | / | Promote high-efficiency CHP based on RES |
| Program for HP in industry | / | / | / | / | National Action Plan to uptake HP in buildings and industry |
| Promote uptake of more efficient H&C systems | / | / | / | / | Optimisation of engines, pumping, ventilation & compression systems, etc. |
| Increasing awareness regarding efficient use of H&C systems | / | / | / | / | Promoting efficient use through consumer information, stimulating consumer participation in aggregation |

There is a **need to focus more on this sector**. Given the unique characteristics of the industry sector, key changes in energy efficiency and RES uptake are driven by strategies identified by a plant or industry group to improve competitiveness or economics. In such a situation, **KSF** measures based on providing **direct subsidies for RES** such as high-power heat pumps or cogeneration based on renewable fuels become relevant. Indirect **KSF**s are programs designed to make decision-makers aware of the need to perform **energy audits** of enterprises, along with **information on how they can finance the energy upgrades resulting from the audit recommendations**.

### 4.1.5 Key Success Factors for uptake of renewable energy in other areas

In the analysis undertaken we have identified additional **KSF** that are difficult to classify under the categories discussed above but which nonetheless are very important to supporting the decarbonization of the heating and cooling sector. These **KSF** groups are presented in Table 8 and discussed below.

*Table 8 Classification of common KSFs in relation to five Member States in other areas*

| Key success Factor groupings | PL | DE | HR | EL | PT |
|---|---|---|---|---|---|
| Programs to decrease energy poverty | Direct support for replacement coal boiler | | Direct support for replacement of old heat sources | | Delivering on the long-term strategy to combat energy poverty |
| Obligation scheme (white certificate) | Energy efficiency certificate > 10toe of final energy with RES as possibility | / | / | / | / |
| High efficiency biogas cogeneration (municipalities) financial supporting | Digestor fed by municipal bio-waste, high-efficiency CHP (RES only) | / | / | / | / |
| Increase cities' authorities' capacity towards RES transformation | Get staff in cities educated and prepared for managing energy transformation | Get staff in cities educated and prepared for managing energy transformation | Get staff in cities educated and prepared for managing energy transformation | / | / |
| Public awareness campaign | / | / | / | Many public awareness campaigns, communication campaigns, and general publicity through the media | / |
| Training installers | Strengthen RES-educated installers | Strengthen RES-educated installers | Strengthen RES-educated installers | / | Strengthen RES-educated installers |

#### 4.1.5.1 *Energy poverty factors*

There is a correlation between measures to combat energy poverty and the support for the uptake of renewables in the H&C sector.[61] The **KSF**s identified under this topic have usually an indirect effect on the uptake of RES in H&C. Whereas most measures in this area aim to reduce energy

costs, they must also take into account the use of RES, i.e. solutions required by current directives and implementing national legislation.

#### *4.1.5.2 Skills and public awareness*

Development of trainings and skills is a pre-requirement for the energy transition, and this is also the case for the heating and cooling sectors. To be able to make informed decisions and deliver high-quality, efficient services both for the installation of renewable-based heating systems and for undertaking broader building energy efficiency measures. Currently, many countries in the EU face, shortages in trained installers, builders and other specialists.[62] Thus, programs to train installers (identified in PL, DE, HR and PT) are essential to support the uptake of renewables in the sector.

Public awareness is another key element, especially when it comes to the residential buildings sectors. The decarbonisation of this sector will have a direct impact on the citizens, affecting their day-to-day life quality (thermal comfort, air quality) and their economy (investment in heating and cooling equipment, building renovation). Thus, it is of utmost importance to be able to communicate the benefits of transitioning to renewable based heating and cooling equipment. Information campaigns play a key role in increasing public support towards the transition.

For cities, comprehensive energy transition planning is an important element for supporting RES uptake in the H&C sector. Thus, measures aimed at increasing the capacity of city authorities to plan a transformation of the heating and cooling sector in their localities should be considered key success factors.

## 4.2 Applicability of KSFs and KPIs identified to other EU27 Member States

As mentioned earlier, the participating partner countries, namely Greece, Croatia, Portugal, Germany and Poland, are located in different European climate zones, representing different types of economies, diverse building stock, different H&C infrastructure and natural resources. Thus, other Member States, identifying themselves in some way with any of the REDI4HEAT partner countries, will be able to use the results of this work in ongoing modification and improvement of activities and programs to support the implementation of RES in H&C. Of course, it is difficult to prejudge which similarities will be decisive in the aspect of heating and cooling transformation, each of the other member countries should be guided by their own priorities, depending on several other factors influencing the prioritisation (cf. some of the parameters are

developed below). For example, one can expect that the identified **KSF** and related **KPI**s for Poland can be also of interest to the Czech Republic due to the similarity of its technical infrastructure (like high temperature DHS). Thus, the body of knowledge developed and accumulated during the project should be treated as an opportunity to acquire information useful to the country in the specific area and trajectory of H&C transformation. Among the factors influencing the national prioritisation, the progress made so far in deploying renewables in heating and cooling is probably an important, but also the status of assets (e.g. single houses vs apartments; heavy industry vs SMEs), or the availability of renewable resources (e.g. availability of geothermal energy or biomass feedstock) are key aspects to consider. In other terms, the prioritise will **directly depend on the scenario of pathway of the country for the deployment of renewables in H&C**. The results of the REDI4HEAT project can be replicated by any other country. As a first step, it is suggested to check whether the **KSF**s described as "common" (the table at the beginning of Discussion chapter) relate to the essential elements of heating and cooling transformation (in other words whether it is aligned with the H&C decarbonisation scenario). In the second step, a closer look at the **KSF**s in the excel repository (Attachment) is recommended, referring to the specifics of the project partner countries, and selecting the most relevant to the given heating and cooling situation. The third step is to review and verify the **KPI** attributes associated with the selected, **KSF**s (Assigning Key Performance Indicators section in Methodology chapter).

There are however some **KSF**s which are not directly related to the decarbonisation scenario, like guiding actions that should be taken at local level, as these actions can apply in any case, whatever the scenario. This justifies why the next deliverable of this project, is looking at **KSF** of best practices at local (i.e. regional, municipal and city) level, to complement the **KSF** identified via the screening of the former NECPs.

When planning a fundamental reconstruction of a set of key success factors, we recommend using the methodology provided in the report. It is worthwhile to develop a detailed PESTEL analysis, which is an important basis in the process of identifying **KSF**s. Here PESTEL is an instrument used to analyse factors affecting the country's heating and cooling sector.

# 5. CONCLUSIONS

In the REDI4HEAT project, the issue of identifying **Key Success Factors** critical to the renewable energy sources deployment process was addressed in a national context. The conclusions of this report arise both from the identification of **KSF**s in individual countries, identification of **KSF groups** across countries, as well as from the interconnectedness and interdependence of different **KSF groups** with each other. The work in this deliverable also points towards the important of other levels of government, namely regional and local levels, in the implementation of many measures which make for successful transitions towards a decarbonised H&C supplied with renewable energy sources. In this regard, the work provides interesting outputs that will be further developed under Deliverable 3.2 which is focused on much more on the local level. Further, many of the KSFs identified in this report have synergistic or complementary effects which often can best be appreciated at city-level. Below the main conclusions and observations stemming from this work are presented.

The identification of **KSF** involves considering the possibility of objectively assessing their impact on the implementation of RES for heating and cooling in the areas shown, and therefore selecting appropriate performance indicators (**KPI**s). There are large differences between the real possibility of collecting reliable data, no matter what country is considered. The easiest is to obtain it from organizations that need to keep records and reporting on installations and energy consumption. These include municipal offices, housing cooperatives, district heating and industrial companies, but also possibly installers, chimney sweepers, or energy suppliers. In the specific case of single-family buildings scattered around the country, national or regional data can also be available on subsidies allocated and from national databases, such as the Central Emissions Database, which inventories heating equipment in buildings.

In the area of single-family buildings dispersed around the country it is possible to speak of standalone **KSF**s, the operation of which is not influenced by **KSF**s from other areas. These **KSF**s consist mostly of bans (prohibition of solid-fuel boilers) and mandates (certain parameters of buildings), as well as financial programs to facilitate compliance with the said requirements. For industry, generally, when located outside of cities can their **KSF**s not be subject to the relationship with the **KSF**s of district heating or the energy transition of cities toward the use of renewable fuels. Examples of such relationships include **KSF** in the form of a program financing urban biogas plants, **KSF** in the form of a program financing high-efficiency cogeneration, and **KSF** financing RES consulting for enterprises. This example is only one illustration of the many relationships between the different KSFs across the sub(sectors), meaning that only in rare cases **KSFs** can been addressed in isolated mode.

The above conclusions lead to the observation that it is necessary to best coordinate the planning of policies and programs resulting from the identified **KSF**s, both for cities, regions, and the country (see Deliverable 3.2 for further work on this topic). These actions are currently at a far insufficient level, resulting in counter-effectiveness instead of synergy. An example of this is the co-financing programs that do not consider the broader context and realities of operation of local municipal heating companies.

The development of detailed programs based on **KSF**s requires a realistic and critical approach to the possibility of defining planned goals and quantitative **KPI**s with appropriate attributes enabling measurement of the progress of the RES implementation process in H&C in a given area. This is crucial, especially when large funds are involved. An example is a direct action **KSF**, for example co-financing the replacement of fossil fuel boilers with heat pumps - on a national scale this may concern millions of beneficiaries. When it comes to **KSF**s, such as environmental and vocational education or consulting, it should be realized that their impact on the transformation of heating and cooling is indirect and difficult to measure: **KPI**s such as the value of funds spent annually or the number of participants are not sufficient for evaluation and should be used to monitor indicative trends rather than as absolute values. Or at least it should recognise that the concerned KSF might be successful thanks to other enabling measures.

