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POWERING CITIZENS

Empowering energy citizenship among energy-poor people through joint actions

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ABSTRACT

This research report investigates how the European Union's strategies for sustainable development and climate neutrality, specifically the European Green Deal, Fit for 55 package, and NextGenerationEU, can contribute to empowering energy-poor citizens and advancing energy democracy across six European countries: Italy, Greece, Germany, Kosovo, Albania, and the Netherlands. Special attention is given to the Western Balkans, where structural vulnerabilities, economic challenges, and limited infrastructure have intensified energy poverty. Through a mixed-methods approach, combining a qualitative policy analysis with quantitative assessments based on the Energy Poverty Advisory Hub (EPAH) indicators, the research evaluates the alignment between national and European frameworks and their effectiveness in addressing the needs of vulnerable groups. It examines how national and local governance structures facilitate citizen engagement, support inclusive energy transition processes, and alleviate energy poverty through targeted policies and community-based initiatives. The findings reveal a significant gap between the ambitions outlined in European and national strategies and the realities on the ground. Although legislative and financial instruments have been introduced to promote sustainability and social inclusion, implementation remains fragmented. Procedural delays, limited administrative capacities, uneven regional deployment, and weak mechanisms for citizen participation hinder the development of effective solutions, especially in the Western Balkans context. Moreover, energy poverty policies often fail to sufficiently integrate a rights-based approach that empowers citizens as active participants in the green transition, rather than passive beneficiaries. The report concludes with a set of strategic recommendations aimed at overcoming these challenges. Key priorities include strengthening multilevel governance cooperation, enhancing local administrative capacities, promoting citizen-led energy initiatives (such as renewable energy communities), and mainstreaming the concept of energy justice into climate action plans. A people-centered, inclusive approach is essential to ensure that the EU's climate neutrality goals are achieved equitably, leaving no community behind. These insights provide valuable guidance for policymakers, local authorities, civil society organisations, and other stakeholders committed to fostering resilient, fair, and participatory energy systems across Europe.

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ACRONYMS

Acronym	Analysis
AfD	Alternative for Germany
BAU	Business-As-Usual
BEK	Berlin Energy and Climate Protection Programme
CCC	Climate Change Center Berlin Brandenburg
CCfD	Carbon Contracts for Difference
CCS	Carbon Capture Storage
CDU	Christian Democratic Union
CDD	Cooling Degree Day
CHP	Combined Heat and Power
CRN	Comparative Research Network
CSU	Christian Social Union
DACCS	Direct Air Capture and Carbon Storage
DOOR	Society for Sustainable Development Design / Drustvo za Oblikovanje Odrzivog Razvoja
DTC	Deferred Tax Credit
EC	European Commission
ECS	Energy Community Secretariat
EIHP	Energy Institute Hrvoje Požar
ENEA	Italian National Agency for New Technologies, Energy and Sustainable Economic Development.
EPAH	Energy Poverty Advisory Hub
EPOV	Energy Poverty Observatory
ERO	Energy Regulatory Office
ESI	Economic Sentiment Indicator
ETS	Emission Trading System
EU	European Union
EU-SILC	European Union Statistics on Income and Living Conditions
EV	Electric Vehicle
FDP	Free Democratic Party
FSRU	Floating Storage and Regasification Unit
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HDD	Heating Degree Day
HEAVENN	Hydrogen Energy Application
HGV	Heavy Goods Vehicle
HICP	Headline Inflation
HVDC	High-Voltage Direct Current
IEA	International Energy Agency
INZEB	Initialising Energy Balance Towards Zero

ISTAT	National Institute of Statistics
KEA	Social Solidarity Income
LED	Light-Emitting Diode
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LULUCF	Land use, land-use change, and forestry
MLUK	Ministry of Agriculture, Environment, and Climate Protection
NABIS	National Biomass Strategy
NAPRER	National Action Plan for Renewable Energy Resources
NECP	National Energy and Climate Plan
NTUA	National Technical University of Athens
OECD	Organisation for Economic Cooperation and Development
PBVEK	Municipal Energy Efficiency Plan
PEAR	Regional Environmental Energy Plan
PIK	Potsdam Institute for Climate Impact Research
PKEK	National Energy Efficiency Action Plan
PMI	Purchasing Managers' Index
PNIEC	National Integrated Energy and Climate Plan
PNRR	National Recovery and Resilience Plan
PV	Photovoltaics
REC	Renewable Energy Community
RES	Renewable Energy Source
RFNBO	Renewable Fuel of Non-Biological Origin
SAF	Sustainable Aviation Fuel
SDE	Renewable Energy Grant Scheme
SDG	Sustainable Development Goal
SEN	National Energy Strategy
SGI	Sustainable Governance Indicator
SILC	Survey on Income and Living Conditions
SME	Small and Medium-sized Enterprise
SPD	Social Democratic Party
TOE	Tons of Oil Equivalent
UBA	German Environment Agency
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax
VZBV	The Federation of German Consumer Organisations (Verbraucherzentrale Bundesverband e.V.)
WAM	With Additional Measures
WEM	World Energy Model

WKB	Scientific Climate Council of the State of Brandenburg

1. Introduction

1.1. Energy poverty definition

Energy poverty occurs when a household must reduce its energy consumption to a degree that negatively impacts the inhabitants' health and well-being. It is mainly driven by three underlying causes: *a high proportion of household expenditure on energy, low income, and low energy performance of buildings and appliances*. This is how the phenomenon is presented in the web portal of the European Commission (EC) [1]. The term energy poverty was formally introduced into European Union (EU) legislation through the Directive on common rules for the internal electricity market (2009/72/EC). In 2016, the EC launched the Energy Poverty Observatory (EPOV), and in 2017, energy was officially recognised as an essential service under the european pillar of social rights [2], which also emphasised the right to assistance and protection against eviction. This work has since been continued through the Energy Poverty Advisory Hub (EPAH). The clean energy for all european package (2019) [3] required EU countries to identify, monitor, and address energy poverty in their National Energy and Climate Plans (NECPs) [4]. In response, many member states have started developing tailored approaches, including definitions, measurement tools, and targeted policies. The Commission's first Recommendation on energy poverty (EU/2020/1563) [5], part of the renovation wave strategy [6], provided guidance on measuring energy poverty, encouraged sharing of best practices, and highlighted EU funding focused on vulnerable groups. Building on this, the Fit for 55 package (2021) introduced measures to pinpoint the root causes of energy poverty, including structural vulnerabilities and inequalities. To help address surging energy prices in 2021, the Commission issued "tackling rising energy prices: a toolbox for action and support" (EU/2021/660) [7], outlining national-level actions to protect vulnerable consumers in the short and medium term. In 2022, the EU created the energy poverty and vulnerable consumers coordination group (Decision EU/2022/589) [8] to exchange best practices and policy coordination among member states to support energy-poor households. The social climate fund [9], launched in 2023, is designed to help vulnerable households, energy-poor individuals, and small businesses by financing energy efficiency upgrades. To access this funding from 2026, member states must submit social climate plans

by June 2025. The fund aims to mitigate the impact of the upcoming emissions trading system [10], which takes effect in 2027. The updated energy efficiency directive (EU/2023/1791) [11] emphasises more vigorous efforts to reduce energy poverty and enhance consumer empowerment through broad-based measures. In 2023, the Commission issued the recommendation on energy poverty [12] (C/2023/4080), along with a supporting guidance document [13] and a renewed joint declaration on enhanced consumer protection for the winter [14]. The revised energy performance of buildings directive (EU/2024/1275) [15], effective May 2024, includes specific provisions to support energy-poor and vulnerable households, particularly those in social housing. It mandates that national building renovation plans address energy poverty with dedicated policies and awareness efforts to alleviate it. The 2024 reform of the electricity market design [16] and revised gas market legislation enhance consumer protection, especially those facing energy poverty. These reforms ensure better access to information and support in case of disconnection and empower EU countries to shield at-risk consumers from unaffordable prices during a natural gas price crisis.

1.2. Global energy poverty overview and statistics

As of 2022, around 760 million people globally lacked access to electricity, and 2.3 billion still depended on unsafe and polluting cooking fuels like wood, charcoal, agricultural waste, and animal dung, a major contributor to early deaths and severe health problems, especially in the world's poorest areas [17]. According to the energy progress report (2024) [18], in 2022, the global number of people without electricity rose for the first time in over ten years. While electricity access remained at 91%, population growth outpaced progress, resulting in 685.2 million people without electricity, an increase of around 10 million compared to 2021. This setback is partly due to major global disruptions, including the COVID-19 pandemic and the geopolitical instability in Ukraine. Most people still without electricity live in Sub-Saharan Africa and the least-developed countries, many of which face heightened impacts from crises and suffer from instability, conflict, and violence. Governments in these regions are dealing with limited financial capacity due to ongoing inflation and high borrowing costs. If current trends continue, 8% of the global population, about 660 million people, will still lack electricity by 2030 (Fig. 1).

Figure 1: Global progress in access to electricity from 2000 to projected levels in 2030 [18]

According to the united nations development programme [19], 1.18 billion people live in energy poverty despite increasing access to electricity (Fig. 2). According to the same source, surprisingly, 447 million people are officially recorded as having electricity access but do not use it. This may be due to poor data accuracy or more serious service issues like frequent blackouts, broken infrastructure, or missing distribution lines. Sometimes, even connected households avoid using electricity because they lack appliances and support services or cannot afford the cost.

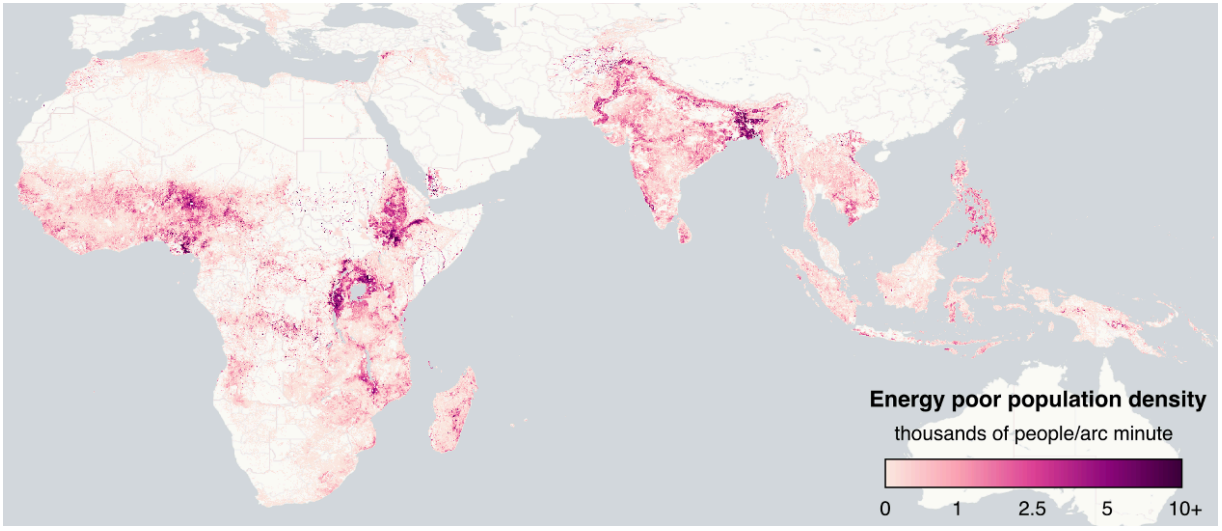


Figure 2: 1.18 billion people were energy-poor in 2020 [19]

1.3. European energy poverty overview and statistics

Depending on the measure used, 8% and 16% of the EU population experience energy poverty. Interestingly, based on a detailed review of key energy poverty indicators, many of those considered energy poor do not fall below the income poverty line [20]. Energy poverty varies widely across EU countries, influenced by diverse national conditions such as geography, climate, access to natural resources, infrastructure, and public policy. Cultural factors also affect how people report their own experiences of energy deprivation. According to [20], in Greece and Bulgaria, around 30% of the population qualifies as energy-poor based on at least two indicators, whereas in Western and Northern Europe, this rate drops below 5%. The contrast is even more significant with subjective measures which tracks the inability to keep homes warm, ranging from nearly zero in Sweden and Luxembourg to about 40% in Bulgaria. A similar pattern is seen with missed utility payments. At the same time, the 2M indicator (spending over twice the national median on energy) shows more consistent levels across countries, with rates from around 10% in the Netherlands and Hungary to just over 20% in Sweden, Malta, and Latvia (Fig. 3).

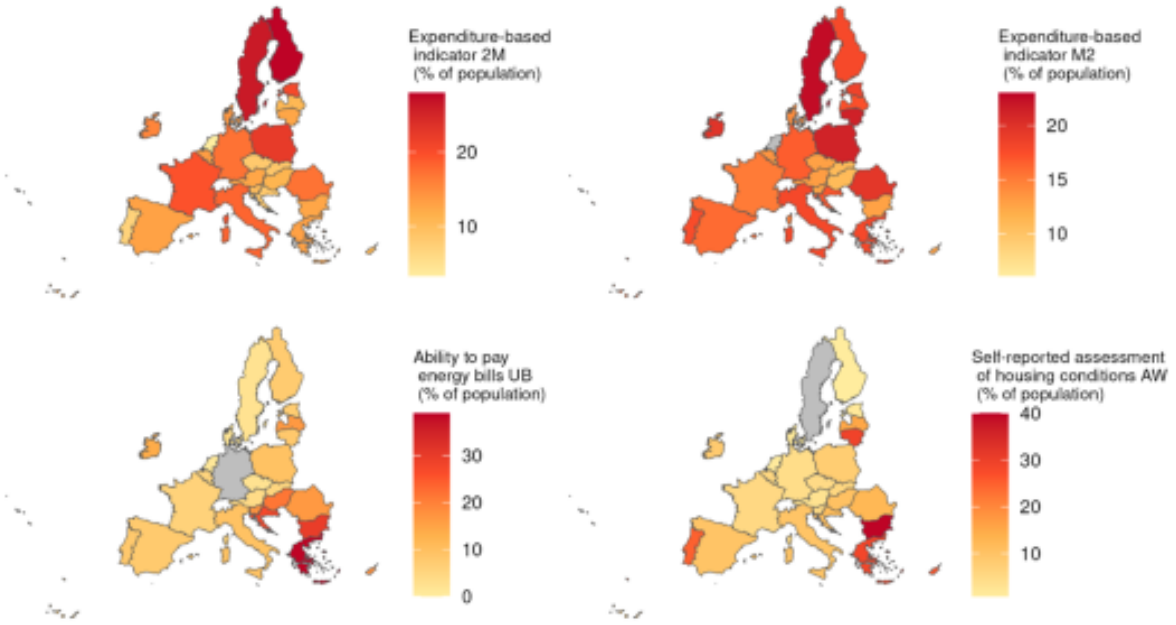


Figure 3: Share of energy-poor population by country expressed in % of the total population [20]

In particular, Fig. 3 presents four maps showing different dimensions of energy poverty across European countries, using varying shades from yellow (low) to red (high) to indicate the percentage of affected populations.

- **Top Left (2M Indicator):** Shows the share of people spending more than twice the national median on energy, highest in Northern and Eastern Europe, signaling high energy cost burdens.
- **Top Right (M2 Indicator):** Reflects those spending less than half the median, also prominent in the North and East, hinting at under consumption due to affordability issues.
- **Bottom Left (UB Indicator):** Depicts the share unable to keep homes warm, particularly high in Southeast Europe (e.g., Greece, Bulgaria), pointing to struggles with energy access.
- **Bottom Right (AW Indicator):** Shows self-reported poor housing conditions, worst in parts of Eastern Europe, especially Romania and Bulgaria.

Overall, Eastern and Southern Europe emerge as hotspots of energy poverty, while Nordic countries, despite high costs, show fewer perceived hardships, likely due to stronger social systems. These findings highlight the need for policy solutions tailored to each country's context, considering income, energy costs, and household investments in energy efficiency. They also stress the importance of choosing the right indicators when comparing energy poverty across nations.

1.4. Western Balkans energy poverty overview and statistics

The Western Balkans are home to over 17 million people, living in approximately 5.5 million households. Serbia holds the largest share in regional energy-related matters among these countries, with nearly 7 million residents and 2.5 million households. Energy poverty is a topic highlighted for this region, though no specific policies are in place for all countries. This chapter provides an analysis for each Western Balkan country.

Albania

Albania does not yet have an official definition of energy poverty, although its legal and regulatory framework recognises the concept of vulnerable customers. Multiple laws ensure support for low-income or socially vulnerable groups, including legal protections against electricity disconnection and establishing a registry of energy customers in need. Financial support is provided through direct subsidies, including compensation schemes for electricity usage below a 300 kWh/month threshold. In 2023, at least 11,200 households received a small subsidy of maximum of ALL 648 (5 €)/month/household. Additionally, a solar thermal collector installation programme targeting low-income families aims to reduce energy costs, with around 20,000 families expected to benefit. However, Albania still lacks long-term structural solutions, such as large-scale building retrofits or widespread incentives for energy efficiency [21].

Bosnia and Herzegovina

Bosnia and Herzegovina does not have a unified national definition of energy poverty or a national target for its reduction. Definitions of vulnerable customers vary by region, Republika Srpska, the Federation of Bosnia and Herzegovina, and Brčko District all have slightly different criteria. Most energy poverty support comes from local-level programmes. For example, Sarajevo provides seasonal subsidies for heating, and in the Federation, low-income pensioners receive subsidised electricity through utility reallocation schemes. Despite these efforts, the country lacks a national-level coordination mechanism, a centralised database of vulnerable customers, and long-term structural measures such as incentives for energy-efficient housing improvements or heating system upgrades [21].

Kosovo

Kosovo does not yet have a legally adopted definition of energy poverty, though one is proposed in the draft Law on Energy, which is aligned with the EU's definition. The existing support system relies heavily on social assistance schemes, which subsidise electricity for more than 36,000 households, including war invalids, veterans, and persons with disabilities.

A block-tariff system introduced in 2022 protects low-consumption users from price hikes. Future measures under the Energy Strategy 2022–2031 aim to expand support to 200,000 households, establish green housing for vulnerable groups, and promote energy efficiency. However, Kosovo lacks comprehensive energy efficiency or renewable energy measures targeted at the energy-poor, and a registry of vulnerable customers has not yet been established [21].

Montenegro

Montenegro has not adopted a formal definition or set a national target for reducing energy poverty, although it legally recognises the concept of vulnerable consumers. The country's current approach is primarily focused on financial relief. For example, subsidies covering 30% to 50% of electricity bills are offered up to 47,573 households, especially low-income pensioners and welfare recipients. Other subsidy programmes provide partial bill coverage to over 21,000 families. Despite this support, Montenegro lacks long-term energy efficiency initiatives or renewable energy programmes to address poverty. The national response remains centered on compensatory financial schemes rather than structural improvements [21].

North Macedonia

North Macedonia doesn't have an energy poverty definition, though the country has formally recognised "vulnerable consumers" in its legislation and integrated related targets into its NECP. The main instruments used to support energy-poor households include block tariffs, direct subsidies, and targeted social programmes. An estimated 53,000 households receive annual financial support. The government and the energy efficiency fund also coordinate efforts to implement energy-saving measures and improve housing conditions. Planned reforms aim to enhance energy efficiency further, introduce heating system upgrades, and develop more tailored support for energy-vulnerable households, moving beyond purely financial aid [21].

Serbia

Serbia has one of the Western Balkans' most comprehensive energy poverty frameworks. The country has legally defined energy poverty and incorporated related strategies in its national planning. Over 200,000 households receive support through electricity bill compensation schemes. Additional local government programmes help subsidise heating and electricity costs, particularly for socially vulnerable households. Serbia also implements energy efficiency initiatives, including replacing inefficient appliances and improving insulation, especially targeting social housing units. The combination of national financial support and local energy efficiency programmes makes Serbia relatively advanced in its approach to tackling energy poverty [21].

2. Research & Methods

This research adopts a structured framework for assessing energy poverty, primarily based on the indicators of the Energy Poverty Advisory Hub (EPAH). These indicators allow for a comprehensive evaluation of energy vulnerability by considering four key dimensions: climate-related energy needs, housing and facilities, mobility constraints, and socioeconomic conditions. The analysis incorporates qualitative and quantitative data, including national policy documents, statistical reports, and case studies from selected European countries. Specific parameters were chosen from the broad range of EPAH indicators to assess energy poverty in the POWERINGCITIZENS project countries. These include household arrears on utility bills, the inability to keep homes adequately warm, a high percentage of income spent on energy, and inadequate heating and cooling systems. Additional indicators such as housing conditions, energy carrier types, and vulnerability to economic difficulties provide deeper insights into the extent and causes of energy poverty. The methodological approach also includes country-specific assessments of energy poverty policies in the Western Balkans, especially Albania and Kosovo, which are part of the project. