BRINGING EUROPEAN BUILDING POLICY TO LIFE

Development of Article 9: Policy guidelines for Romania

Francesca Conselvan, Andreas Müller, and Marcus Hummel (e-think energy research)
Ece Özer, Irma Imamovic, Paul Söder, Lukas Kranzl (TU Wien)
Sara Ortner (ifeu)

Authors

Francesca Conselvan, Andreas Müller, and Marcus Hummel, **e-think energy research**

Ece Özer, Irma Imamovic, Paul Söder, Lukas Kranzl, **TU Wien**

Sara Ortner, **ifeu**

Graphic design

Helena Gil

Focus country reviewer
Mihai Moia, ROENEF

Publication date
March 2026

Project number	101120194
Start date of Project	October 2023
Duration of the Project	33 months
Deliverable Number	3.2
Deliverable Leader	e-think Energy Research

For more information, follow EPBD.wise on LinkedIn or visit our webpage.

ABOUT EPBD.wise

EPBD.wise aims to kickstart action to bring Europe's buildings directive to life and make our climate goals a reality. Over the course of three years, project partners are working with public authorities (such as municipalities, energy agencies, etc.) in six European countries (Bulgaria, Greece, Hungary, Poland, Romania and Ukraine) for the design, implementation and evaluation of key provisions to ensure our buildings are in line with our climate goals. Starting with the six focus countries, EPBD.wise builds a replicable model to support the widespread implementation of these measures across Europe.

Executive summary

This report provides policy guidelines to support Romania in the implementation of Article 9 of the Energy Performance of Buildings Directive (EPBD, 2024/1275). Article 9 introduces two major obligations for Member States: (1) the establishment of minimum energy performance standards (MEPS) for non-residential buildings, requiring renovation of the 16% and 26% worst-performing segments by 2030 and 2033 respectively; and (2) the development of a national trajectory for reducing the average primary energy use of residential buildings by 16% by 2030 and 20–22% by 2035, with progressive improvement until 2050. This report outlines the methodological foundations, data requirements, modelling insights, and governance considerations needed to fulfil these obligations.

The analysis employs a hybrid archetype-based and statistical approach using the Invert/EE-Lab modelling framework, calibrated against national energy statistics. Building stock analysis reveals significant variation in primary energy use, with the non-residential health sector exhibiting the highest specific consumption.

The modelling analysis – using the Invert/EE-Lab framework – compares five policy scenarios that combine varying levels of regulatory ambition, CO_2 prices and subsidies. Results show that MEPS-based regulatory pathways (Regulatory and Regulatory+) are the only scenarios capable of delivering both short-term compliance and long-term transformation. For non-residential buildings, strong regulatory measures substantially reduce primary energy use in high-consumption sectors such as health, wholesale/retail and offices. For residential buildings, only scenarios with MEPS achieve the 2030 and 2035 trajectory milestones, while purely economic instruments fall short despite high CO_2 prices. The modelling also highlights the amplifying effect of declining primary energy factors (PEFs) as Romania's electricity and district heating systems decarbonise.

Stakeholder consultations reveal several implementation challenges:

1. Lack of a comprehensive national building database, though work on a digital building registry is ongoing with 400,000 EPCs already extracted to help develop the national building renovation plan (NBRP)

2. Need for coherence between financial instruments (NRRP, Social Climate Fund, Cohesion Funds) and renovation trajectories

3. Overlap between worst-performing buildings and vulnerable households requiring coordinated support through energy poverty mapping developed under the Social Climate Fund

4. Absence of centralised one-stop shops to guide renovation processes

5. Insufficient workforce with qualified energy efficiency specialists

6. Weak EPC verification systems requiring strengthened institutional oversight.

The report presents a set of policy recommendations to ensure efficient and socially balanced implementation of Article 9. These include establishing sector-specific MEPS thresholds, prioritising multi-family buildings in urban areas, aligning renovation pathways with PEF trajectories, developing integrated financial support packages, and introducing simplified compliance tools supported by improved EPC and building logbook systems. Ensuring coherence between Article 9, the NBRP, EPC reforms and renovation passports is essential for creating a unified national renovation strategy.

Overall, Romania can meet the Article 9 requirements, the implementation of MEPS and the reduction of primary energy consumption in the residential sector, with strong regulatory frameworks. Without regulatory measures, such as MEPS or renovation obligations, targets for progressive building renovation trajectories will be difficult to achieve, in particular if primary energy factors for electricity and district heating do not decrease as planned. Moreover, data infrastructure should be rapidly strengthened, and financial and technical assistance mechanisms scaled to match the needs of vulnerable households and high-priority buildings.

LIST OF ABBREVIATIONS

EPBD	Energy Performance of Buildings Directive
EPC	Energy performance certificate
MEPS	Minimum Energy Performance Standards
NBRP	National building renovation plan
nZEB	Nearly zero energy building
PEF	Primary energy factor
RP	Renovation Passport
ZEB	Zero-emission building

CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Scope and objectives of the deliverable

This document provides guidelines to policymakers for implementing Article 9 of the Energy Performance of Buildings Directive (EPBD 2024/1275) into the national context for two selected countries, Poland and Romania. It builds on the policy needs and good practice examples identified in a previous phase of the project (see Deliverable 3.1 – Article 9: MEPS and trajectories for progressive renovation [1]). That report includes advice on how to set up the required database of buildings, define worst-performing buildings, derive the related thresholds for minimum energy performance standards (MEPS) for non-residential buildings, and define the reduction of the primary energy use in the national trajectory for residential buildings.

This draft document intends to initiate discussion among stakeholders and policymakers on developing the national building renovation plans (NBRPs) and how EPBD.wise can effectively support this process. In particular, the document is intended to identify those parts in the NBRP template provided within the EPBD 2024/1275 Annex II, to which the final policy guideline documents should provide specific inputs.

The implementation of Article 9 is closely connected to the development of other policy elements specified in the EPBD 2024/1275. In particular, there is a strong link between the provisions in Article 9 and NBRPs, since the trajectories of progressive building renovation for residential buildings and MEPS for non-residential buildings form an integral part of the projections to be presented in the NBRP. The scenarios shown in this document build on the general scenario outline, framework and modelling approach described in the policy guideline document for NBRPs.

Both documents refer to each other, and some elements, like the description of the scenario assumptions and modelling approach described in this document, are also relevant for Article 9. Table 1 provides an overview of how the content is organised across the two reports. For a full understanding, we recommend reading both.

Table 1: *Distinction of content regarding policy guideline documents for NBRP and Article 9.*

	Policy guideline NBRP [2]	Policy guideline Art. 9
Building stock data	Data collection and description of building stock data, including its distribution regarding energy consumption levels	How to derive worst performance buildings and 16th/26th quantile thresholds for MEPS
Modelling assumptions and scenario design	Overall modelling approach, scenario design and scenario framework data (e.g. energy prices)	Specific elements affecting the effectiveness of Art. 9 instruments, such as evolution of primary energy factors
Scenario results	Overall pathway results, e.g. in terms of final energy demand by energy carrier	Specific results showing the target achievement of Art. 9 split by residential and non-residential buildings
Checking target achievement	Overall evaluation of target achievement, including consistency with zero-emission buildings, Renewable Energy Directive, fossil fuel phase-out	Art. 9 targets, in particular regarding compliance with trajectories for residential buildings
Stakeholder engagement	Included	Not included
Monitoring, evaluation	Monitoring of renovation activities and establishing a continuous feedback and evaluation mechanism	Focus on compliance with MEPS (non-residential buildings)

1.2 Structure of the deliverable

This report begins with an introduction to the **Article 9 framework** in accordance with the EPBD 2024/1275 (Section 2), providing a foundational understanding of the legislative context.

Section 3 outlines the **policy needs identified earlier in the project**, detailing the specific requirements in Romania and highlighting good practices.

Section 4 delves into the **development of policy recommendations**, with sub-sections focusing on building stock data, identification of worst-performing buildings, and a detailed methodology using the Invert/EE-Lab Model Approach to set up the trajectory for reducing primary energy use. This section also includes scenario assessments and policy measures for achieving energy efficiency goals.

Section 5 presents **strategies for monitoring, evaluation and continuous improvement**, ensuring ongoing assessment of the implemented policies.

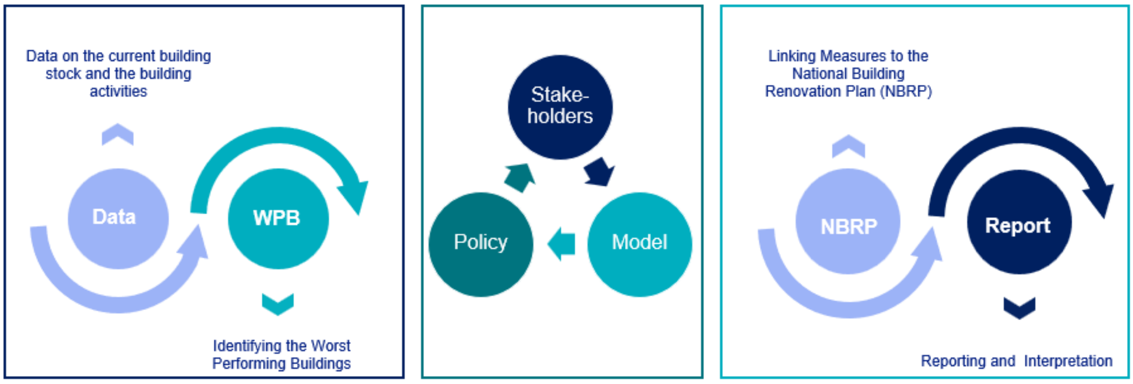
Section 6 introduces the compliance, monitoring and enforcement framework needed to effectively implement MEPS for non-residential buildings.

Section 7 positions Article 9 alongside other policy instruments established by the Directive, which are essential for its successful implementation.

Section 8 presents the necessary requirements for the effective implementation of Article 9 based on the scenario results and discussion with national stakeholders.

1.3 Methodology and approach

The methodology and approach for drafting this guidance follows a three-step process:



Overview of the process linking building performance, policy and reporting for renovation planning

Step 1: Identification of data sources and worst-performing buildings

The first step involves identifying **relevant data sources** and characterising the **current state of the residential building stock**. This ensures a clear understanding of the existing conditions and energy performance across the building sector. In the next step we **identify** the **worst-performing buildings**, which are characterised by high energy consumption, low energy efficiency ratings or older construction years. This identification process is supported by a continuous cycle of data analysis and worst-performing building classification, allowing for the prioritisation of the most critical buildings for renovation. Reliable data sources for this process may include energy performance certificates (EPCs), renovation rates and historical consumption patterns.

Step 2: Policy modelling and stakeholder engagement

This phase involves defining and designing policy measures that will support and enable the reduction in average primary energy use. The workflow follows three steps:

a. Discussion with **stakeholders** from Romania and integration of their feedback into the policy design.
b. Setting up **policy measures**, which include financial incentives, regulatory frameworks, and other strategies designed to promote energy efficiency in residential buildings.
c. Using **data-driven models** to assess renovation scenarios, predict energy savings and optimise investment strategies.

Step 3: Linking the measure to Article 9

The final step is to integrate identified measures into the implementation of Article 9. A feedback loop between Article 9 and the reporting process ensures continuous monitoring and assessment. The **reporting and monitoring** phase helps policymakers evaluate the effectiveness of implemented measures and make adjustments to improve outcomes.

2 DESCRIPTION OF THE ARTICLE 9 FRAMEWORK IN ACCORDANCE WITH EPBD (2024/1275)

Article 9 of the EPBD (2024/1275) [3] focuses on accelerating building renovations to achieve a fully decarbonised building stock by 2050. It introduces MEPS for non-residential buildings and a national trajectory for residential buildings.

1. **9(1) Non-residential buildings (MEPS)**: Member States must renovate the **16% worst-performing non-residential buildings by 2030** and **26% by 2033**. They can set energy performance thresholds based on **primary or final energy use** and may define additional energy indicators. Certain buildings, like historical and religious structures, may be exempt under clear criteria.

2. **9(2) Residential buildings (national trajectory)**: Member States must ensure a **16% reduction in average primary energy use by 2030, 20-22% by 2035**, and further progressive reductions until 2050. This trajectory must align with national building renovation plans and identify the number of buildings/units or floor area to be renovated annually, prioritising the worst-performing buildings. Addressing energy poverty is a key aspect, requiring financial and technical support for vulnerable households.

Member States must also implement monitoring and enforcement mechanisms, including penalties, to ensure compliance with the new standards.

New buildings and demolished buildings are not counted in the calculations for renovation targets and energy performance improvements.

3 COMPILATION OF THE POLICY NEEDS IN ROMANIA

The key policy needs related to developing and implementing Article 9 were identified through a structured research approach. Our methodology began with extensive desk research, analysing existing European and national initiatives, projects and reports to establish a comprehensive understanding of the challenges and best practices related to implementing Article 9 requirements – including both policy transposition mechanisms and practical barriers to executing building renovations. To refine our findings, we engaged directly with Romanian representatives based on a targeted questionnaire and bilateral meetings. Additionally, the policy forums and stakeholder roundtables organised provided a platform for in-depth discussions on policy needs, implementation barriers and potential solutions. This multilayered approach allowed us to identify country-specific challenges while ensuring that the findings remain broadly applicable to other EU Member States. While structuring our recommendations to address the specific policy needs of Romania, we also aim to provide a replicable framework for supporting the effective implementation of Article 9 across the EU, facilitating progress in building renovation and energy efficiency goals.

Policy Need	Challenges identified	Proposed solutions
National building registry	Lack of a comprehensive database for building stock.	Development of a national building registry integrating building data and EPCs to help identify worst-performing buildings.
Identification of worst-performing buildings	No clear definition or identification of the worst-performing buildings in the current stock.	Use the national building registry and renovation passport to identify the worst-performing buildings.
Minimum energy performance standards (MEPS)	Lack of clarity about the standards to apply, especially for certain building categories like single-family homes.	Develop national MEPS, including thresholds for different building categories, and a resolution on including single-family homes.
Renovation standards	Renovation programmes are not aligned with nearly zero-energy building (nZEB) or zero-emission building (ZEB) standards.	Update programme indicators to align with nZEB/ZEB standards to improve renovation quality.
Financial support for renovations	Lack of financial support and absence of laws to attract private investment.	Increase funding options, including grants, subsidies, low-interest loans, and develop laws to attract private investment.
Workforce development	Limited number of qualified workers and insufficient training programmes.	Expand and reinforce training programmes for qualified energy efficiency workers and specialists in green construction.
Centralised one-stop shops	Absence of centralised one-stop shops to guide renovation processes.	Establish regional one-stop shops to facilitate renovation projects at the local level.
EPC verification	Lack of an efficient system for verifying the quality and accuracy of EPCs.	Strengthen institutional oversight to ensure high standards and reliable EPC audits.
Public building renovation	There is a need for a clear definition and indicators for renovation targets, especially for public buildings.	Set clear targets for the renovation of public buildings to ZEB standards.
Data gaps	Insufficient data on the existing building stock, especially for non-residential buildings.	Address data gaps and create a comprehensive, accessible database of all building categories.
Private investment	Lack of mechanisms to attract private investment in building renovation projects.	Develop specific policies and mechanisms aimed at attracting private investment in building renovation projects.

4 MODELING THE IMPACT OF ARTICLE 9-RELATED POLICIES

This chapter outlines the methodology for addressing the implementation of Article 9 of the EPBD. It begins by providing an overview of the building stock, including the identification and analysis of worst-performing buildings based on their current energy consumption. The first step is collecting accurate building stock data, examining key data sources and the current status of buildings and building activities.

The second step focuses on setting up a trajectory to reduce primary energy use, with a particular emphasis on establishing a sub-target for the worst-performing buildings. This provides a clear path for achieving meaningful reductions in energy use. Finally, this chapter explores the development and assessment of different scenarios, outlining potential policy measures to drive improvements and evaluating their impact through scenario analysis.

4.1 Identifying building stock data and estimating primary energy use

Building stock data is fundamental to assessing the achievement of targets set by Article 9. The analysis requires a detailed description of the building stock based on two key dimensions: conditioned floor area and primary (or final) energy use per floor area, for both residential and non-residential buildings. The distribution curve derived from this data enables the identification of the worst-performing buildings and the establishment of performance thresholds mandated by the Directive[1] to target the bottom 43% of the building stock [1]. It is important to note that in Romania, "primary energy" refers specifically to non-renewable primary energy rather than total primary energy. This distinction is critical when comparing primary energy indicators (e.g., defining the 16% and 26% of buildings with the worst performance) across different EU countries.

1 The Directive requires that Member States renovate the 16% worst-performing non-residential buildings by 2030 and the 26% worst-performing by 2033.

There are four main methodologies to **derive primary energy use data** for buildings:

1. **Archetype-based modelling** – This bottom-up approach relies on reference buildings with predefined geometries, U-values, and installed technologies. It uses data from sources such as the EU Building Stock Observatory, national building statistics, and initiatives like TABULA/EPISCOPE. However, it often lacks key details like the impact of past retrofitting efforts or heating system distribution among different building segments. This approach may underestimate real-world variance, as seen when comparing modelled distributions with actual measured energy consumption.

2. **Measured energy consumption** – This method uses actual consumption data from a representative sample of buildings. It accounts for real-world factors such as user behaviour, refurbishment status and climatic conditions. While gas or district heating consumption data is often available from grid operators, electricity consumption data is more fragmented. Additionally, secondary heating systems (e.g., biomass, oil) are difficult to incorporate, and privacy regulations may limit data access. A key concern is the potential for bias if measured gas consumption is used to represent total energy consumption.

3. **Energy performance certificates** – EPC databases contain structured and standardised data based on a well-defined methodology. Many countries centralise EPC data in a single or a few databases. However, a significant issue is that EPC-reported energy use often does not align with national energy balance statistics. Additionally, EPC datasets may be biased toward refurbished buildings, leading to potential distortions in energy performance assessments.

4. **Statistical approaches** – Some countries, like Austria, use statistical models to estimate energy consumption. Here, climate-corrected energy data is divided by gross floor area, with adjustments based on volume-to-surface ratios to reflect variations in building efficiency. A normal distribution is assumed, ensuring that the most energy-efficient buildings align with the latest building code standards. This method provides a systematic link between energy performance, EPC classifications and regulatory frameworks.

For a more exhaustive description, see D2.2 "Development of NBRP: Policy Guidelines for Romania"[2].

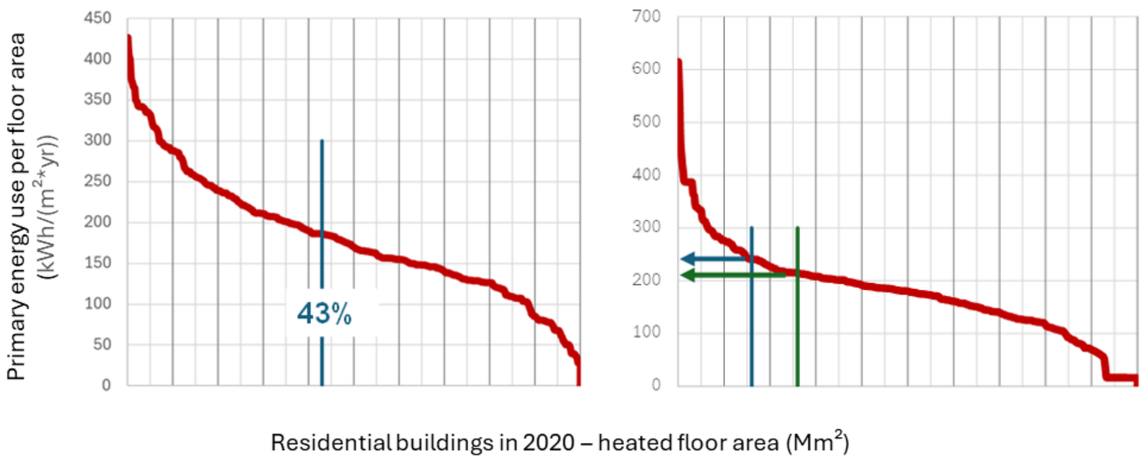


Figure 1: *Relationship between primary energy use per floor area (kWh/(m²year)) and the heated floor area of residential and non-residential buildings in 2020 (Mm²) (X country)*

Derived distribution of primary energy use of the national residential building stock

For Romania, we used a hybrid approach combining archetype-based and statistical methodologies to address specific data validation challenges encountered during the analysis. The approach uses the Invert/EE-Lab model, which is built on building archetypes representing different construction periods, building types and energy performance characteristics, calibrated against national energy statistics to ensure alignment with real-world consumption patterns.

The variation in primary energy use per heated floor area ([kWh/(m²·year)]) for residential buildings is calculated based **on three distinct methods** of calculation of energy consumption (Figure 2).

1. The first method is based on **national usage profiles** combined with the **heated floor area** of buildings. This approach uses average data for energy consumption patterns across the country, which are then applied to the total heated floor area of the building stock.

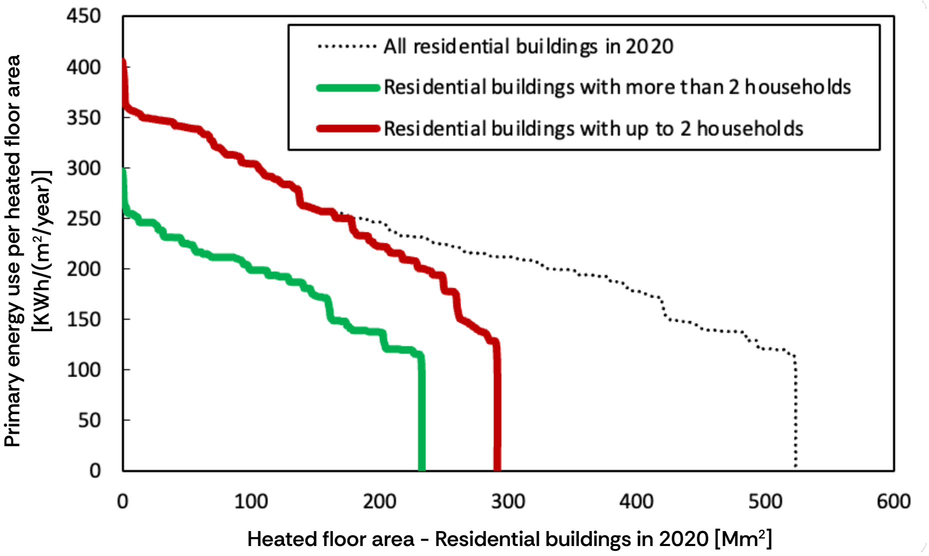


Figure 2: *Distribution of primary energy use per heated floor area for residential buildings in 2020, differentiated by number of households*

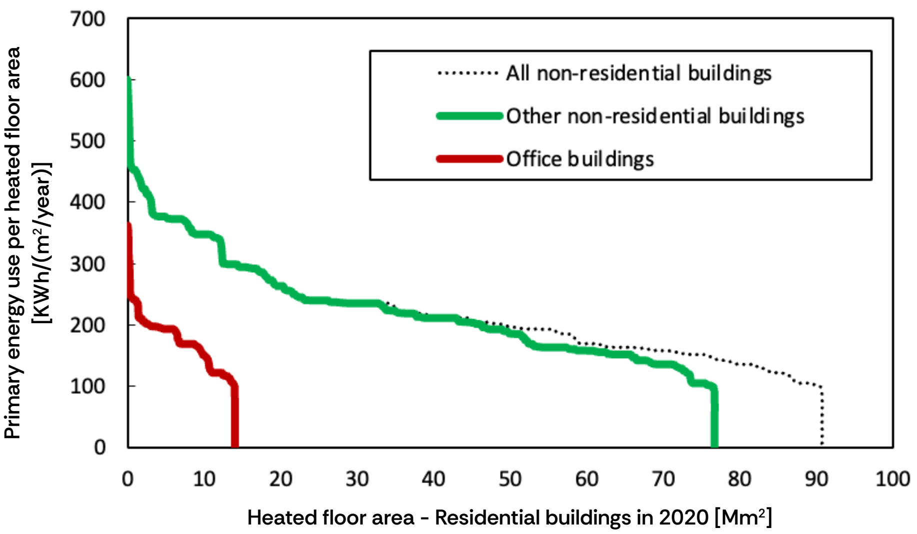


Figure 3: *Distribution of primary energy use per heated floor area for non-residential buildings in 2020*

2. The second approach uses a more refined calculation, where **energy use** is **corrected for user-specific behaviour** (Figure 4). This method accounts for individual variations in energy consumption based on the heated floor area, offering a more personalised estimate of energy use. By factoring in how users interact with their spaces, this method aims to provide a closer reflection of actual energy consumption patterns.

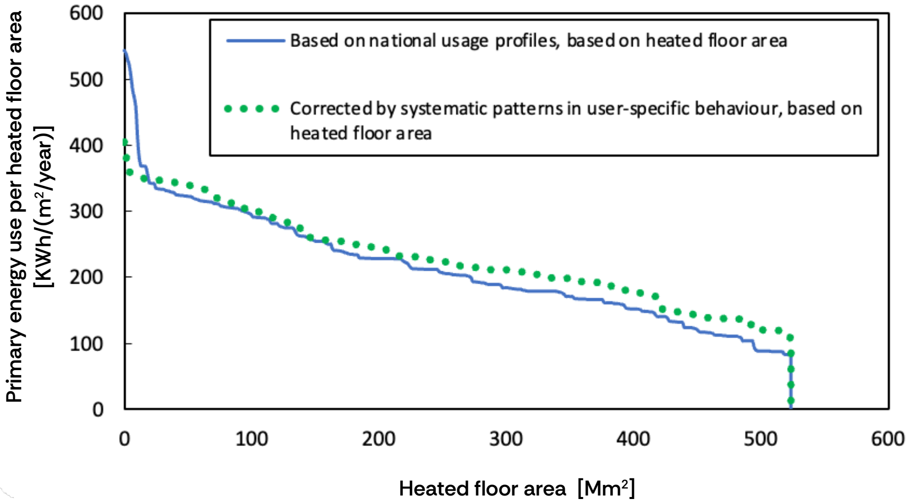


Figure 4: *Primary energy use per heated floor area ([kWh/(m²·year)]) for residential buildings in 2020*

3. The third method draws on **national usage profiles** but calculates results according to the **number of buildings** rather than total floor area (Figure 5). This method helps to understand energy consumption from a broader perspective, focusing on the building count as a variable that influences overall energy use.

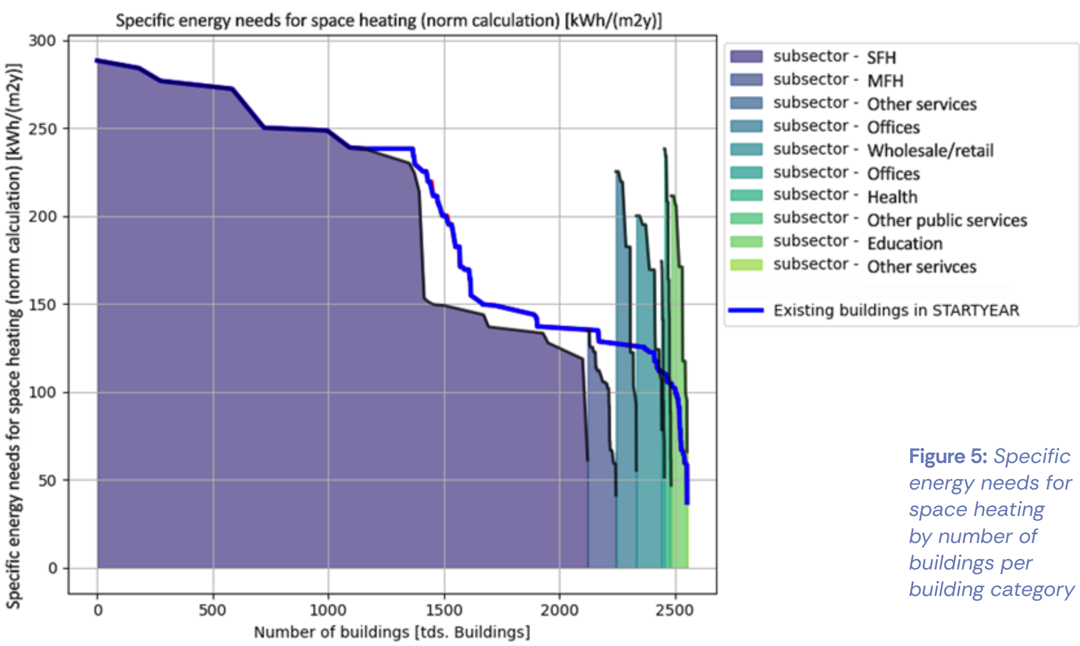


Figure 5: *Specific energy needs for space heating by number of buildings per building category*

4.2 Identifying worst-performing buildings based on primary energy use

To assess and identify the worst-performing buildings within the national building stock, we employed an **archetype-based modelling approach**, integrating various data sources. The analysis is based on key indicators that influence energy performance, supporting targeted renovation strategies and policy interventions.

The primary dataset includes information on the number of buildings and total floor area categorised by construction periods. This data is sourced from the **Building Stock Observatory** and enriched with additional **national and regional datasets**. Key parameters defining building performance, such as geometry, thermal transmittance values (U-values) and envelope characteristics, are derived from national building typologies. Data on the distribution of energy carriers and heating systems per building type enables the identification of inefficient heating systems and high-emission energy sources.

However, **critical gaps** remain in the available data, particularly regarding the share of refurbished buildings per construction period and building type, which is often estimated rather than directly measured. Similarly, information on the distribution of different energy carriers across various construction periods is limited, requiring further refinement through estimation techniques and complementary data sources.

A key aspect of understanding the energy performance of buildings is the relationship between the heated floor area and primary energy use per square metre categorised by the number of households. The model shows that smaller residential buildings often exhibit higher energy consumption per floor area (Figure 6), potentially due to factors such as lower insulation efficiency, higher surface-to-volume ratios or outdated heating systems.

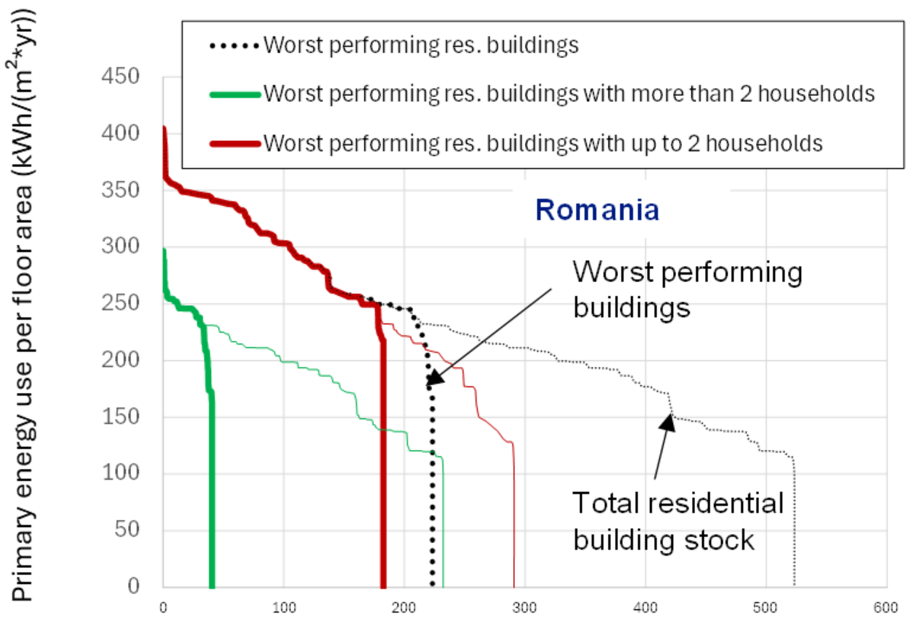


Figure 6: *Distribution of specific primary energy use over heated floor area of worst-performing buildings (residential sector) by size in 2020*

4.3 Defining thresholds based on primary energy use

An essential step for implementing MEPS is the definition of the threshold value for the 16% and 26% worst-performing buildings (or 16th and 26th quantiles) based on the primary energy use per heated floor area. According to the Invert/EELab simulation, in 2020, the baseline primary energy use ranges from approximately 50 kWh/(m²·year) to a maximum of 580 kWh/(m²·year) across building categories, while the 2033 threshold varies between 150 and 380 kWh/(m²·year) across different building types. These preliminary results are based on the building stock data and distributions presented above and in the policy guideline document on NBRPs.[2]

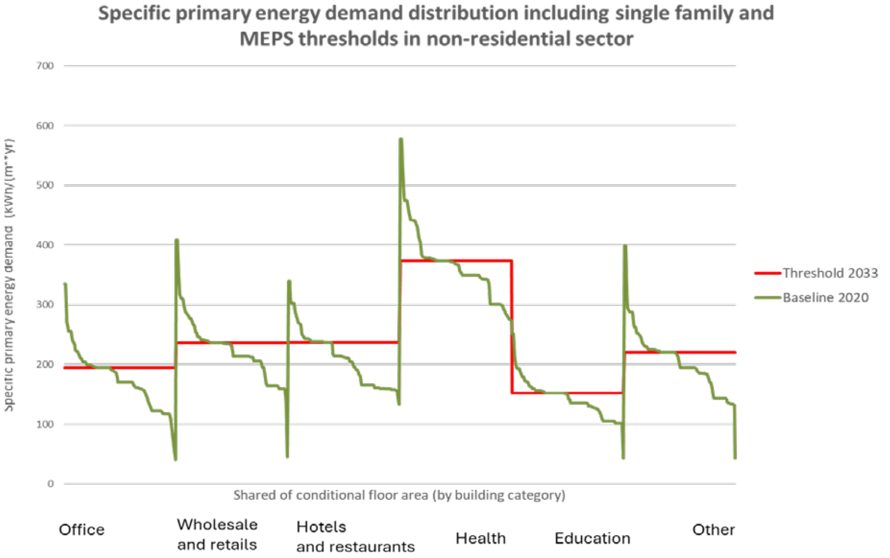


Figure 7: *Specific primary energy use of buildings in 2021 by building category, shown as a share of conditioned floor area, compared with the proposed 2033 threshold values (red lines)*

4.4 Methodology: Invert/EE-Lab model approach and scenario designs

To outline and explore scenarios for the transformation of the building stock, we used the **Invert** modelling framework, which combines two complementary components: **Invert/EE-Lab** and **Invert/Opt** [4]. Together, they provide a comprehensive understanding of how energy performance in buildings evolves under different policy scenarios, capturing both economic efficiency and realistic decision-making dynamics. For a detailed description of the modelling, see Annex A: Model documentation.

The Invert model was run under scenarios that simulate different policy pathways for implementing Article 9 (Table 2). The scenarios combine varying levels of regulatory stringency, economic instruments and technological ambition to reflect alternative policy approaches. Five main scenarios are assessed:

1. **Regulatory+** scenario representing a strong top-down approach with a ban on fossil boilers and stringent MEPS.

2. **Regulatory** scenario with moderate standards but no fossil ban.

2 See D2.2 "Development of NBRP: Policy Guidelines for Romania"[2]

3. **Mix** scenario combining high CO_2 prices (€300/t) and generous subsidies with partial regulatory measures limited to the non-residential sector.

4. **Moderate** scenario having moderate subsidies, limited regulation and a CO_2 price of €75/t.

5. **Pure economic** scenario relying solely on market-based instruments such as CO_2 pricing and subsidies.

Each scenario is defined by specific assumptions on **CO_2 prices, subsidy budgets**, and the presence or absence of **regulatory instruments** for both the residential and non-residential sectors. This design allows assessment of the interactions between policy tools, their effectiveness in driving renovation and fuel switching, and their overall impact on energy demand, emissions and investment needs in the European building stock.

For a more detailed description of the scenario workflow, refer to D2.2 "Development of NBRP: Policy Guidelines for Romania"[2].

Table 2 *Overview of policy scenarios used in the modelling*

Scenario name	CO_2 price	Subsidies	Ban fossil-based boilers	Residential	Non-residential
Regulatory+	75€/t	Moderate	Yes	MEPS	MEPS
Regulatory	75€/t	Moderate	No	MEPS	MEPS
Mix	300€/t	High	No	No MEPS	MEPS
Moderate	75€/t	Moderate	No	No MEPS	MEPS
Pure economic	300€/t	High	No	No MEPS	No MEPS

4.5 Scenario results for non-residential buildings

Article 9.1 of the revised EPBD requires that all non-residential buildings remain below defined maximum primary energy threshold values by 2033, ensuring the progressive phase-out of the worst-performing stock. This section presents modelling results that illustrate how different policy scenarios influence the distribution of primary energy demand across building categories and assesses the extent to which Romania can meet the required thresholds under each framework.

The **2020 data** provides a clear baseline: most building categories currently show high specific primary energy use, with a large share of the conditioned floor area lying above the 2033 threshold values.

The **Regulatory+ scenario** – which combines stringent MEPS, a CO_2 price of €75/t and a ban on fossil fuel boilers – drives substantial improvements across all building typologies (Figure 8). The distribution curves shift markedly downward relative to the 2020 baseline, with a significant compression of the spread indicating more homogeneous performance levels. The most pronounced improvements are observed in the health and wholesale sectors, which have the highest energy intensities in the baseline year. The health sector, for instance, shows baseline primary energy consumption of approximately 580 kWh/(m^2·year), which is reduced to approximately 350 kWh/(m^2·year) under this scenario, roughly a 40% decrease.

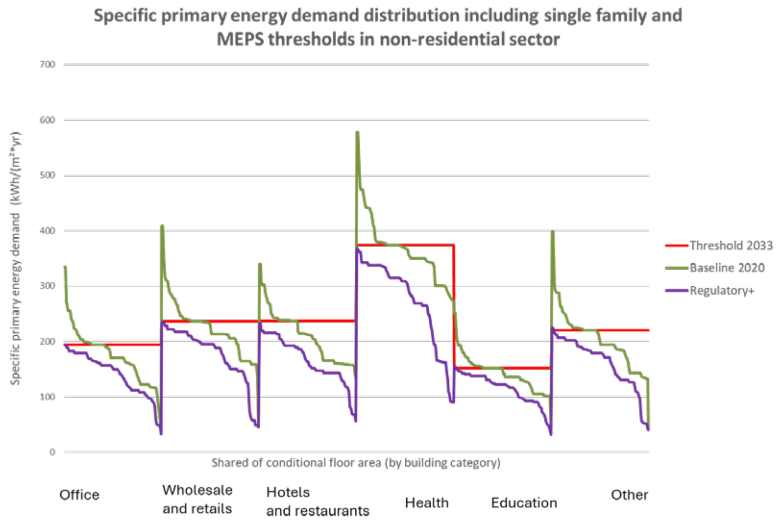
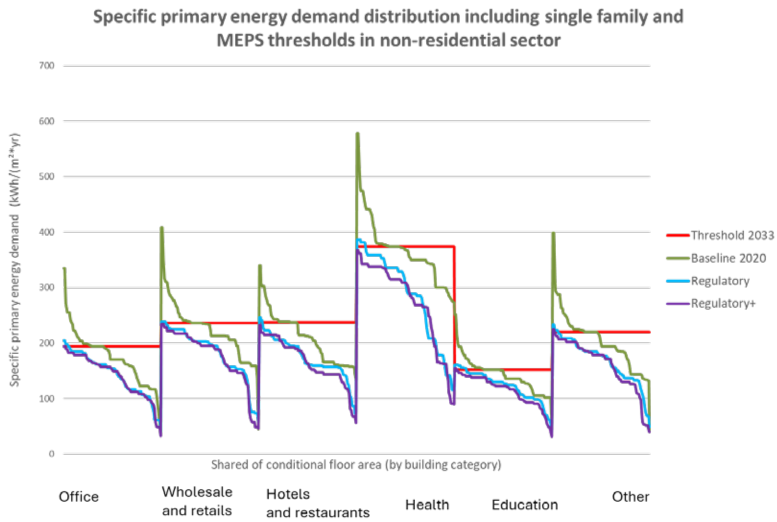


Figure 8: *Primary energy demand distribution across building sectors under the Regulatory+ scenario (MEPS and ban of fossil boilers)*

The **Regulatory scenario** – with a CO_2 price of €75/t and the introduction of MEPS –delivers a slightly lower level of improvement compared to the Regulatory+ scenario (Figure 9). This is particularly evident in the health and office sectors, where energy use drops from approximately 580 to 380 kWh/(m²·year) and 400 to 220 kWh/(m²·year) respectively —representing reductions in primary energy demand of approximately 35% and 45% respectively. In practice, the health sector remains at or near the threshold of 380 kWh/(m²·year), while the office sector successfully falls well below the threshold.



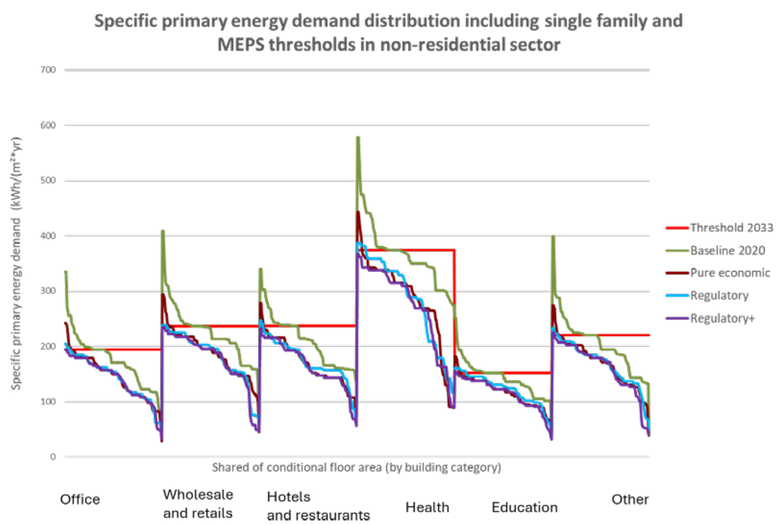


Figure 9: *Comparison of primary energy demand distribution under Regulatory+ (MEPS and ban of fossil boilers) and Regulatory (MEPS and €75/tCO₂)*

The divergent outcomes between these scenarios stem from different energy carrier transitions (Figure 10). The Regulatory+ scenario, through its ban on fossil fuel boilers, actively drives a long-term shift toward increased biomass use and electric heat pumps, while substantially reducing natural gas consumption. In contrast, the Regulatory scenario – relying on MEPS combined with a relatively modest CO_2 price of €75/t – does not create sufficient economic incentive to drive widespread fuel switching away from natural gas. Instead, natural gas consumption remains relatively stable in the long term, with improvements primarily achieved through efficiency measures mandated by MEPS rather than through decarbonisation of heating systems.

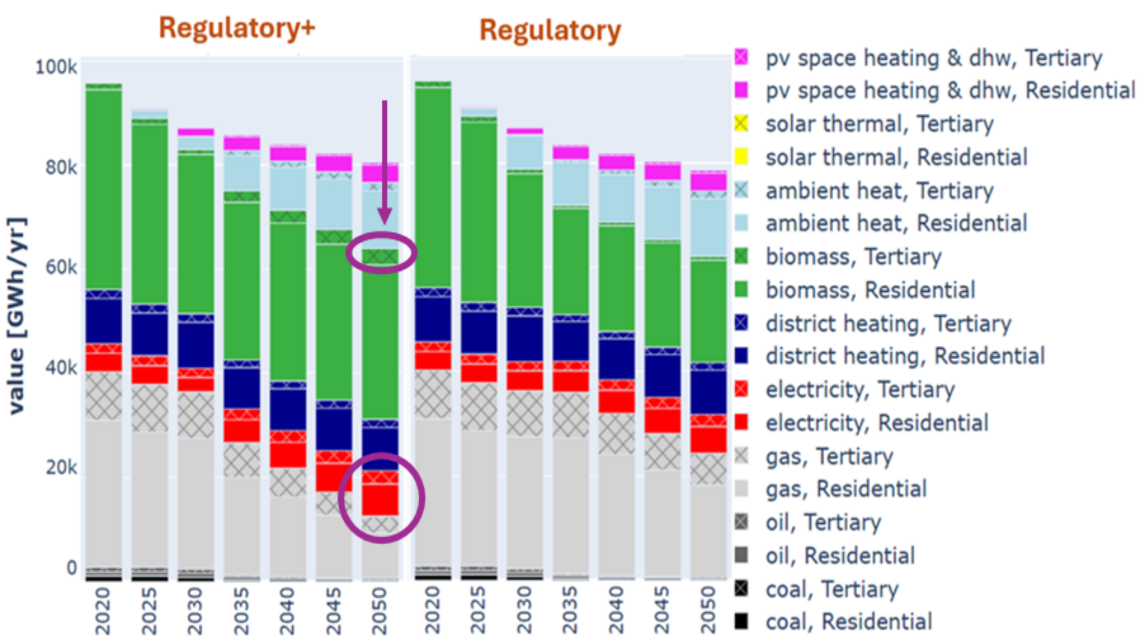


Figure 10: *Comparison of final energy demand across sectors and carriers under the two policy scenarios Regulatory+ (with a ban on fossil boilers) and Regulatory (without a ban on fossil boilers)*

Across both scenarios, the wholesale and retail, the accommodation and the service sectors demonstrate strong responsiveness to policy interventions. The education and office sectors also show marked improvements, though their baseline performance is closer to the threshold compared to health and retail.

4.6 Scenario results for residential buildings

Meeting the revised EPBD's residential sector targets – 16% average primary energy reduction by 2030 and 20–22% by 2035 [5] – depends on two interconnected factors: the ambition of building renovation policies and the pace of energy supply decarbonisation. This section presents scenario modelling results that assess Romania's compliance pathway under varying policy frameworks, exploring how targets can be met and methodological choices regarding primary energy factors.

Energy savings across all scenarios follow a consistent upward trend from 2022 to 2050, but the pace and scale of improvement depend heavily on both the policy ambition and the timeframe considered. By 2030, clear differentiation already emerges: the **Regulatory** and

Regulatory+ scenarios reach approximately **16-24% reduction**, meeting or exceeding the EPBD target of 16%, while the **Moderate** and **Mix scenarios fall short of the 2030 target**, remaining below the 16% threshold. By 2035, this divergence becomes even more pronounced: the Regulatory and Regulatory+ scenarios deliver the strongest performance, reaching approximately 35% and 30% savings respectively, well exceeding the 20-22% target. In contrast, the Moderate and Mix scenarios struggle to reach the 2035 compliance levels.

However, beyond 2035, performance trajectories change strikingly. While the Regulatory and Regulatory+ scenarios successfully drive rapid near-term improvements through mandatory standards, they ultimately achieve lower long-term savings – reaching approximately 49% and 54% by 2050 respectively. In contrast, the Moderate scenario, despite its slower start and failure to meet early targets, maintains steady progress throughout the projection period, ultimately achieving the highest savings at approximately 65% by 2050 (Figure 11).

This divergence suggests that while MEPS implementation is critical for meeting short- to mid-term compliance targets (2030 and 2035), moderate economic instruments may unlock deeper long-term transformations by allowing market-driven innovation and more flexible pathways to decarbonisation.

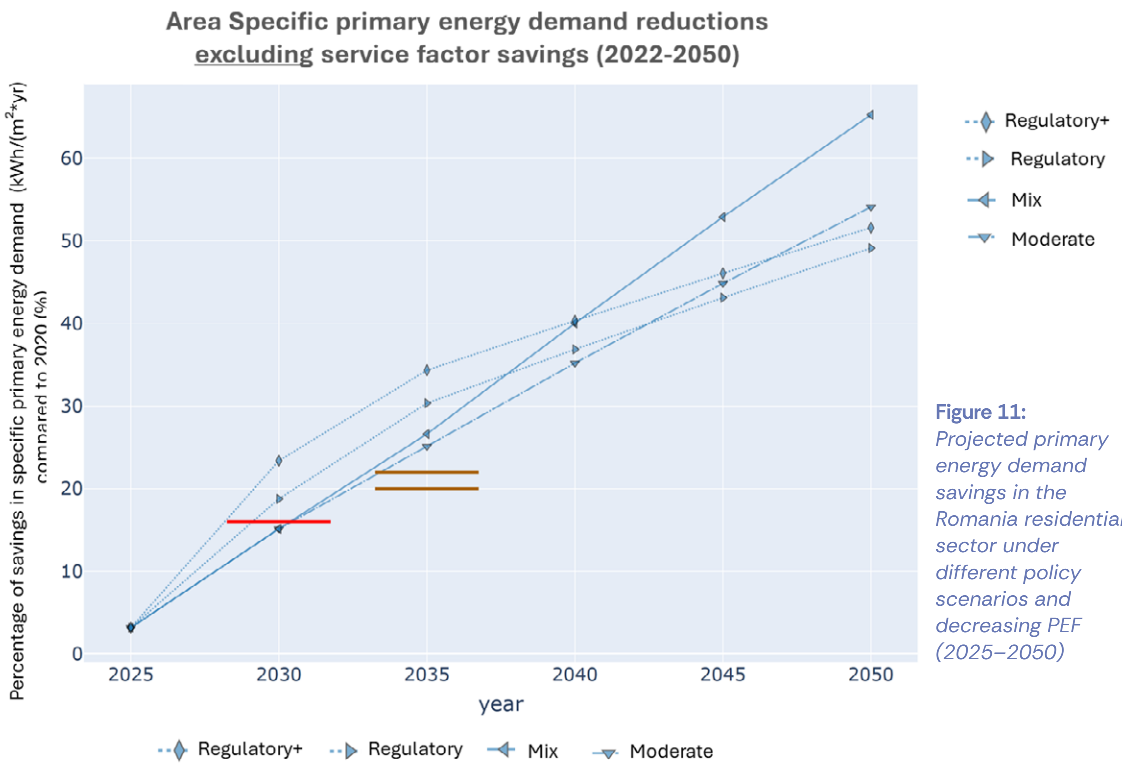


Figure 11: *Projected primary energy demand savings in the Romania residential sector under different policy scenarios and decreasing PEF (2025–2050)*

The choice of **primary energy factors** also matters (Figure 12). When lower PEF values are applied – reflecting a cleaner, more electrified energy system – calculated savings increase noticeably, especially beyond 2035 as fossil heating gives way to renewable electricity. This demonstrates that building efficiency gains and energy sector decarbonisation need to advance in tandem to maximise overall impact.

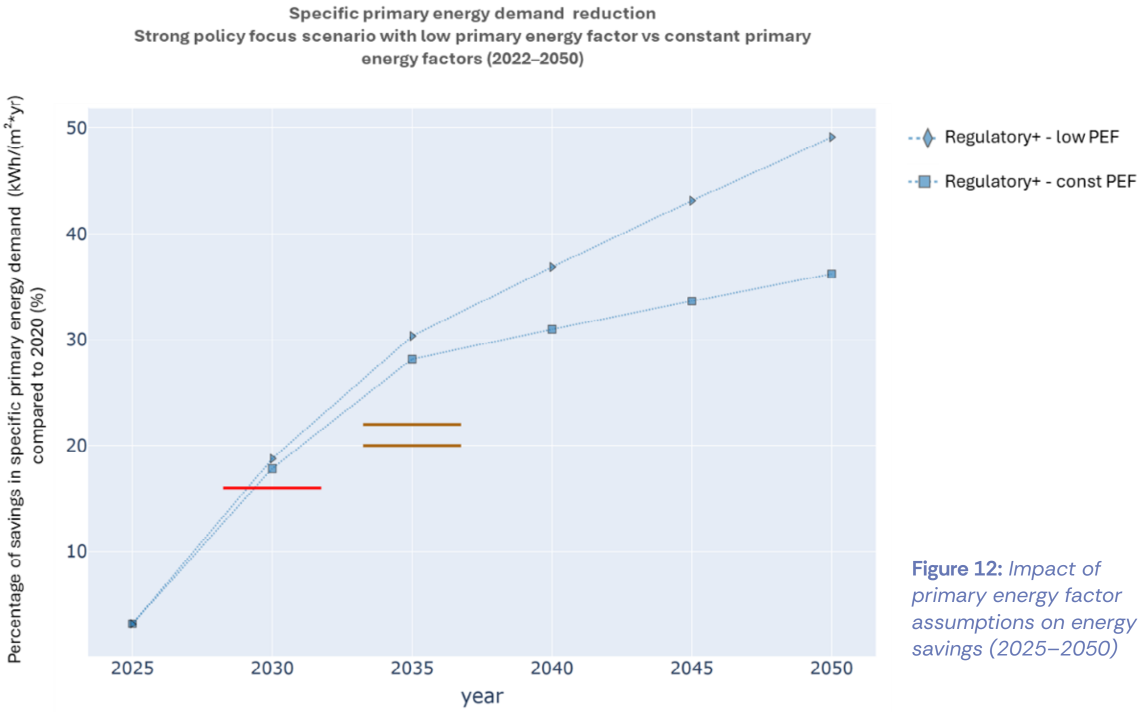


Figure 12: *Impact of primary energy factor assumptions on energy savings (2025–2050)*

Service factor assumptions introduce another layer into energy savings projections, revealing the gap between technical potential and actual consumption outcomes (Figure 13). When **service factor savings are excluded** (left panel), the Regulatory and Regulatory+ scenarios clearly meet the 2030 and 2035 targets, reaching energy savings between 16–24% by 2030 and 30-35% by 2035. However, the Moderate and Mix scenarios fall short of both targets, remaining below 16% in 2030 and struggling to reach 20–22% by 2035. By 2050, the scenarios diverge significantly: the Moderate scenario achieves approximately 63% savings, followed by the Mix scenario at approximately 52%, while the Regulatory and Regulatory+ scenarios reach approximately 50% and 49% respectively.

When **service factors are included** (right panel), all scenarios benefit from additional savings due to improved operational efficiency, user behaviour and control systems. This inclusion helps the weaker policy scenarios approach the 2030 target more closely, while strengthening the performance of the Regulatory and Regulatory+ scenarios to 20–31% by 2030 and 32–44% by 2035. By 2050, the inclusion of service factors amplifies long-term savings across all scenarios: the Moderate scenario reaches approximately 65%, the Mix scenario approximately 53%, and the Regulatory and Regulatory+ scenarios approximately 51% and 50% respectively.

However, the fundamental policy hierarchy remains: the Moderate scenario maintains the highest long-term trajectory under both methodologies, while the Regulatory+ scenario shows the lowest final savings despite its superior short-term performance. This suggests that while service factor improvements enhance overall energy demand reduction by 1–3 percentage points, they cannot fundamentally alter the relationship between policy ambition, near-term compliance and long-term transformation pathways.

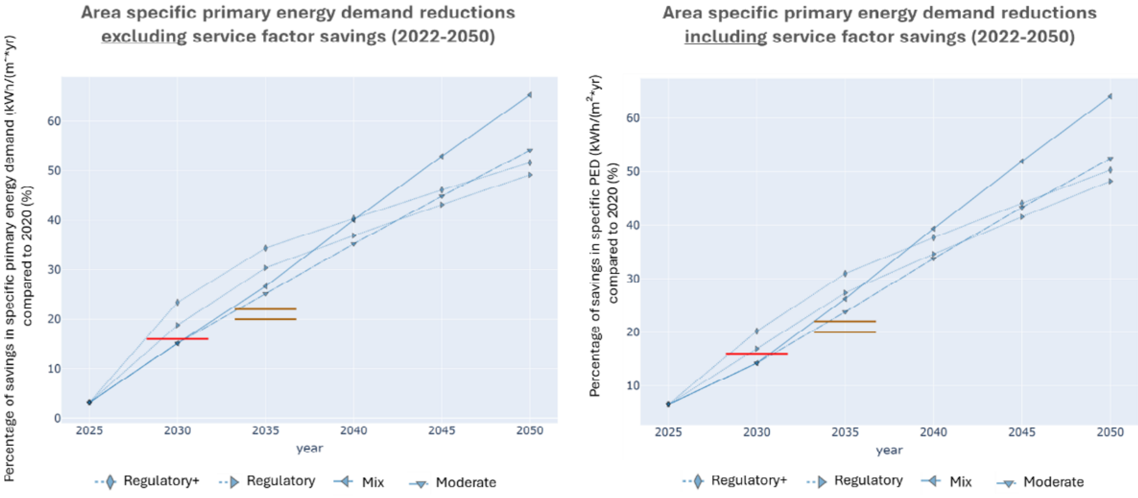


Figure 13: *Effect of service-factor (with/without) improvements on primary energy demand reduction under decreasing PEF (2025–2050)*

The interaction between service factors and primary energy factors adds further complexity to the savings calculation. As shown in Table 3, electricity PEF declines from 2.5 in the base year to 1.8 by 2050, while district heating PEF decreases from 1.5 to 1.15 over the same period – reflecting progressive decarbonisation of energy supply.[3] These declining PEF values amplify the calculated savings from electrification strategies, particularly in later years when heat pumps replace fossil fuel systems at scale.

Table 3: Primary energy factors for Romania for the base year and the years 2027–2050

Romania								
	Base	2027	2030	2033	2035	2040	2045	2050
Gas	1.1							
Oil	1.1							
Biomass	1.13							
Electricity	2.5	2.4	2.3	2.2	2.1	2	1.9	1.8
District heating	1.5	1.45	1.4	1.35	1.3	1.25	1.2	1.15

The results suggest three takeaways:

- ✔ Regulatory ambition through MEPS is the most powerful lever for achieving early compliance with 2030 and 2035 targets, though economic instruments may unlock greater long-term transformation by 2050.
- ✔ Energy system decarbonisation (declining PEF) amplifies building efficiency benefits and calls for coordinated policy action across sectors.
- ✔ Service factor improvements provide additional energy savings while reflecting real-world operational efficiency, though they do not fundamentally alter the policy hierarchy between scenarios.

3 District heating PEF values are assumed to decrease over time without detailed technology modelling. Values below 1.0 reflect expected integration of waste heat and heat pumps. The specific PEF for waste heat and technology contributions have not been explicitly modelled.

5 STAKEHOLDER ENGAGEMENT FOR ARTICLE 9 TRANSPOSITION

As part of the exchange and feedback process on the best implementation of the policy instruments, EPBD.wise hosted online and in-person policy forums with Romanian stakeholders and policymakers. While Article 9 was not one of the central points of discussion, the exchange around the NBRP some key points related to Article 9 emerged relating to the need for:

1. **Robust and accessible building data**, given that MEPS and national renovation trajectories depend on accurately identifying worst-performing buildings. The Ministry confirmed ongoing work on a national digital building registry, which should enable systematic tracking of building characteristics, EPCs, renovation status and geographic distribution of worst-performing buildings – necessary preconditions for credible MEPS design. The extraction of 400,000 EPCs for the NBRP also shows the scale of the data effort required.

2. **Coherence between financial instruments** (national recovery and resilience plan, Social Climate Fund, Cohesion Funds) and the renovation trajectory, especially for worst-performing buildings and vulnerable households, which often overlap in Romania. Several ministries acknowledged that energy poverty mapping developed under the Social Climate Fund can support identification and prioritisation of worst-performing buildings under Article 9.

6

COMPLIANCE, MONITORING AND EVALUATION

To ensure effective implementation of MEPS for non-residential buildings as well as for the national trajectory, Romania must establish clear frameworks for compliance, monitoring and enforcement. These elements are essential to track progress, secure building owner engagement, and achieve national energy and climate targets.

Compliance mechanisms for MEPS:

1. Initial efforts may focus on sectors with stronger administrative control and better data availability, such as **public or large commercial buildings**, as recommended in Deliverable D3.1 "EPBD Article 9 – Minimum Energy Performance Standards (MEPS) and trajectories for progressive renovation: Policy needs and analysis of good practice examples" [1].

2. Where data coverage is incomplete, **simplified compliance methods** (e.g. modelled estimates, statistical proxies) may be required in the short term, alongside efforts to improve EPC and building logbook coverage. These methods are particularly relevant given this report's findings on insufficient baseline data and the need to develop practical, scalable interim solutions.

3. **Enforcement mechanisms** should include proportionate sanctions and clearly defined exemption criteria. Penalty revenues could be reinvested to strengthen administrative capacity or support renovation efforts. Compliance tracking should also be aligned with the long-term renovation strategies and trajectories defined in the national building renovation plan.

Guidance on monitoring and evaluation of the national trajectory can be found in D2.2 "Development of NBRP: Policy Guidelines for Romania"[2].

1. Romania should **designate competent authorities** and define transparent procedures to verify compliance with MEPS.

2. Building owners must be informed early about the applicable energy thresholds (2030, 2033, 2040, 2050) and supported with appropriate technical and financial assistance.

3. It should be assessed whether compliance can primarily be demonstrated through updated **EPCs**, or whether alternative approaches should be considered – such as compliance based on a defined list of renovation measures linked to national energy performance standards. This reflects a key policy to reduce overreliance on EPCs due to data gaps and limited coverage, particularly in the private sector. Even if EPCs are used as the main tool, issuing an EPC for every individual building may not be necessary. Targeted spot checks could be prioritised in segments with a high likelihood of non-compliance, reducing administrative burden while ensuring credible enforcement (as recommended in D3.1 "EPBD Article 9 – Minimum Energy Performance Standards (MEPS) and trajectories for progressive renovation: Policy needs and analysis of good practice examples" [1])

Suggested first steps:

- Appoint national and regional authorities for MEPS oversight.
- Define the data sources and methods for compliance verification.
- Set out compliance rules and publish clear guidance for building owners.
- Launch early communication and outreach campaigns, especially for public and commercial building owners.
- Pilot compliance checks and digital monitoring tools in selected municipalities.

Clear roles, transparent procedures and accessible data systems will be essential to ensure that MEPS drive large-scale, cost-effective renovations.

7

CONSISTENCY AND INTERACTION WITH OTHER POLICY INSTRUMENTS

7.1 National building renovation plan

The **NBRP** is the **central coordination and reporting framework** within which Article 9 mechanisms must be planned, quantified and monitored. The two are therefore deeply interdependent: while Article 9 provides the regulatory engine for achieving measurable reductions in energy demand, the NBRP provides the **strategic roadmap** that integrates those targets into a coherent national policy framework.

Each Member State must include in its NBRP the thresholds for non-residential MEPS and the national trajectory milestones for residential buildings (2030, 2035, 2040, 2050). The plan must also identify the number and floor area of the worst-performing buildings, the policy measures to address them, and the financing and administrative resources required. This ensures that Article 9's quantitative obligations are embedded in a transparent, long-term strategy subject to Commission review.

The **interaction** is therefore **cyclical**: the NBRP informs Article 9 by supplying baseline data on the building stock (often derived from EPC databases) and implements Article 9 by translating thresholds into concrete programmes and investments. Conversely, the milestones in Article 9 structure the NBRP's timeline and provide measurable indicators of progress. A coherent link between the two avoids fragmentation, guarantees consistency with national energy and climate plans, and facilitates the assessment of compliance at both national and EU level.

To maximise effectiveness, Member States should synchronise the development of their Article 9 trajectories with the first draft NBRP due by December 2025, enabling early feedback from the European Commission. Integrating MEPS and trajectories within the NBRP transforms the latter from a descriptive plan into a dynamic governance tool that tracks the transition toward a zero-emission building stock.

7.2 Energy performance certificates

The **EPC** system is both a **compliance and monitoring instrument** for Article 9. For non-residential buildings, EPCs provide the data required to identify the 16% and 26% worst-performing segments and to verify renovation compliance with MEPS. For residential buildings, EPC databases underpin the statistical overview needed to establish and monitor national trajectories of average primary energy demand reduction.

The revised EPBD strengthens this link by requiring recalibration of EPC classes (A–G) by 2026, aligning class A with the zero-emission building (ZEB) standard and class G with the worst-performing stock – precisely the segment targeted by Article 9. This creates a consistent reference scale across the EU, allowing Member States to express MEPS thresholds and trajectory milestones either in absolute (kWh/m²) or relative (EPC-class) terms.

An EPC thus serves three complementary functions:

- **Data foundation**: it generates harmonised, verifiable information on energy use, emissions and renovation progress.
- **Compliance mechanism**: it enables building-level verification of MEPS compliance and facilitates enforcement.
- **Policy feedback loop**: aggregated EPC data feeds into NBRP monitoring and helps evaluate the effectiveness of Article 9-driven measures.

The interaction also extends to **communication** with building owners. Updated EPCs issued after major renovations document the improvement achieved under Article 9 schemes, reinforcing transparency and consumer confidence. To ensure reliability, Member States must strengthen quality control and align EPC issuance cycles with MEPS milestones. The more robust and comparable EPC systems become, the more effectively Article 9 can function as a measurable and enforceable driver of renovation.

7.3 Renovation passports

The **renovation passport** complements Article 9 by providing a **building-level roadmap** that guides owners through staged deep renovations consistent with national trajectories and MEPS targets. While Article 9 defines aggregate energy-reduction milestones, renovation passports translate these into actionable steps for individual buildings, turning regulatory obligations into practical renovation pathways.

For Member States that choose to meet their national trajectory targets through **staged deep renovations**, renovation passports are indispensable. They allow each building to plan a sequence of interventions – envelope upgrades, system replacements, integration of renewables – that cumulatively achieve the deep-renovation depth required to reach the average reduction targets of 16% by 2030 and 20–22% by 2035. Issuing renovation passports jointly with EPCs ensures technical coherence between assessment and planning, reduces costs, and provides a direct feedback mechanism for policy evaluation.

Within the broader governance framework, renovation passports support the implementation of Article 9 in three ways:

- **Operationalisation**: translating national targets into tailored building-level actions.
- **Monitoring**: creating a digital record of renovation progress, feeding into national databases used to assess Article 9 compliance.
- **Social acceptance**: improving homeowner understanding and engagement, mitigating resistance to mandatory performance standards.

To ensure coherence, NBRPs should explicitly reference the renovation passport scheme as a supporting instrument for achieving national trajectories and MEPS, including provisions for quality control, data integration, and financial incentives linked to renovation passport milestones. Together, building renovation passports and Article 9 create a **micro–macro link** between individual renovation pathways and national decarbonisation trajectories.

8 POLICY GUIDELINES AND RECOMMENDATIONS

The successful implementation of Article 9 requires a comprehensive and coordinated approach across multiple dimensions. This section outlines the key actions and strategic considerations necessary to achieve the Directive's objectives.

1 Establishment of minimum energy performance standards

Analysis of Romania's building stock distribution reveals significant variations in baseline energy consumption across non-residential sectors. The establishment of sector-specific thresholds acknowledges these differences while setting ambitious but achievable targets. Recommended thresholds, based on the database and calculation framework of the Invert building stock model are:

- Health sector ~380 kWh/(m^2·yr) for 2030 reducing to 380 kWh/(m^2·yr) by 2033
- Wholesale/retail ~240 kWh/(m^2·yr) for 2030 reducing to 220 kWh/(m^2·yr) by 2033
- Office buildings ~230 kWh/(m^2·yr) for 2030 reducing to 220 kWh/(m^2·yr) by 2033.

Critical to achieving deep decarbonisation is the integration of MEPS with targeted restrictions on fossil fuel heating systems. Modelling results demonstrate that MEPS alone maintain gas dependency, as buildings can meet performance thresholds without fundamental fuel switching. Rather, in neglecting the difference between fossil and renewable primary energy, the shift from biomass to gas could even contribute to higher primary energy savings. The Regulatory+ scenario combining MEPS with fossil fuel restrictions drives substantial improvements, reducing health sector consumption from baseline peaks of ~580 kWh/(m^2·yr) to around 350 kWh/(m^2·yr) – approximately a 40% reduction. This dual approach ensures both improved efficiency and genuine decarbonisation rather than incremental improvements that preserve fossil fuel infrastructure.

Other European countries have already enacted legislation on MEPS and targeting worst-performing buildings. **France** has introduced strict measures for buildings exceeding 450 kWh/(m^2*y) and requires homes to reach EPC class E by 2028. Scotland established minimum energy efficiency standards for private rented domestic properties, requiring new tenancies to meet EPC E from October 2020, extended to all properties from April 2022 with a higher standard of D required from April 2025[6].

2 Development of national renovation strategies

Romania's building stock is characterised by a pronounced urban-rural divide, with single-family homes predominating in rural areas where they face implementation challenges including dispersed locations, individual ownership structures, limited access to qualified contractors, and weaker administrative capacity at the municipal level. In contrast, urban areas contain concentrated blocks of flats with established condominium management structures, better access to construction professionals, and stronger municipal technical capacity. Stakeholder consultations identified these urban-rural differences as a fundamental implementation constraint. There is ongoing debate in Romania regarding whether single-family homes should even be included in MEPS given these challenges, though ultimately the national strategy must encompass all residential sectors as mandated by the Ministry of Regional Development's responsibility to develop MEPS at national level.

Renovation strategies must align with Romania's planned electricity and district heating PEF reductions – electricity declining from 2.5 to 1.8 by 2050, district heating from 1.5 to 1.15 by 2050 – while ensuring physical building improvements remain the primary driver. Declining PEFs will automatically improve buildings' calculated primary energy performance, but this cannot substitute for actual fabric improvements. Renovation strategies must prioritise envelope measures, efficient heating systems and renewable integration to achieve genuine decarbonisation, treating PEF evolution as a complementary factor that enhances rather than replaces physical interventions.

France targets worst-performing buildings (EPC classes F and G) with progressive deadlines: no class G buildings by 2025, class F renovated by 2028, and all buildings achieving at least EPC D by 2034, with penalties for non-compliance. For large commercial buildings over 1,000 m^2, France mandates final energy consumption reductions of 40% by 2030, 50% by 2040 and 60% by 2050[6]. Similarly, **England and Wales** established progressive deadlines for rented properties, requiring residential buildings to achieve EPC class E by 2020 and C by 2028, while rented non-residential properties must meet EPC class E by 2021, D by 2025 and C by 2028[7]. **Brussels**' phased renovation obligation model represents another progressive approach, requiring homeowners to implement selected EPC measures incrementally every five years toward a 2050 performance target of 100 kWh/(m^2*y)[8].

3 Financial and technical support mechanisms

From the discussions with national stakeholders, it emerged that Romania faces a significant financing challenge, with the government adopting a medium-ambition renovation target requiring approximately €30 billion in funding. Currently, Romania has several financing programmes supporting smaller-scale measures like photovoltaic panel installation but lacks adequate comprehensive financial support for deep building renovation. The coordination challenge is compounded by the absence of policies and mechanisms to attract private investment, meaning renovation financing relies almost entirely on public funds and EU programmes. There is a need for a coordination mechanism that establishes clear eligibility criteria explicitly linking funding to Article 9 worst-performing buildings, rather than opportunistic first-come-first-served allocations that have characterised past renovation programmes. Programme indicators should be updated to align with nZEB or ZEB standards for approved projects, ensuring that public investment drives the performance improvements required under Article 9 rather than supporting minimal interventions.

France consolidated renovation support through MaPrimeRénov launched in 2019, merging multiple previous subsidies into a single streamlined programme prioritising low-income households and tying support levels to energy performance improvements. Complementary programmes like SARE and FAIRE provide free information and guidance through a public service platform, creating a comprehensive ecosystem of financial and advisory support that has significantly increased renovation uptake.

Additionally, Romania currently lacks centralised one-stop shops, representing a critical gap in implementation infrastructure. The establishment of regional one-stop shops providing integrated technical and financial advisory services is a stated government goal that addresses complexity and information barriers particularly acute in the Romanian context. Building owners, especially in the residential sector dominated by single-family homes in rural areas, often lack expertise to navigate regulatory requirements, technical options and the fragmented landscape of available funding programmes. The one-stop shop model must be designed to bridge the urban-rural divide, with regional centres capable of serving dispersed populations and addressing the specific challenges of renovating single-family homes in rural areas. Given that Romania has limited numbers of qualified workers, one-stop shops can also serve as coordination points for workforce deployment, matching available skilled professionals with renovation demand. The regional structure should be established through pilot programmes in 2-3 regions during the foundation phase (2024-2026), testing service delivery models before national scaling, with particular attention to developing approaches that work in both urban multi-family contexts and rural single-family home settings.

Brussels demonstrates effective one-stop shop implementation through the IRISbox platform, which standardises and simplifies administrative procedures for building renovation grants. This digital platform allows applicants to manage all aspects of applications through a single interface, reducing processing time and administrative burden for both applicants and authorities.

4 Compliance and monitoring mechanisms

A comprehensive national building registry represents the foundational requirement for effective Article 9 implementation and Romania's most critical immediate priority. Currently, Romania lacks clarity on which buildings perform worst and their proportion in the overall building stock. As a consequence, renovations occur on a first-come-first-served basis rather than strategically targeting the worst performers. Romania's current building stock database derives from statistical data and fragmented institutional databases, with the government planning to create a national building registry integrating building data and existing EPCs. Romania should accelerate registry development to integrate the approximately 400,000 existing EPCs plus statistical modelling for uncovered buildings, with a completion target of December 2026. The registry must address the particularly severe data gaps in the non-residential segment, which currently lacks comprehensive coverage. Building renovation passports can play a crucial role in both identifying worst-performing buildings and implementing MEPS by providing standardised assessment and improvement pathways. The government plans to integrate EPCs into the building renovation passport standard so that information on worst-performing buildings, including category classification and target performance levels, is systematically captured.

Simplified compliance pathways using standardised lists of renovation measure are particularly critical for Romania given its building stock composition and institutional capacity constraints. With single-family homes prevalent especially in rural areas, Romania must develop compliance approaches that work for dispersed, individually owned properties where full energy assessments may be prohibitively expensive relative to building value. Standardised measure packages – such as insulation to specified R-values, window replacement standards, and heating system upgrade requirements – provide clear requirements while maintaining performance outcomes. This approach should be developed for different building typologies, recognising the distinct characteristics of blocks of flats versus single-family homes, and urban versus rural contexts. The Ministry of Regional Development, tasked with implementing the political framework of MEPS, should develop these standardised pathways at national level encompassing all residential sectors, with particular attention to making them accessible and economically viable for single-family homeowners in rural areas where administrative capacity and market infrastructure are most limited.

England and Wales use transactional trigger points, prohibiting rental of properties not meeting minimum EPC E standard since 2018 for domestic properties and 2023 for non-domestic properties. Local authorities can impose financial penalties up to £4,000 for renting non-compliant properties for three months or more, £2,000 for shorter periods, and £1,000 for providing misleading information[9]. **Belgium's Flanders** region employs a penalty point system where rental homes not meeting minimum insulation standards accrue penalty points, with homes accumulating 15 points banned from rental as of January 2020[10]. **The Netherlands** uses EPCs as a compliance verification tool, with penalties ranging from pecuniary fines to prohibition of rental for non-compliant buildings[11].

5 Stakeholder engagement and qualified workforce

Developing a qualified workforce capable of delivering required renovation services represents a critical constraint in the Romanian context. While Romania has existing programmes for building energy efficiency professionals – such as the Green Building Professional certification and training programme organized by the Romanian Council for Green Buildings – the number of qualified workers remains limited, and training schemes require significant reinforcement to meet the scale of Article 9 requirements. Professional capacity building must expand substantially through structured training programmes for energy auditors, renovation contractors, building system installers and quality assurance inspectors. A particular challenge is the current lack of a clear and efficient system to verify the quality of energy audits conducted by certified auditors, meaning that strengthening institutional oversight is essential to ensure higher standards and more reliable outcomes. The workforce development strategy should address both quantitative expansion – training sufficient numbers of professionals – and qualitative improvement through better verification systems and continuing education requirements. This workforce development should anticipate the scale of renovation activity required, with particular attention to developing capacity in rural areas where qualified professionals are scarce and supporting the deployment of workers across the urban-rural divide.

The Netherlands established an approved register of energy advisors through the Netherlands Enterprise Agency, ensuring building owners receive qualified guidance. Combined with online tools for assessing investment costs and carbon savings, this system provides both digital resources and human expertise, proving particularly effective for office buildings complying with the EPC C requirement.

9

REFERENCES

[1] BPIE - Buildings Performance Institute Europe. 2024. *EPBD Article 9 - Minimum Energy Performance Standards (MEPS) and trajectories for progressive renovation: Policy needs and analysis of good practice examples.* www.bpie.eu/publication/epbd-article-9-minimum-energy-performance-standards-meps-and-trajectories-for-progressive-renovation-policy-needs-and-analysis-of-good-practice-examples

[2] Özer, E. et al. 2026. Development of NBRP: *Policy Guidelines for Romania*.

[3] European Parliament and Council. 2024. *Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast) (Text with EEA relevance).* https://eur-lex.europa.eu/eli/dir/2024/1275/oj/eng

[4] Kranzl, L. et al. 2019. 'Are scenarios of energy demand in the building stock in line with Paris targets?' *Energy Efficiency* 12(1): 225–243. doi: 10.1007/s12053-018-9701-1

[5] European Commission. 2025. *Commission Notice providing guidance on new or substantially modified provisions of the recast Energy Performance of Buildings Directive (EU) 2024/1275.* 2025. https://data.europa.eu/eli/C/2025/6438/oj

[6] French government. 2015. Légifrance, *Code de l'énergie [Energy code]. (Article L100-4, as modified by Law n° 2015-992 of 17 August 2015).* www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000047303609

[7] UK government. 2015. *The Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015.* www.legislation.gov.uk/ukdsi/2015/9780111128350/contents

[8] Regional Government of Brussels-Capital. *Stratégie de réduction de l'impact environnemental du bâti existant en Région de Bruxelles-Capitale aux horizons 2030-2050.* https://environnement.brussels/sites/default/files/user_files/strategie_reno_fr.pdf

[9] UK government. 2020. *The Domestic Private Rented Property Minimum Standard.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/882957/Domestic_Private_Rented_Property_Minimum_Standard_-_Landlord_Guidance_2020.pdf

[10] Vlaamse Regering. 2020. *Long-Term Strategy for the Renovation of Flemish Buildings.* https://energy.ec.europa.eu/document/download/921e2081-983c-4812-b416-4de8943df275_en?filename=beflanders_ltrs_2020_en.pdf

[11] Netherlands Enterprise Agency. 2020. *Energielabel C kantoren — de stand van zaken [Energy label C offices — the state of affairs].* www.rvo.nl/actueel/nieuws/energielabel-c-kantoren-de-stand-van-zaken

10

ANNEX A:
MODEL DOCUMENTATION

A.1 Invert EE-Lab

Invert/EE-Lab is a comprehensive bottom-up techno-socio-economic building stock model that simulates energy-related investment decisions in buildings, specifically focusing on space heating, hot water generation and space cooling end-uses[13]. The model is based on a highly disaggregated description of building stocks across EU-27+ countries (including Iceland, Norway, Switzerland and the UK), incorporating:

- Building characteristics: type, construction period, renovation state, existing heating systems
- User structure: ownership patterns, occupancy types, decision-making behaviour
- Regional elements: availability of energy infrastructure (district heating, natural gas) at the sub-country level
- Climate zones: heating and cooling degree days by region.

The model simulates investment decisions in building envelope improvements and heat supply/distribution systems through a combination of discrete choice approaches and technology diffusion theory. As a myopic simulation tool, it evaluates the effects of different policy interventions, including economic incentives, regulatory measures and technology development programmes, on total energy demand, energy carrier mix, emission reductions and costs.

Key model capabilities include:

✔ Simulation of renovation decisions under different policy frameworks
✔ Assessment of heating system replacement choices
✔ Projection of energy demand by carrier and end-use
✔ Evaluation of policy cost-effectiveness.

Analysis of technology diffusion patterns

Invert/EE-Lab has been applied in over 40 projects across EU-27+ countries over more than 10 years, supporting policymakers, researchers and industry professionals in energy efficiency and building technology assessment [11], [12].

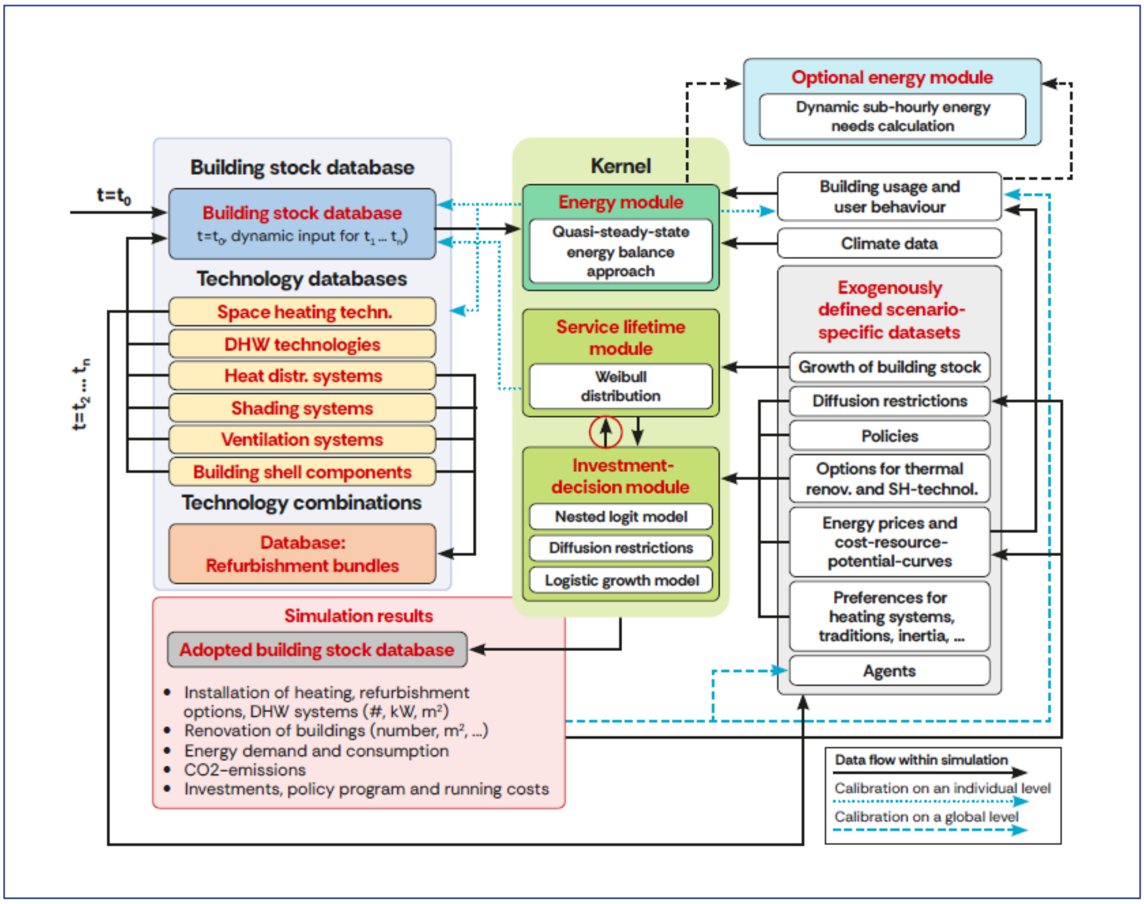


Figure 14: *Overview of the structure of Invert/EE-Lab*

The figure illustrates the model's structure, showing the interaction between building stock characterisation, policy inputs, investment decision modules and output indicators. The discrete choice module determines renovation and heating system decisions based on economic factors, policy incentives and behavioural parameters. Technology diffusion constraints ensure realistic deployment rates for new technologies.

A.2 Invert/Opt Model

Invert/Opt is a derived model version specifically designed to calculate cost-optimal renovation scenarios. Unlike the simulation-based Invert/EE-Lab, Invert/Opt uses optimisation algorithms to identify the most cost-effective combination of technology options for both heat savings (envelope measures) and heat supply (heating systems) across different time periods.

Key features of Invert/Opt include:

- ✔ Cost-optimality calculation: Identifies renovation measures that minimise total costs (investment + operating) while meeting energy or emission targets
- ✔ High disaggregation: Varies by country from several hundred to several thousand building segments, split across multiple climate regions
- ✔ Diffusion constraints: Accounts for limited availability of tradeable biomass, energy infrastructure constraints, and suitable roof areas for solar technologies

Technology mix outputs: Produces diverse technology portfolios even in optimisation mode, reflecting real-world constraints.

The model calculates cost-optimality for:

✔ Building envelope retrofitting (insulation of walls, roofs, floors; window replacement)
✔ Heating and hot water supply system replacement
✔ Integration of renewable energy technologies (solar thermal, heat pumps, biomass)

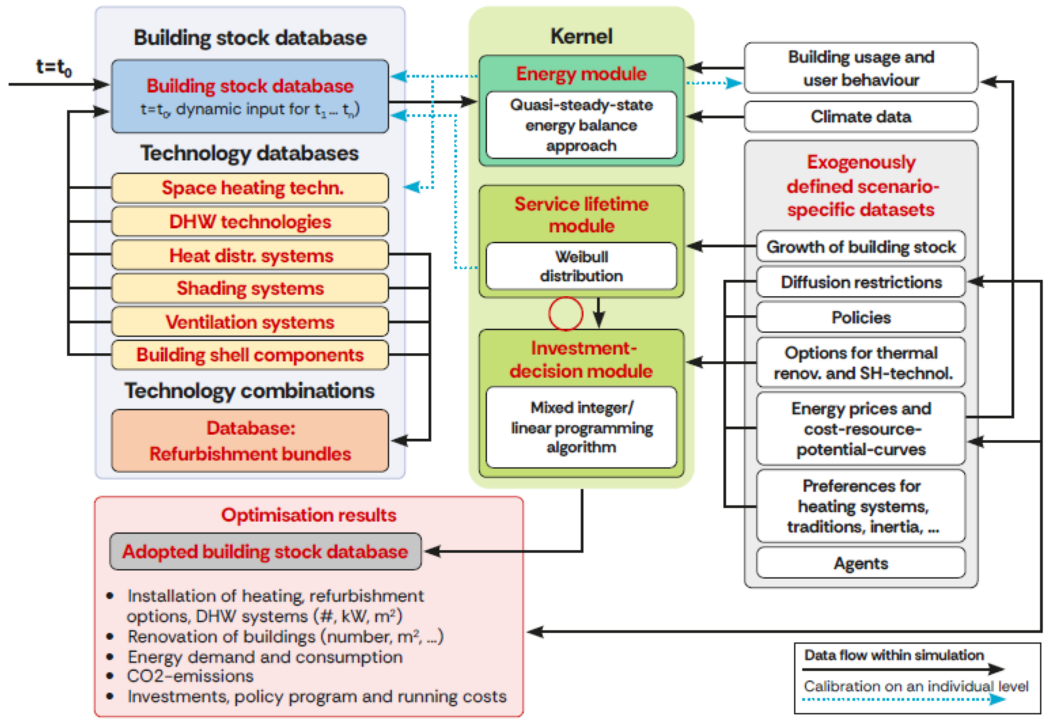


Figure 15: *Overview of the structure of the Invert/Opt*

The figure shows the optimisation framework, illustrating how building stock segments, technology options, cost parameters and constraints feed into the optimisation algorithm to produce cost-optimal renovation pathways.

EPBDwise

CONSORTIUM

Adene
Agência para a Energia

ENEA

think
Energy Research

Efficient Buildings Europe

TECHNISCHE UNIVERSITÄT WIEN

KTI

HOUSING AND MUNICIPAL REFORM SUPPORT CENTRE

BPIE

SERA
Institute for Sustainable Energy and Resources Availability

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor CINEA can be held responsible for them.