With reference to the above, it should be noted that DHC are a very important and difficult area when it comes to relations and striving for synergistic operation of **KSF**s. District heating in many Member States is based on high-temperature sources (coal and gas) and urban heating networks and building installations were designed accordingly. Lowering the output parameters in DHC significantly facilitates the use of RES, such as high-power heat pumps or solar thermal installations. However, this is not possible without thermal modernization of large groups of existing buildings, combined with replacing the heating installation with a low-parameter one. At the same time, the issue of replacing old heating networks should be considered and possibly they should be designed for lower temperature parameters.

It is important to increase public authorities' capacity towards RES transformation. They must develop a sustainable development plan in the field of energy and climate. Synergistic interaction of programs and policies can therefore be achieved only through cooperation and coordination of various institutions during their development. It is worth adding that such cooperation must also include defining the appropriate **KPI**s.

Cooling networks are not developed in the countries considered, which results in a very small amount of cold transferred. At this stage in the development of these systems, we have not been able to identify specific KSFs. Of course, many KSFs related to energy-efficient systems are also important in cooling systems.

***Key messages from the work on identifying KSFs for the deployment of renewable energy in heating and cooling***

**Integration of Renewable Energy Sources:** the use of energy carriers based on renewable energy sources, such as solar thermal, geothermal, bioenergy, and waste heat recovery, into heating and cooling systems is a key element to achieve the decarbonisation of the system. Combined with increased energy efficiency, renewable energy sources help reduce carbon emissions, (if chosen correctly) promote sustainability as well as support the achievement of more energy security and independence. It is advisable to support renewable energy technologies most suited to the local resource availability (e.g. solar thermal in places with high solar irradiation all year round and not very cold winters, presence of geothermal potential, etc.).

**Energy Efficiency Measures:** Implementing energy efficiency measures to reduce energy consumption and optimize the performance of heating and cooling systems is necessary. In accordance with the 'Energy Efficiency First' Principle, the cleanest energy is the one which is not used. Energy efficiency is a no regret option and should be prioritised. Maximum climate gains can be achieved through coherent approaches between energy efficiency measures and renewable energy deployment. This may include building insulation, efficient HVAC equipment, efficient (e.g. low temperature) district heating and cooling networks, and smart energy management technologies.

**District Heating and Cooling Networks:** The development of district heating and cooling networks to efficiently distribute thermal energy from centralized sources to multiple buildings or facilities should be considered as a concrete option to significantly increase the use of renewables. District energy systems enable the use of waste heat and renewable energy sources at scale, reducing overall energy consumption and emissions.

**Policy and Regulatory Support:** An appropriate regulatory framework and the right policies are a prerequisite for a successful transition towards decarbonising heating and cooling. It is crucial to develop supportive policies, regulations, and incentives at the local, regional, and national levels to encourage the adoption of sustainable heating and cooling solutions. This may include financial incentives, building codes, zoning regulations, renewable energy mandates, and carbon pricing mechanisms. However, deploying measures at various policy levels should be strongly coordinated to ensure coherence between all measures (contradictory measures are sometimes taken, leading to high confusion and limited implementation).

**Public Awareness and Education:** It is necessary that the concerned actors be on board with the energy transition. Especially in the case of the heating and cooling sectors, the decisions made to achieve decarbonisation will have a direct impact on the citizens. Raising public awareness and educating residents, businesses, and institutions about the benefits of sustainable heating and cooling practices is essential. Promoting energy conservation, behavioural change, and the adoption of energy-efficient technologies through outreach campaigns, educational programs, and community engagement initiatives should be prioritised. Engagement with stakeholders, including local authorities, businesses, communities, utilities, and environmental organizations, could accelerate the energy transition. All these above-mentioned reasons also justify the need to act at local level, with municipalities and cities having a central role to play.

**Comprehensive Planning and Assessment:** It is recommended to conduct a thorough assessment of the local energy landscape, including existing infrastructure, energy demand, sources of energy supply, and potential for renewable energy integration. Developing a comprehensive plan that addresses both heating and cooling needs, considering factors such as building types, societal challenges, land use patterns and climate conditions is important to ensure the best pathway towards decarbonisation is chosen. Again, this can be tackled in the most efficient way at local level, rather than at central.

**Monitoring, Evaluation, and Feedback:** Establishing monitoring and evaluation mechanisms allows to track the performance of heating and cooling systems, assess progress towards goals, and identify areas for improvement. In this regard, soliciting feedback from stakeholders and incorporate lessons learned into future planning and decision-making processes is helpful.

**Long-Term Vision and Commitment:** Maintaining a long-term vision and commitment to sustainability, resilience, and equitable access to heating and cooling services needs to be part of planning. It is important to continuously review national strategies including the National Energy and Climate Plans (Deliver D3.3 focuses on providing guidelines for reviewing the NECPs) and update heating and cooling roadmaps to reflect changing priorities, technologies, and needs over time. By incorporating as many key success factors as appropriate to national (and local) plans and strategies the transition towards more sustainable, resilient, and equitable energy systems that support economic development, environmental protection, and social well-being can be made more attainable.

# 6. Annex 1: Database of Key Success Factors and Key Performance Indicators

| POLAND | KSF Group | KSF name | KSF description | Direct - RES Indirect -EE | Target/ binding | Target base level | Target: binding/ non-binding | KPI name | KPI measure | KPI value | Source | PESTEL category | Additional info |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **District Heating** | | | | | | | | | | | | | |
| KSF1_DH | **Disincentivise financing non efficient DHC** | Threat of no financing of investments availability for energy inefficient DH systems | banks will not credit dh enterprise if its system is not energy efficient, no funding from EU, as well; it is impossible to achieve ees status without RES implementation | indirect | | 20% in 2015 | get 85% of energy efficient DH systems till 2030 | development of energy efficient DH systems | % DH energy efficient systems in 2020, 2021, 2022<br>Number of DH network refurbishment to increase Energy Performance | to be calculated in 2024 - backwords looking | NECP2020 | political | |
| KSF2_DH | **Connecting buildings to DHC which are supplied by RES/energy efficient systems** | Connecting buildings to DH networks which are supplied by RES/energy efficient systems | priority in connecting buildings to DH in cities (less direct and indirect emission); indirect, because this action is not always connected with new RES installation | indirect | | 58,8% in 2015 | get 70% apartments connected to DH network in cities in 2030 | better usage of DH networks | % of apartments / dwellings connected to DH in 2020,2021,2022 | | NECP2020 | political | |
| KSF3_DH | **Promote RES in DHC** | Target for RES technology deployment in DH - heat pumps | it shows directly growing share of RES - heat pumps - in heat production | direct | | 4% in 2018 | get 8% heat from HP (P2H) in DH till 2030 | heat pump deployment in DH | % of total heat production of DH in 2019, 2020, 2021,2022 | | Strategy for District Heating | technological | |
| KSF4_DH | **Promote RES in DHC** | Target for RES technology deployment in DH - solar thermal | it shows directly growing share of RES - solar thermal - in heat production | direct | | app. 0,0% in 2018 | get over 0,5% heat from solar thermal in 2030 | solar thermal sources deployment in DH | % of total heat production of DH in 2019, 2020, 2021,2022 | | Strategy for District Heating | technological | |
| KSF5_DH | **Promote RES in DHC** | Target for RES technology deployment in DH - geothermal | it shows directly growing share of RES - geothermal installations - in heat production | direct | | 1,5% in 2018 | get 2% heat from geothermal sources in 2030 | geothermal sources deployment in DH | % of total heat production of DH in 2019, 2020, 2021,2022 | | Strategy for District Heating | technological | |
| KSF6_DH | **Promote RES in DHC** | Target for RES technology deployment in DH - biogas | it shows directly growing share of RES - biogas - in heat production | direct | | 1,3% in 2018 | get 4% heat from biogas installations | biogas installations deployment in DH | % of total heat production of DH in 2019, 2020, 2021,2022 | | Strategy for District Heating | technological | |
| KSF7_DH | **Support High efficient DHC (def. on RES)** | Financial support for high efficiency cogeneration (DH) fin 2022-2023 | Investments concerning the construction and/or reconstruction of high-efficiency cogeneration units, together with their connection to the transmission network, in which energy production uses:<br>waste heat, energy from renewable sources, gaseous fuels, gas mixtures, synthetic gas or hydrogen; it is indirect,because programme allows gas CHP, as well | indirect | | 65,2% of heat production from CHP in 2020 | Promoting the use of high-efficiency cogeneration in the heating sector | high efficient cogeneration deployment in DH | % of total heat production of DH in 2021 (for comparison), 2022, 2023 | | NECP2020 | economic | |
| **Residential (single and multi-family) buildings** | | | | | | | | | | | | | |
| KSF1_RB | **Building codes (limiting annual primary energy use) for new construction (& deep renovation), incl. RES % obligation** | WT2017 i WT2021 Technical Guidelines (used as building code), which limit the annual Primary Energy Indicator value of new designed buildings | New buildings are obliged to achieve certain level of energy efficiency. It has direct influence as it is impossible to achieve without implementation of RES | direct | Annual Primary Energy Indicator for designed buildings limited to 85 (WT2017) and 65 | NA | NA | Energy efficiency in new buildings construction | Number of new buildings in 2020,2021,2022 number of new buildings with RES in 2020, 2021, 2022 | to be calculated in 2024 - backwords looking | Technical Guidelines | legal | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | kWh/m2 (WT2021 | | | | | | | | |
| KSF2_RB | **Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation** | Incentive for RES implementation together with building energy efficiency modernization | The amount of the thermomodernization bonus from Thermomdernisation and Renovation Fund is 26 % of the cost of the thermomodernization project or 31 % of the total cost of the thermomodernization project together with RES implementation. It influences indirectly, as RES is not always included in building modernization plan | indirect | | NA | Existing buildings energy efficiency increase, totally 70 ktoe/y of final energy in 2021-2030 | Energy efficiency of existing buildings | nbr of buildings using this programme in 2020,2021,2022 of these buildings, share with RES | | NECP2020 | economic | |
| KSF3_RB | **Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation** | Incentive for RES implementation together with building energy efficiency modernization intended for single family houses | Thermal Upgrading Tax Credit for single family houses - deduction of expenses from the tax base, including heat pump, solar thermal, and PV installation. It is indirect as an owner can modernize a house without heat source replacement. | indirect | | NA | Existing buildings energy efficiency increase, totally 200 ktoe/y of final energy in 2021-2030 | Energy efficiency of existing single family buildings | nbr of buildings using this programme in 2020,2021,2022 of these buildings, share with RES | | NECP2020 | economic | |
| KSF4_RB | **Ban fossil based systems** | Ban fossil fueled systems based on the anti-smog resolution of 15 (out of 17) vojvodeships | The anti-smog resolution makes it mandatory to replace old off-grade coal and wood boilers (below class 3 or 4 according to EN 303-5:2012). The influence on RES installation is indirect because gas boiler can be an option.<br>Deadlines: By January 1, 2022, for installations that have been in operation for more than 10 years from the date of manufacture or installations that do not have a nameplate,<br>By January 1, 2024 for installations in operation between 5 and 10 years from their date of manufacture,<br>By January 1, 2026 for installations in operation less than 5 years from their date of manufacture, | indirect | | NA | Reduce of CO2 and dust emissions | Coal and wood boiler exchange into RES | number of coal boilers replaced by RES heating eq. | depending on data availability - forward looking | Pestel | political | |
| KSF5_RB | **Electricity tarif for HP** | Special - lower - electricity prices for supplying heat pumps | Heat pump installation in Poland is strongly driven by electricity price. There are expectations of lectricity price decrease in a few years. Preferential prices could immediately increase number of air-to-water heat pumps installation | direct | | NA | Speed-up heat pumps deployment | Incentive for heat pumps installation by special electricity price | number of new heat pump installations | | Pestel | economic | Note that this KSF is a suggested one. It is not a measure that the government has commited to yet |
| **Public buildings** | | | | | | | | | | | | | |
| KSF1_PB | **Incentive programmes for RES in H&C, incl. with target (e.g. EPC level), via** | Public buildings energy efficiency support scheme | National program EPC+ (funding up to 49% of investment cost), supporting EPC projects | indirect | Renovate at least 3% of public buildings every year to achieve | NA | NA | RES implementation via EPC/ESCO projects | Environmental effect in energy savings of all subsidied EPC project or Nbr of buildings | depending on data availability - forward | NECP2020 | economic | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **building renovation** | | | | near-zero energy buildings | | | | renovated<br>Nbr of renovated buildings investing in new RES | | | | |
| | | | | | | **Idustry** | | | | | | | |
| KSF1_I | **High efficiency cogeneration (Industry) financial support** | High efficiency cogeneration (Industry) financial support | Investments for construction and/or reconstruction of high-efficiency cogeneration units, together with their connection to the transmission network, in which energy production uses:<br>waste heat, biogas, bioeenergy; it is indirect, because programme allows gas CHP, as well | direct | | NA | Promoting the use of high-efficiency cogeneration in the heating sector | high efficient cogeneration deployment in DH | % of RES in total heat production in 2020, 2021,2022 | to be calculated in 2024 - backwords looking | NECP2020 | economic | |
| | | | | | | **Other** | | | | | | | |
| KSF1_O | **Program to decrease energy poverty** | Programme to decrease energy poverty | Heat pumps deployment and heating cost decrease due to government direct support for replacement coal boilers (60% of energy-poor live in single family houses); indirect influence as gas boiler can be an option | direct | | 10% of energy-poor in 2020 | decrease energy poverty factor to 6% in 2030 | Energy poverty level | % of residents with energy expenses above the energy poverty threshold in 2020, 2021, 2022 or<br>nbr of households installing HP as a way to fight against energy poverty | to be calculated in 2024 - backwords looking | NECP2020 | social | |
| KSF2_O | **Obligation scheme (white certificate)** | White Certificates | An energy efficiency certificate can be obtained for an activity resulting in an annual saving of not less than 10 tons of oil equivalent (toe) of final energy; ndirect as RES installation is one of possibilities | indirect | | NA | increase energy efficiency in industry and buildings | RES implementation triggered by White Certificate system | total toe value in certificates issued in 2020, 2021, 2022 or total toe value in certificates issued in 2020, 2021, 2022 with RES | | NECP2020 | economic | |
| KSF3_O | **High efficiency biogas cogeneration (municipalities) financial supporting** | High efficiency biogas cogeneration (municipalities) financial supporting | Cogeneration units powered by biogas from new or upgraded digestion facilities for selectively collected municipal bio-waste and the use of the resulting biogas for power generation under conditions of high-efficiency cogeneration; renewable fuel only | direct | | NA | Promoting energy generation under conditions of high-efficiency cogeneration using municipal biogas | city biogas cogeneration deployment | total power in MW(e) & MW(h) installed<br>expected MWh on annual basis (i.e. replacing fossil heat) | depending on data availability - forward looking | NECP2020 | economic | |
| KS4_O | **Increase cities' authorities capacity towards RES transformation** | Increase cities' authorities capacity towards RES transformation | get the staff in cities educated and prepared for managing energy transformation which indirectly influence RES implementation both in buildings and in DH systems | indirect | | 25% of all obliged cities in 2020 | in 2030 get 100% obliged cities having updated energy plan, acc. to Energy Law and based on art. 25 of the EED | Nbr of cities obliged<br>Nbr of cities with Plan<br>Nbr of cities with plan and strong transition towards RES in H&C | no of city energy plans existing in 2020, 2021, 2022 | | Energy Law | political | |
| KSF5_O | **Training installers** | Training installers | Suitable base of RES-educated installers is a critical condition of RES transformation success in buildings H&C | direct | | NA | Align RES market needs with workforce potential | State licenses to installers of renewable energy generation sources | number of licences issued | | NECP2020 | technological | |

| GERMANY | KSF Group | KSF name | KSF description | Direct - RES Indirect - EE | Target/ binding | Target base level | Target/ non-binding | KPI name | KPI measure | KPI value | Source | PESTEL category | Additional info |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **District Heating** | | | | | | | | | | | | | |
| KSF1_DH | **Disincentivise financing non efficient DHC_DH** | Threat of no financing of investments availability for energy inefficient DH systems | banks will not credit dh enterprise if its system is not energy efficient, no funding from EU, as well; it is impossible to achieve ees status without RES implementation | indirect | | 0,1 TWh 2021 | get 23,1 TWh heat from renewable sources in 2030 | development of energy efficient DH systems | RES heat introduced into DH networks in 2021,2022 or Nbr of DH network refurbishment to increase Energy Performance | to be calculated in 2024 - backwords looking | CA 2020 DE | political | target according to current coalition agreement of German government |
| KSF2_DH | **Promote RES in DHC** | Targett for RES technology deployment in DH - heat pumps | it shows directly growing share of RES - heat pumps - in heat production | direct | | 0 TWh in 2020 | get 16 TWh heat from large scale HP in DH till 2030 | heat pump deployment in DH | % of total heat production of DH in 2019, 2020, 2021,2022 | | CA 2020 DE | technological | |
| KSF3_DH | **Promote RES in DHC** | Target for RES technology deployment in DH - solar thermal | it shows directly growing share of RES - solar thermal - in heat production | direct | | 0 TWh in 2020 | get 3 TWh heat from solar thermal in DH till 2030 | solar thermal sources deployment in DH | % of total heat production of DH in 2019, 2020, 2021,2022 | | CA 2020 DE | technological | |
| KSF4_DH | **Promote RES in DHC** | Target for RES technology deployment in DH - geothermal | it shows directly growing share of RES - geothermal installations - in heat production | direct | | 1,5 TWh in 2020 | get 5 TWh heat from geothermal sources in 2030 | geothermal sources deployment in DH | % of total heat production of DH in 2019, 2020, 2021,2022 | | CA 2020 DE | technological | |
| KSF5_DH | **Support High efficient DHC (def. on RES)** | High efficiency cogeneration (DH) financial supporting | Investments concerning the construction and/or reconstruction of high-efficiency cogeneration units, together with their connection to the transmission network, in which energy production uses: waste heat, energy from renewable sources, gaseous fuels, gas mixtures, synthetic gas or hydrogen; it is indirect,because programme allows gas CHP, as well | indirect | | 23,1 TWh of heat production from CHP in 2020 | Promoting the use of high-efficiency cogeneration in the heating sector | high efficient cogeneration deployment in DH | % of total heat production of DH in 2020, 2021,2022 | | NECP2020 | economic | |
| KSF6_DH | **Promote RES in DHC** | Connecting buildings to DH networks which will be converted to RES/energy efficient systems | priority in connecting buildings to DH in cities (less direct and indirect emission); indirect, because this action is not always connected with new RES installation | direct | | 1,2 million (out of 18 million) buildings are connected to DH in 2021 | number of buildings connected to DH shall triple by 2045, at least 100 000 new buildings connected yearly to DH in DE, 50% or DH supplied via RES in 2030 | better usage of DH networks | % of apartments / dwellings connected to DH | no value - forward looking | www.bmwk.de | | |
| **Residential (single and multi-family) buildings** | | | | | | | | | | | | | |
| KSF1_RB | **Building codes (limiting annual primary energy use) for new construction (& deep renovation), incl. RES % obligation** | Building Energy Act - technical guidelines, which limit the annual Primary Energy Indicator value of new designed buildings | New buildings are obliged to achieve certain level of energy efficiency. It has direct influence as it is impossible to achieve without implementation of RES | direct | Nearly zero-energy buildings from 2021 and min. 65% renewable energy for heating | min. 15-50% RES for heating depending on source according to GEG 2020 | NA | Energy efficiency & renewable in new buildings construction | no of new buildings in 2021,2022 or % with 100% RES | to be calculated in 2024 - backwords looking | www.bmwsb.bund.de | legal | |

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| | | | | | starting<br>- 01.01.2024 for new buildings in new building areas<br>- 01.07.2026 for new heatings in big cities (min 100.000 inhabitants)<br>- 01.07.2028 for new heatings in small towns (less than 100.000)<br>Thus, from 01.07.2026/ 28 new oil/gas heatings are only permitted if they are run with min. 65% RES | | | | | | | | |
| KSF2_RB | **Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation** | Incentive for RES implementation together with building energy efficiency modernization | Financial support under CO2 Building Modernisation Programme, if building meets KfW40 and efficiency standard after refurbishment. It influences indirectly, as RES is not always included in building modernization plan | indirect | | 119 mln tons of CO2 in buildings sector in 2023 | Existing buildings energy efficiency increase, with average 7,7 mln tons of CO2 reduction/a | Energy efficiency of existing buildings | no of buildings using this programme in 2020,2021,2022 or<br>nbr of buildings using this programme & installing new RES | | NECP2020 | economic | |
| KSF3_RB | **Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation** | Incentive for RES implementation together with building energy efficiency modernization intended for single family houses | Thermal Upgrading Tax Credit for single family houses - deduction of expenses from the tax base, including heat pump, solar thermal, and PV installation. It is indirect as an owner can modernize a house without heat source replacement. | indirect | | 789 TWh final energy consumption from heating (room and water) in 2022 | Existing buildings energy efficiency increase, totally 35,3 TWh of final energy in 2021-2030 period | Energy efficiency of existing single family buildings | no of buildings using this programme in 2020,2021,2022 or<br>nbr of buildings using this programme & installing new RES | | NECP2020 | economic | |
| KSF4_RB | **Promote RES** | Target for RES technology deployment residential buildings - heat pumps | it shows directly growing share of RES - heat pumps - in heat production | direct | | 2,5% in heat production in 2019 | get 20% share in 2030 | heat pump deployment in residential buildings | % of total heat production of DH in 2019, 2020, 2021,2022 | | CA 2020 DE | technological | |
| KSF5_RB | **Promote RES** | arget for RES technology residential buildings - solar thermal | it shows directly growing share of RES - solar thermal - in heat production | direct | | 1,6% in heat production in 2019 | get 10% share in 2030 | solar thermal sources in residential buildings | % of total heat production of DH in 2019, 2020, 2021,2022 | | CA 2020 DE | technological | |
| KSF6_RB | **Consulting - providing guidance** | Thermomodernisation consulting for residential buildings owners | Federal funding (EBW) helps in proper configuration of modernization scope with RES sources via project dedicated consultation | indirect | - | NA | NA | RES optimization of residential buildings thermomodernsation | Number of consulted projects in 2020,2021,2022 | | NECP2020 | Economic | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KSF7_RB | **Electricity tariff for HP** | Special - lower - electricity prices for supplying heat pumps | Heat pump installation in Poland is strongly driven by electricity price. There are expectations of electricity price decrease in a few years. Preferential prices could immediately increase number of air-to-water heat pumps installation | direct | | NA | Speed-up heat pumps deployment | Incentive for heat pumps installation by special electricity price | nbfr of new heat pump installations applying for special price | depending on data availability - forward looking | Pestel | economic | Note that this KSF is a suggested one. It is not a measure that the government has commited to yet |
| KSF8_RB | **Ban fossil based systems** | Ban of fossil equipment | a bill to ban most new oil and gas heating systems from 2024.<br>In March2023 Germany's governing coalition reached an agreement that every newly installed heating system in the country must use 65% renewable energy from 2024. | direct | | 48.2% gas heating and 25.6% oil heating in 2019 | NA | Coal and wood boiler exchange into RES | number of coal boilers replaced by RES heating eq. | | GEG - Gebäudeenergiegesetz https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/neues-gebaeudeenergiegesetz-2184942 https://www.euractiv.com/section/energy-environment/news/germany-aims-to-connect-100000-buildings-to-district-heating-every-year/ | political | - |
| **Public buildings** | | | | | | | | | | | | | |
| KSF1_PB | **Facilitate / support Energy Performance Contracts (ESCO)** | Public buildings energy efficiency | Funding energy performance contracts consulting for non-residential buildings owned by municipalities. | indirect | Renovate at least 3% of public buildings every year to achieve near-zero energy buildings | In 2021, the renovation rate was below 1% | NA | RES implementation via EPC/ESCO projects | Number of EPC contracts consulted in 2020, 2021, 2022 | to be calculated in 2024 - backwords looking | NECP2020 | economic | |
| KSF2_PB | **Consulting - providing guidance** | Thermomodernisation consulting for municipalities | Federal funding (EBK) helps municipalities in proper configuration of modernization scope with RES sources usage | indirect | | NA | NA | RES optimization of public buildings thermomodernsation | Number of consulted projects in 2020,2021,2022 | | NECP2020 | economic | |
| **Industry** | | | | | | | | | | | | | |
| KSF1_I | **High efficiency cogeneration (Industry) financial support** | High efficiency cogeneration (Industry) financial supporting | Investments concerning the construction and/or reconstruction of high-efficiency cogeneration units, in which energy production uses:<br>waste heat,<br>energy from renewable sources,<br>gaseous fuels, gas mixtures, synthetic gas or hydrogen; it is indirect,because programme allows gas CHP, as well | direct | | 10,0 TWh of heat production from CHP in 2020 | Promoting the use of high-efficiency cogeneration | high efficient cogeneration deployment in DH | % of RES in total heat production in 2021,2022 | to be calculated in 2024 - backwords looking | NECP2020 | economic | |
| KSF2_I | **NA** | Thermomodernisation consulting for SMES | Federal funding (EBM) helps SMEs in proper configuration of modernization scope with RES sources usage | indirect | | NA | NA | RES optimization of SMES infractructure | Number of consulted projects in 2020,2021,2022 | | NECP2020 | economic | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Other** | | | | | | | | | | | | | |
| KSF1_O | **Increase cities' authorities capacity towards RES transformation** | Increase cities' authorities capacity towards RES transformation | get the staff in cities educated and prepared for managing energy transformation which indirectly influence RES implementation both in buildings and in DH systems | indirect | - until 30.06.2026 all municipalities with >100.000 inhabitants are obliged to introduce a heat plan - the deadline for municipalities with <100.000 inhabitants is 30.06.2028 | In the federal state Baden-Wurtemberg - heat plans are obligatory since 2021 (state climate protection law) | NA | Nbr of cities obliged Nbr of cities with Plan Nbr of cities with plan and strong transition towarss RES in H&C | no of City Heat Plans in 2020, 2021, 2022 | to be calculated in 2024 - backwords looking | CA 2020 DE | sociocultural | |
| KSF2_O | **Training installers** | Establishing installers base, educated for RES deployment | Suitable base of RES-educated installers is a critical condition of RES transformation success in buildings H&C | direct | | NA | Align RES market needs with workforce potential | State licenses to installers of renewable energy generation sources | no of licences issued | depending on data availability - forward looking | NECP2020 | Technological | |

| CROATIA | KSF Group | KSF name | KSF description | Direct - RES Indirect - EE | Target/ binding | Target base level | Target/ non binding | KPI name | KPI measure | KPI value | Source | PESTEL category | Additional info |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **District heating** | | | | | | | | | | | | | |
| KSF1_DH | **Connecting buildings to DHC which are supplied by RES/energy efficient systems** | Connecting buildings to DH networks which are supplied by RES/energy efficient systems | priority in connecting buildings to DH in cities (less direct and indirect emission); indirect, because this action is not always connected with new RES installation | indirect | | NA | NA | better usage of DH networks | % of apartments connected to DH in 2020,2021,2022 | to be calculated in 2024 - backwards looking | NECP2020 | political | |
| KSF2_DH | **Promote RES in DHC** | Target for RES technology deployment in DH - geothermal | it shows directly growing share of RES - geothermal installations - in heat production | direct | | 1,5% in 2019 | get 8% heat from geothermal sources in 2030 | geothermal sources deployment in DH | % of total heat production of DH in 2019, 2020, 2021,2022 | | CA2020 | technological | |
| KSF3_DH | **de-incentivize financing non efficient DHC** | Threat of no financing of investments availability for energy inefficient DH systems | banks will not credit dh enterprise if its system is not energy efficient, no funding from EU, as well; it is impossible to achieve EES status without RES implementation | direct | | NA | get 100% of energy efficient centralized heating and cooling systems till 2030 | development of energy efficient DH systems | % DH energy efficient systems in 2020, 2021, 2022 | | NECP2020/ JUNE2023 update | political | |
| **Residential (single and multi-family) buildings** | | | | | | | | | | | | | |
| KSF1_RB | **Promote RES** | Strategy based on Comprehensive Assessment on RES technology deployment single and multifamily buildings | it shows directly growing share of RES - heat pumps - in heat production | direct | | 0,8% in 2019 | get 2,5% heat from HP till 2030 | heat pump deployment in single and multifamily buildings | % of total heat production of DH in 2019, 2020, 2021,2022 | to be calculated in 2024 - backwards looking | CA2020 | technological | |
| KSF2_RB | **Promote RES** | RES technology deployment in single and multifamily buildings - solar thermal | it shows directly growing share of RES - solar thermal - in heat production | direct | | 2,9% in 2019 | get 15% heat from solar thermal in 2030 | solar thermal sources deployment in single and multifamily buildings | % of total heat production of DH in 2019, 2020, 2021,2022 | | CA2020 | technological | |
| KSF3_RB | **Building codes (limiting annual primary energy use) for new construction (& deep renovation), incl. RES % obligation** | Technical Regulation on Rational Use of Energy and Thermal Insulation in Buildings | New and modernized buildings are obliged to achieve certain level of energy efficiency. It has direct influence as it is impossible to achieve without implementation of RES | indirect | Annual Final Energy Indicator from 2020 is 30 kWh/m2 per a | NA | NA | Energy efficiency in new buildings construction | no of new buildings in 2020,2021,2022 or % with 100% RES | | Technical Guidelines | legal | |
| KSF4_RB | **Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation** | Incentive for RES implementation in new or existing multifamily buildings | Energy renovation programme for multifamily buildings. Continuation of programme started in 2014. It influences indirectly, as RES is not always included in building modernization plan | indirect | | NA | 520 000 m2/a in 2021-2030 | Energy efficiency of existing buildings | buildings area in m2, using this program in 2020,2021,2022 or % of RES in total heat supplied of renovated buildings/dwellings | | NECP2020 | economic | |
| KSF5_RB | **Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation** | Incentive for RES implementation in new or existing single-family buildings | Energy renovation program for single-family buildings. Continuation of program started in 2014. It influences indirectly, as RES is not always included in building modernization plan | indirect | | NA | 350 000 m2/a in 2021-2030 | Energy efficiency of existing buildings | buildings area in m2, using this program in 2020,2021,2022 or % of RES in total heat supplied of renovated buildings/dwelling | | NECP2020 | economic | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KSF6_RB | **Electricity tariff for HP** | Special - lower - electricity prices for supplying heat pumps | Heat pump installation is strongly driven by electricity price. There are expectations of electricity price decrease in a few years. Preferential prices could immediately increase number of air-to-water heat pumps installation | direct | | NA | Speed-up heat pumps deployment | Incentive for heat pumps installation by special electricity price | nbr of new heat pump installations applying for special price | depending on data availability - forward looking | Pestel | economic | Note that this KSF is a suggested one. It is not a measure that the government has commited to yet |
| **Public buildings** | | | | | | | | | | | | | |
| KSF1_PB | **Incentive program for RES in H&C, incl. with target (e.g. EPC level), via building renovation** | Public buildings energy efficiency support scheme | Energy renovation program for public buildings. Continuation of program started in 2016. It influences indirectly, as RES is not always included in building modernization plan | indirect | | NA | 350 000 m2/a in 2021-2030 | Energy efficiency of public buildings | buildings area in m2, using this program in 2020,2021,2022 or % of RES supply in total heat use | to be calculated in 2024 - backwards looking | NECP2020 | economic | |
| **RES in industry** | | | | | | | | | | | | | |
| NA | | | | | | | | | | | | | |
| **Other** | | | | | | | | | | | | | |
| KSF1_O | **Program to decrease energy poverty** | Program to decrease energy poverty | Heat pumps deployment and heating cost decrease due to government direct support for replacement of old heat sources; indirect influence as gas boiler can be an option | indirect | | 20,3% in 2018 | decrease energy poverty factor to 10% in 2030 | Energy poverty level | % of residents with energy expenses above the energy poverty threshold in 2020, 2021, 2022 | to be calculated in 2024 - backwards looking | NECP2020, European Commission 2020) | social | |
| KSF2_O | **Increase cities' authorities capacity towards RES transformation** | Increase cities' authorities capacity towards RES transformation | get the staff in cities/counties educated and prepared for managing energy transformation which indirectly influence RES implementation both in buildings and in DH systems | indirect | counties and cities over 35000 inhabitants obliged to update energy efficiency plan on 3 years base | NA | in 2027 get 100% counties/obliged cities having updated spatial/energy plan | Nbr of cities obliged<br>Nbr of cities with Plan<br>Nbr of cities with plan and strong transition towards RES in H&C | no of counties/obliged cities with valid energy plans in 2020, 2021, 2022 | | NECP2020/ JUNE2023 update | sociocultural | |
| KSF3_O | **Training installers** | Establishing installers base, educated for RES deployment | Suitable base of RES-educated installers is a critical condition of RES transformation success in buildings H&C | direct | | NA | Align RES market needs with workforce potential | State certificates to installers of renewable energy generation sources | no of licenses issued in 2019, 2020,2021,2022 | | NECP2020 | technological | |

| Portugal | KSF group | KSF name | KSF description | Direct - RES Indirect - EE | Target: binding | Target base level | Target: non-binding | KPI name | KPI measure | Source | PESTEL category | Additional info |
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| **District Heating** | | | | | | | | | | | | |
| Little to no applicability for DHC. The potential for urban heating and cooling networks in Portugal was very low or almost zero. The main obstacles to the adoption of urban heating and cooling networks are identified as: a very low building density in interior areas with more climate extremes; in contrast, a mild climate in coastal areas that support denser urban areas. But other economic, sociocultural and practical barriers were also identified. It was concluded that, unlike most other EU countries, Portugal is not expected to obtain significant improvements in energy efficiency through the adoption of district heating and cooling network solutions.<br>However, opportunities for urban heating networks have been found for certain specific situations in which there are geothermal or industrial waste heat sources close to the urban area (Chaves, Amadora, Parque das Nações). Furthermore, it has been investigated, and it appears possible, although not strictly economically viable in itself, to adopt heat and cold networks in historic and tourist districts, in order to reduce the impact on the urban landscape of intrusive heating and cooling solutions, namely air conditioning devices. | | | | | | | | | www.dgeg.gov.pt | Technology | |
| **Residentia (single and multi-familiy) buildings** | | | | | | | | | | | | |
| KSF1_RB | **Promote RES** | Promote replacement of inefficient H&C systems by RES based ones | Encourage the replacement of outdated heat and cold production systems with more efficient and renewable energy systems. [Planned date: 2020-2030] | Direct | N/A | NA | Increas % RES supply for heating Increase EE | Replacment of inefficient systems | No. of (fossil-based) heating systems replaced by new RES based heating systems between 2020 and 2030 | New NECP 2023/PE STEL | Technology | |
| KSF2_RB | **Promote RES** | Electrification of heating and cooling by promoting the procurement and use of heat pumps for AQS and ambient air heating and cooling in buildings | [Planned date: 2020-2030] | Direct | N/A | NA | Increas % RES supply for heating Increase EE | | No. of heat pumps installed between 2020 and 2030 | New NECP 2023/PE STEL | Technology | |
| KSF3_RB | **Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation** | Programa de Apoio a Edifícios mais Sustentáveis (PAES) | Program aimed at supporting energy efficiency in existing residential buildings (detached houses, multifamily buildings), national coverage (RRP). It funds the acquisition/replacement and installation of renewable heating and cooling systems and hot water production systems (class A+ and higher). Also, applies to the acquisition of PV systems and other production units/systems for self-consumption, with and without storage. | Direct | N/A | NA | Increas % RES supply for heating Increase EE | Building upgrades to increase EE | No. of applicants to the program over the time-period of its duration<br>No. of applicants replacing fossil heat systems by RES systems | New NECP 2023/PE STEL www.portugal.gov.pt | Economic | Types of works included:<br>Typology 1: Replacement of non-efficient windows with efficient windows, with an energy class equal to «A+»;<br>Typology 2: Application or replacement of thermal insulation on roofs, walls or floors;<br>Typology 3: Space heating and/or cooling and domestic hot water (DHW) systems that use renewable energy, energy class “A+” or higher;<br>Typology 4: Installation of photovoltaic systems and other renewable energy production equipment for self-consumption with or without storage;<br>Typology 5: Interventions aimed at water efficiency. |
| **Public buildings** | | | | | | | | | | | | |

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| KSF1_PB | **Incentive programmes for RES in H&C, incl. with target (e.g. EPC level), via building renovation** | Programa de Apoio à Renovação e Aumento do Desempenho Energético dos Edifícios de Serviços | Program aimed at supporting the renovation and energy performance improvement (i.e. thermal comfort, indoor air quality, etc.) of existing services buildings. It funds the acquisition and installation of renewable heating and cooling systems and hot water production systems. Also, applies to the acquisition of PV systems and other production units/systems for self-consumption, with and without storage. | Indirect - funding for RES H&C is only one aspect | N/A | NA | Increas % RES supply for heating Increase EE | Renovation and energy performance improvments to commercial buildings | No. of applicants to the program over the time-period of its duration / energy savings over time No. of applicants replacing fossil heat systems by RES systems | New NECP 2023 www.invest2030.pt | Economic | Supported by the Environmental Fund, available untill 2022. |
| KSF2_PB | **Combine EE & RES renovation** | Prosumer program | In state- (and privately owned) housing buildings promote the energy rehabilitation of roofs, with improved thermal insulation, sealing and renewable energy systems for electricity and hot water production [Planned date: 2023-2030] | Indirect - RES H&C only one element | N/A | NA | Increas % RES supply for heating Increase EE | Renovation and energy performance improvments | No. of applicants to the program over the time-period of its duration / energy savings over time No. of applicants replacing fossil heat systems by RES systems | New NECP 2023 www.invest2030.pt | Economic | |
| KSF3_PB | **Combine EE & RES renovation** | Suport schemes to promote the uptake of easy wins, energy efficiency and/or renewable energy uptake solutions | Support Schemes based on the Environmental Fund and the Recovery and Resiliance Fund.The solutions to be adopted include the promotion of the electrification of buildings accompanied by an increase in the incorporation of renewables, through the installation of solar thermal collectors for heating in buildings or equipment with high needs such as swimming pools, sports grounds, schools and multi-purpose halls and the implementation of more efficient air conditioning solutions, as well as the installation of solar systems for self-consumption electricity production. [Planned date: 2020-2030] | Direct - electrification being considered as supporting RES uptake | N/A | NA | NA | Promotion of the electrification of public buildings accompanied by an increase in the incorporation of renewables | No. of applications/No. of public buildings upgraded over the period of the program | New NECP 2023 | Economic | |
| **Industry** | | | | | | | | | | | | |
| KSF1_I | **Program for HP in industry** | Development of a National Action Plan to accelerate the uptake of heat pumps in Portugal in buildings and industry, with the framework of the EU Heat Pumps Action Plan | Development of a National Action Plan to accelerate the uptake of heat pumps in Portugal in buildings and industry, with the framework of the EU Calor Bombas Action Plan. [Planned date: 2023-2025] | Direct | N/A | 2021: 2 140 293 HPs | Increase in heat pump uptake for industry | NA | No. of heat pumps installed between 2023 and 2025 in industry | New NECP 2023 www.eurobserv-er.org | Technology | |
| KSF2_I | **High efficiency cogeneration (Industry) financial support** | Promote high-efficiency cogeneration based on renewable energy sources | high-efficiency cogeneration systems that take advantage of renewable resources should be added, making it possible to improve the cost of production, making industry more competitive and contributing to the achievement of energy and climate targets. This should also include retrofitting | Direct | N/A | NA | NA | Promotion of co-generation | No. of projects over period 2024-2030 | New NECP 2023 | Technology | |

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| | | | cogeneration units for operation also with renewable gases. [Planned date: 2024-2030] | | | | | | | | | |
| KSF3_I | **Promote uptake of more efficient H&C systems** | Promoting the uptake of more efficient technologies | Optimisation of engines, pumping systems, ventilation and compression systems, combustion systems, heating and cooling systems, exchangers and heat recovery, industrial cold. Also promote efficient lighting. [Planned date: 2020-2030] | Indirect | N/A | NA | NA | NA | No.of new RES systems installaed in industry between 2020-2030 | New NECP 2023 | Technology | |
| KSF4_I | **Increasing awarness regarding efficient use of H&C sysems** | Increasing Awareness regarding efficient use of heating and cooling systems | Promoting efficient use through consumer information, stimulating consumer participation in aggregation for demand participation through heating/cooling systems Large consumers of heat/cold. [Planned date: 2023-2027] | Indirect | N/A | NA | NA | Consumer participation in promoting efficient use of H&C systems | Increase in consumer engagment in participation in aggregation for demand during 2023-2027 | New NECP 2023/PE STEL | Societal | |
| **Other** | | | | | | | | | | | | |
| KSF1_O | **Fiscal incentives for RES in H&C and EE** | Taxation for the decarbonisation of the residential sector and services | Introduce tax incentives for energy efficiency and the introduction of renewable energy and a more favourable tax regime for renewable energy buildings (e.g.: create tax incentives, such as reducing IMI, for nearly zero-energy buildings (NZEB). [Planned date: 2020-2025] | Indirect | Non-binding | NA | Increas % RES supply for heating Increase EE | Fiscal incentives for RES in H&C and EE | No. of applicants for this tax incentive between 2020 -2025 | New NECP 2023 | Economic | |
| KSF2_O | **Training** | Promote new training strands for specialised technicians for the energy efficiency and renewable energy sector | Among the new skills to be promoted, focus on: (I) Energy Efficiency Project and Audit, complying with the technical standards to be introduced by the Energy Efficiency Regulations in Services Buildings, Industry and Transport; (II) design and installation of Solar Thermic and Solar Photovoltaic complying with technical standards defined by the State; (III) Energy Management and Service Building Maintenance; (IV) professionalisation and qualification of public lighting installers and designers; (v) control management systems to meet the requirements arising from the revision of the EPBD Directive and the introduction of new technological solutions in buildings; (VI) Measurement & Verification of energy efficiency improvement projects, based on IPMVP (International Protocol for Measurement and Verification) methodologies, as a means of matching the quantification of avoided | Indirect | Non-binding | NA | Increase number of skilled workers in RES and EE | Training for specialised technicians in RES H&C and EE | No. of trained professionals in the categories listed in column D | New NECP 2023 | Societal | |

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| | | | consumption and standardising methodologies for assessing energy savings; (VII) efficient window designers and installers and thermal insulation applicators in buildings; (VIII) water efficiency and water-energy nexus technicians and specialists in buildings; (IX) technicians for inspection of technical systems (x) technical systems for natural ventilation, mechanical ventilation and indoor air quality (xi) professionalisation and qualification for energy simulation. [Planned date: 2023-2030] | | | | | | | | | |
| KSF3_O | **Training** | Promote training for construction technicians and specialists and NZEB and ZEB buildings | In view of the fact that the implementation of the NZEB concept establishes a new paradigm and the relevance of the link between the NZEB and ZEB buildings and the quality of their construction (in order to ensure their adequate life-cycle performance), support for the technical training of the various actors will be promoted, starting from the design phase, through the construction phase and to the exploitation/use phase of these buildings. [Planned date: 2023-2030] | Indirect | N/A | NA | Increase number of skilled workers in RES and EE | Training on NZEB and ZEB | No. of trained professionas in NZEB and ZEB buildings | New NECP 2023 | Societal | |
| KSF4_O | **Program to decrease energy poverty** | Delivering on the long-term strategy to combat energy poverty | Adopt a long-term strategy for tackling energy poverty that improves knowledge on energy poverty, strives for the best response to the problem and creates a structural change to mitigate it.<br>This strategy, which will be developed together with the relevant bodies, will include, inter alia, representatives of central and local government bodies, consumer associations, representatives of the energy sector and academia. It will aim to obtain a diagnosis and characterisation of the problem, develop monitoring indicators, monitoring strategies, set medium and long-term energy poverty reduction targets at national, regional and local level and propose specific measures to achieve these objectives, as well as forms of financing.<br>The “Valle Efficiency” programme is ongoing and is currently under review.<br>The National Long-Term | Indirect | N/A | NA | Reduce energy poverty | Combating energy poverty | Adoption of long term strategy to combat energy poverty<br>Changes in % of population identified as falling under energy poverty between 2024-2030 | New NECP 2023 | Societal | |

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| | | | Strategy for Combating Energy Poverty 2022-2050 was in public consultation from 20/01/2023 until 03/03/2023 and is estimated to be published by the end of the 3th quarter of 2023. The National Energy Poverty Observatory will be established. [Planned date: 2023-2024] | | | | | | | | | |
| KSF5 | **Program to decrease energy poverty** | Promote and support local strategies to combat energy poverty | Local energy strategies aimed at combating energy poverty should be supported and encouraged in a spirit of proximity and greater scope for policies to mitigate energy poverty (e.g.: Citizen Energy Area). [Planned date: 2020 2030] | Indirect | N/A | NA | Reduce energy poverty | Local strategies on energy poverty | No. of local strategies developed to combat energy poverty | New NECP 2023 | Societal | |
| KSF6 | **Program to decrease energy poverty** | Develop program to promote and support energy efficiency and integration of renewable energy to alleviate energy poverty | Promote more structural program, actions and support mechanisms to combat energy poverty, such as incentives for changes in consumption patterns, targeted interventions for investments in energy efficiency, renovation of buildings and program aimed at the integration of renewable energy (e.g.: programme efficiency). These support mechanisms will be developed together with municipalities in order to better suit reality and promote closer proximity to energy poor consumers. [Planned date: 2020 2030] | Indirect | N/A | NA | Reduce energy poverty | Programs on energy poverty | No. of local programs developed to combat energy poverty | New NECP 2023 | Societal | |
| KSF5 | **Program to decrease energy poverty** | “Vale Eficiência” | Program aimed at vulnerable families, who benefit from the social electricity tariff (RRP). Designed to improve thermal comfort in dwellings. It funds the acquisition and installation of renewable heating and cooling systems and hot water production systems (class A+ and higher). Also, applies to the acquisition of PV systems and other production units/systems for self-consumption, with and without storage. | Direct | N/A | NA | NA | Building upgrades to increase EE for vulnerable households | No. of applicants to the program over the time-period of its duration<br>No. of applicants replacing fossil heat systems by RES systems | New NECP 2023/PESTEL www.fundoambiental.pt | Economic | |

| Greece | KSF Group | KSF name | KSF description | Direct - RES Indirect - EE | Target binding | Target base level | Target/non-binding | KPI name | KPI measure | KPI value | Source | PESTEL category | Additional info |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **District Heating** | | | | | | | | | | | | | |
| KSF1_DH | **Promote RES in DHC** | Implementation of geothermal DHC through co-financing of project | Project funded by the EU Horizon 2020 program. The Anthelia-Aristino region, geothermal district heating network project that will provide heat for municipal buildings, social housing and greenhouses with a total thermal power estimated at 10 MW. | Direct | N/A | | Increase % RES supply for heating | Geothermal uptake in DH | Total geothermal power installed for DHC between 2022 and 2025 | Total geothermal power installed between 2022 and 2025 forward-looking | Based on additional research www.districtenergy.org | Technology | The Antheia-Aristino low-enthalpy geothermal field is considered as one the most important geothermal fields located in Greece, mainly due to the availability of geothermal fluid of more than 90 degrees Celsius temperature and its potential for exploitation. The investment for the construction of the geothermal district heating network amounted to EUR 6.2 million. The project was eligible for funding by the ERDF Regional Operational Program 2014-2020 of Region of East Macedonia and Thrace, which financed 95,31% of it. The remaining 4,69% was invested by Municipality's own capital.<br>It is considered as the first step of the exploitation of the available geothermal energy since the Municipality aims to expand the geothermal district heating network to residential buildings and potential industrial consumers. |
| KSF2_DH | **Promote DHC** | Building DHC networks | Greece has currently very limited DHC infra. Under the revised NECP it aims for 3,50 km of new or improved networks by 2029 | Indirect | N/A | | 3,50 km by 2029 | DHC pipeline network recently built or improved | DHC pipeline network recently built or improved | Kms of new or improved DHC infra 2024, 2025, 2026, 2028, 2029 | New NECP | Technology | |
| **Residential (single and multi-apartment) buildings** | | | | | | | | | | | | | |
| KSF1_RB | **Building codes (limiting annual primary energy use) for new construction (& deep renovation), incl. RES % obligation** | Obligations on % of RES for water heat in buildings - new buildings | New buildings are obliged to cover at least 60% of the energy needs for water heating with solar thermal or any other renewable energy source proven more efficient than solar thermal | Direct | N/A | | Increased % RES in buildings | New buildings deploying RES for water heating | Number of new buildings that comply with obligation. 2024 - 2026 Number of new buildings that go beyond compliance (more than 60% of SHW supplied by RES) 2024-2026 | To be calculated in 2024, forward looking | Pestel analysis | Legal | |
| KSF2_RB | **Ban fossil based systems** | Ban on fossil equipment | The installation of oil boilers will no longer be allowed from 2025, and from 2030, oil for heating will have to contain at least 30% by volume of renewable liquid fuels | Direct | N/A | | No installation of oil boilers from 2025; 30% renewable liquid fuels in oil for heating from 2030 | Ban on oil boilers | No of installed oil boilers between 2022 and 2024 ( to see if the announcement has an impact before implementation) . Number of installed oil boilers in 2025 | Part 1 to be calculated in 2024, backward looking . Main part to be calculated in when data for 2025 available, forward looking | Pestel analysis | Legal | |
| KSF3_RB | **Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation** | Income tax deduction for investments in RES H&C | Income tax deduction for investments in heating and cooling systems using solar thermal, biogas, biomass, geothermal and heat pumps (air, water and ground-source). The deduction is 10% of qualifying project costs up to a maximum of 3,000€ | Direct | N/A | | Increase % RES in H&C of buildings | Fiscal incentives for investment in RES H&C | Number of projects applying to the program over the time period of its duration | | Pestel analysis www.iea.org . Greek Law 4646/2019 (ΦΕΚ Α' 201/12-12-2019). Valid from 2019 onwards | Economic | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KSF4_RB | **Facilitate access to finance** | Interest-free loans and grants for the installation of RES and EE measures in homes | 'Saving at home' programs and "Energy Saving for young people". They provide interest-free loans and grants for the installation of renewables and energy efficiency measures. | Indirect | N/A | | Increase % RES in H&C of buildings Increase in EE of buildings | Financial product for uptake of RES H&C and EE in buildings | Number of projects applying to the program over the time period of its duration | To be calculated in 2024, backward looking | Pestel analysis More info on the program: www.keeptalkinggreece.com | Economic | This funding program started in 2011 and it is published every now and then. For 2023, the program was called "Energy saving 2023", the link is https://exoikonomo2023.gov.gr, it ended in 15/11/2023 and there were 31.549 applications which were all accepted. A new program will be published in 2024, under the name "Energy saving 2024". |
| KSF5_RB | **Electricity tariff for HP** | Heating Allowance for Electricity | Aid for ~ 1.2 million energy-vulnerable consumers. The average monthly allowance is projected to be 60 euros, with a quarterly minimum of 45 euros, and a cap of 450 euros. However, eligibility for this aid, which will be applied as a direct reduction to electricity bills, is contingent on specific income and property criteria, and excludes recipients of other heating allowances for oil, natural gas, and other fuels, as well those under the Social Tariffs. | Indirect | N/A | | Reduce energy poverty | Financial aid for heating costs | Number of applications | To be calculated in 2024, forward looking | Additional research. Info: bnnbreaking.com | Economic | In the 2023 program, there were 763.307 beneficiaries, and the Government gave to them 175.637.100 euros. It is a heating allowance for vulnerable people, where the Government offers them economical assistance for the heating costs (through oil, gas or electricity). It will run also for 2024, and it is not expected to end in the upcoming years, as it is very popular. The "Energy saving for young people" is a newcomer in 2023. It ended in 15/11/2023. The link is exoikonomoneon.gov.gr . There were 6.679 applications. |
| **Public buildings** | | | | | | | | | | | | | |
| KSF1_PB | **Incentive programs for RES in H&C, incl. with target (e.g. EPC level), via building renovation** | Renovation Programs - public buildings | "ELECTRA" program for energy update of public buildings. It finances the renovation of the whole building, aimed to improve energy efficiency and reach class B and reduce energy demand by 30%. Period 2022-2026 | Indirect | N/A | | Reduce energy demand by 30% in public buildings | Renovations for energy efficiency in public buildings | No of public buildings that have participated in the program in 2022 - 2026 Level of savings achieved | Forward looking | Pestel analysis | Legal | |
| KSF2_PB | **Incentive programs for RES in H&C, incl. with target (e.g. EPC level), via building renovation** | Renovation Programs - local authorities | 'SAVE' programs for Local Authorities. Annual energy renovation in government buildings should cover 3% of the total surface area (indirect). | Indirect | N/A | | 3% share of total surface are for energy renovation in government buildings/yr | Renovation of public buildings to increase EE% | % of total surface area renovated between 2022 - 2025 | Forward looking | Pestel analysis | Legal | |
| KSF3_PB | **Fiscal incentives for RES in H&C and EE** | Subsidies and tax breaks for investments in RES H&C | 2016 Development Law, subsidies and tax breaks are available for investments in solar thermal, biogas, biomass, geothermal and heat pumps (air, water and ground-source) built by private enterprises or social co-operatives. There are minimal project costs ranging from 50,000€ for social co-operatives to 500,000€ for large enterprises. | Direct | N/A | | Increase % RES in H&C of buildings | Fiscal incentives for investment in RES H&C | Number of projects applying to the program over the time period of its duration | | Pestel analysis | Economic | Info on the Development Law is available here: https://www.ey.com/en_gr/tax/tax-alerts/development-law-greece-strong-growth-key-provisions-and-innovations The Development Law has been updated since 2016. mindev.gov.gr new Development Law 4887/2022 (Government Gazette A/16/04.02.2022) is the main development and investment tool in Greece, aiming to achieve well-rounded and systematic intervention in every field and sector of the economy. It aims to improve competitiveness in high added value sectors, offer innovative products and services. The Development Law specifies incentives for supporting and developing healthy businesses, in order to implement mature investment plans throughout Greece within a period of 3 years. Beneficiaries: Companies in Greece, in the sectors: Commerce, Scientific research, Hospitality, Education, and Construction. |
| KSF4_PB | **Appointment of specialists** | Mandatory appointment of energy manager | Mandatory appointment of energy manager for | Indirect | N/A | | Improvements in EE in public buildings | Energy Performanc | % of EE improvements in public | Forward looking | Greece IEA Assessment | Societal | This funding program started in 2011 and it is published every now and then. For 2023, the program was called "Energy saving |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | for optimizing energy use of public buildings | optimizing energy use of public buildings | | | | | e of public buildings | buildings between 2023 - 2025 | | | | 2023", the link is exoikonomo2023.gov.gr , it ended in 15/11/2023 and there were 31.549 applications which were all accepted. A new program will be published in 2024, under the name "Energy saving 2024".<br>The "Energy saving for young people" is a newcomer in 2023. It ended in 15/11/2023. The link is exoikonomoneon.gov.gr . There were 6.679 applications. |
| **Industry** | | | | | | | | | | | | | |
| KSF1_I | **Financial Support Programs for SMEs** | Program "Energy Saving at Enterprises" | Interest-free loans and grants for the installation of renewables and energy efficiency measures in SMEs. Funding 40% for LEs and 50% for SMEs and MEs. | Indirect | NA | | Energy upgrade of SMEs | Energy upgrade of SMEs | - CO2 emissions reduction by at least 35%.<br>- Energy saving by at least 40%.<br>- If building energy upgrade is proposed, then the SME building should be upgraded by at least 2 classes. | | | | pre-published in Oct2022. It is still valid. The beneficiaries should submit a proposal and business plan. |
| KSF2_I | **cost incentives to promote efficient H&C including RES and waste heat** | Energy efficiency in industries | In the draft NECP 2023 (18/12/2023, p.222), the plans for Energy efficiency in the industrial sector are described. The current tax and financial incentives for SMEs will be continued and additional ones will be introduced, for energy saving measures. Introduction of cost incentives to promote efficient heating and-cooling systems including RES technologies including the use of waste heat. Introduction of Energy Efficiency Contracts in the industrial sector, such as subsidizing the cost of lending and facilitating access to finance for Energy Services Undertakings. The existing mandatory energy audits in companies with high energy consumption will be significantly strengthened, through the creation of a system for reporting and monitoring the energy consumption of obligated companies in the tertiary sector, industry and transport. Creation of an open database of energy efficiency measures (best practices) in the industrial and tertiary sectors in order to increase the efficiency of energy audits, especially in the industrial sector. | Indirect | NA | 2019 | Energy upgrade / energy efficiency of enterprises and industries | Energy upgrade / energy efficiency of enterprises and industries | At least 30% reduction of CO2 emissions, from 2019 to 2030, for enterprises that are not subject to emissions trading system. | | | Economic | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Other** | | | | | | | | | | | | | |
| KSF1_O | **Public awareness campaigns** | Public awareness campaigns | Since the publication of the Greek EPBD, many public awareness campaigns, communication campaigns, and general publicity through the media have happened. This is reflected in the wide deployment of RES in heating and cooling and the annual sales of heat pumps and solar thermal systems. | Indirect | | | Higher public awareness on the benefits of RES in H&C | Can this be measured or do we delete? Propose a survey to sample the level of public awareness? | | | Pestel analysis | Societal | |

# 7. Annex 2: Key Success Factor groupings identified

*Table 9 Classification of common KSFs in relation to five Member States*

| | Key Success Factor groupings | PL | DE | HR | EL | PT |
|---|---|---|---|---|---|---|
| Residential Buildings | Building codes (limiting annual primary energy use) for new construction (& deep renovation), incl. RES % obligation | Technical Guidelines - Level of energy performance requires RES | Building Energy Act - Obligation of % RES | Technical Guidelines - Level of energy performance requires RES | Obligations on % of RES for water heat in buildings - new buildings | / |
| | Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation | Incentives for RES with EE (incl. tax credit single fam buildings) | Incentives for RES with EE (CO2 building renovation pgm + tax credit) | Incentives for RES with EE (Ener renovation pgm for multi and single fam buildings) | Income tax deduction for RES H&C systems (STH, biogas, bioenergy, Geo, HP) | Programme (RRP) for EE & RES |
| | Promotion of RES in buildings | / | RES technology deployment (HP, STH) | RES technology deployment (HP, STH) | / | Promotion of acquisition and renewal of H&C systems (STH, HP, biomass) |
| | Electricity tariff for HP | Lower electricity prices for supplying heat pumps | Lower electricity prices for supplying heat pumps | / | / | / |
| | Banning fossil-based systems | Anti-smog programme (ban coal boilers) | Ban of fossil equipment | / | Installation of oil boilers will no longer be allowed from 2025 | / |
| | Consulting - providing guidance | / | Thermomoderniz-ation consulting for residential buildings owners | / | / | / |
| | Facilitate access to finance | / | / | / | Interest-free loans and grants for RES and EE in homes | / |
| Non-residential Buildings | **Incentive programmes for RES in H&C, incl. with target (e.g. EPC level), via building renovation** | **National program EPC+ (funding up to 49% of investment cost)** | **/** | **Energy renovation programme for public buildings (not necessarily RES)** | **“ELECTRA” (public buildings) to improve EE and reach class B & "SAVE" for local authorities program** | **Program aimed at supporting the renovation and energy performance** |
| | Facilitate Energy Performance Contracts (ESCO) | / | Funding EP Contracts for municipality non-residential buildings | / | / | / |
| | Consulting - providing guidance | / | Thermomoderniz-ation consulting for municipalities | / | / | / |
| | Prosumer program | / | / | / | / | Prosumer program (rehabilitation) |
| | Combine EE & RES renovation | / | / | / | / | Promote uptake of easy wins, EE and/or RES solutions |
| Industry | High efficiency cogeneration (Industry) financial support | High-efficiency CHP, sourced with WH, RES, gas, synthetic gas or H2 | High-efficiency CHP, sourced with WH, RES, gas, synthetic gas or H2 | / | / | Promote high-efficiency CHP based on RES |
| | Program for HP in industry | / | / | / | / | National Action Plan to uptake HP in buildings and industry |
| | Promote uptake of more efficient H&C systems | / | / | / | / | Optimisation of engines, pumping, ventilation & compression systems, etc. |
| | Increasing awareness regarding efficient use of H&C systems | / | / | / | / | Promoting efficient use through consumer information, stimulating consumer participation in aggregation |
| Other | **Program to decrease energy poverty** | **Direct support for replacement coal boilers** | **/** | **Direct support for replacement of old heat sources** | **/** | **Delivering on the long-term strategy to combat energy poverty** |
| | Obligation scheme (white certificate) | Energy efficiency certificate > 10toe of final energy with RES as possibility | / | / | / | / |
| | High efficiency biogas cogeneration (municipalities) financial supporting | Digestor fed by municipal bio-waste, high-efficiency CHP (RES only) | / | / | / | / |
| | Increase cities' authorities capacity towards RES transformation | Get staff in cities educated and prepared for managing energy transformation | Get staff in cities educated and prepared for managing energy transformation | Get staff in cities educated and prepared for managing energy transformation | / | / |
| | Public awareness campaign | / | / | / | Many public awareness campaigns, communication campaigns, and general publicity through the media | / |
| | Training installers | Strengthen RES-educated installers | Strengthen RES-educated installers | Strengthen RES-educated installers | / | Strengthen RES-educated installers |

# 8. Annex 3: Method for selecting the most appropriate KPIs

*The ranked KPIs related to Common KSFs*

In this section, we suggest a possible way to choose the most appropriate KPIs in the case where many are possible. It is important to note, that this part of the methodology is meant as an illustrative suggestion to facilitate the practical work of public authorities who may choose to follow the approach used in this work for the five selected Member States. It is important to note that the ranking suggested below was not used in the analysis of KSFs identified across the five Member States.

There is a link between **KPI**s and KSFs, however each **KSF** can be associated with more than one **KPI**. For this analysis, we have defined one set of attributes that each **KPI** should have. When choosing from a range of possible KPIs to monitor KSFs it is recommended to rank them based on their attributes. A helpful method for doing this, is suggested by "Selection of key performance indicators (KPIs) in the transition towards low-carbon urban communities[63].The individual attributes have different relevance for assessing the usefulness of a **KPI**. Following the approach proposed by "Selection of key performance indicators (KPIs) in the transition towards low-carbon urban communities", the highest ranked attribute (1) is Relevance, the lowest (5) is Familiarity.

| 1 Relevance | 2 Availability | 3 Measurability | 4 Reliability | 5 Familiarity |
|---|---|---|---|---|
| The KPI should have a significant importance for the evaluation of the one or more of the goals or targets identified | Data for the KPI should be easily available | The identified KPI should be measurable (qualitative) | The definition of the KPI should be clear and not open to interpretations | The KPI should be easy for the users to understand |

Below we provide a few examples of how assigning attributes to KPIs could be helpful in selecting the most appropriate ones. This summary should be considered illustrative, as individual **KPI**s will or will not have specific attributes depending on the country, details of supporting programs, regulations, or technical realities. The goal is to highlight the need to design an individual set of **KPI** attributes specific to each Member State. Further discussion is therefore intended only to demonstrate by way of example the feasibility of using this tool to properly select **KPI**s for the **KSF**s identified earlier, and to critically review the **KSF**s in cases where the selection of **KPI**s encounters significant difficulties.

*Table 10 Example 1 of assigning KPI(s) to KSFs*

| Key Success Factor | KPI name/example | KPI measure/example | Relevance | Availability | Measurability |
|---|---|---|---|---|---|
| Building codes (limiting primary energy use) for new construction (& deep renovation), incl. RES % obligation | Energy efficiency & renewable in new building construction | No. of new buildings in 2021, 2022 or % with 100% RES | X | | X |

The **KSF** in question is "Building codes", **KPI** name is "Energy efficiency and renewable in new buildings" and its measure is the number of new buildings per year. This **KPI** was assigned attribute (1) Relevance and (3) Measurability but was found to lack attribute (2) Availability. This is a typical situation, where a **KPI** can have attribute (2) Availability in a country where reporting on RES in new buildings is effectively carried out, or not have this attribute (as here) in a country where reporting is on the number of new buildings, but without details on, for example, embedded H&C systems. Thus, it is possible that a particular Member State may consider using the above **KSF** in its plans but selecting a **KPI** and assigning specific attributes to it (perhaps from a different set created for its situation) will assess its usefulness differently.

*Table 11 Example 2 of assigning KPIs to KSFs*

| Key Success Factor | KPI name/example | KPI measure/example | Relevance | Availability | Measurability |
|---|---|---|---|---|---|
| Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation | Energy efficiency of existing buildings | No. of buildings using dedicated programme in 2020, 2021, 2022 or no. of buildings using this | X | | X |

In this case, we are considering **KSF**, which is to increase the energy efficiency of buildings through subsidy programs. The programs must consider regulations on building retrofit rules. The **KPI** used to measure the **KSF**, examines the number of buildings retrofitted with RES using programs. This **KPI** has all attributes except (2) Availability. This is probably true for most countries and is because we are dealing with different programs, operating at different times, operated by different institutions. Hence, it can be difficult to single out all supported projects that use RES.

*Table 12 Example 3 of assigning KPIs to KSFs*

| Key Success Factor | KPI name/example | KPI measure/example | Relevance | Availability | Measurability |
|---|---|---|---|---|---|
| Promote RES | Solar Thermal sources in residential buildings | % of total decentralized heat production of DH in 2019 - 2022 | X | x | X |

**KSF** is a direct influence on decisions to use RES in the form of a solar installation. The **KPI** defined for this **KSF** has all the attributes. That is, it has an obvious connection to the **KSF** performance study, and it is easy to quantify because it relates to programs that support a specific technology. Also, the definition of the **KPI** is unambiguous and understandable to all.

*Table 13 Ranking KPIs based on attributes*

| | KPIs Attributes in descending order | | | 1 Relevance | 2 Availability | 3 Measurability |
|---|---|---|---|---|---|---|
| | Universal Key Success Factors | KPI name/ example | KPI measure/ example | The KPI should have a significant importance for the evaluation of the one or more of the goals or targets identified | Data for the KPI should be easily available | The identified KPI should be measurable (qualitative) |
| District Heating | Disincentivise financing non efficient DHC | development of energy efficient DH systems | % DH energy efficient systems in 2020, 2021, 2022<br>Number of DH network | x | x | x |
| | Connecting buildings to DHC which are supplied by RES/energy efficient systems | better usage of DH networks | % of apartments / dwellings connected to DH in 2020,2021,2022 | x | x | x |
| | Support High efficient DHC (def. on RES) | high efficient cogeneration deployment in DH | % of total heat production of DH in 2020, 2021,2022 | x | x | x |
| | Promote RES in DHC | solar thermal sources deployment in DH | % of total heat production of DH in 2019, 2020, 2021,2022 | x | x | x |
| Residential Buildings | Building codes (limiting annual primary energy use) for new construction (& deep renovation), incl. RES % obligation | Energy efficiency & renewable in new buildings construction | no of new buildings in 2021,2022 or % with 100% RES | x | | x |
| | Incentive for RES in H&C incl. taxation (e.g. deduction), via building renovation | Energy efficiency of existing buildings | no of buildings using dedicated programme in 2020,2021,2022 or nbr of buildings using this | x | | x |
| | Promote RES | solar thermal sources in residential buildings | % of total decentalized heat production of DH in 2019, 2020, 2021,2022 | x | x | x |
| | Electricity tarif for HP | Incentive for heat pumps installation by special electricity price | number of new heat pump installations | | | x |
| | Ban fossil based systems | Coal and wood boiler exchange into RES | number of coal boilers replaced by RES | x | x | x |
| | Training installers | State licenses to installers of renewable energy generation sources | no of licences issued 2019,2021,2022 | x | x | x |
| | Consulting - providing guidance | RES optimization of residential buildings thermomodernsation | Number of consulted projects in 2020,2021,2022 | x | | x |
| | Facilitate access to finance | Financial product for uptake of RES H&C and EE in buildings | Number of projects applying to the program over the time period of its duration | x | x | x |

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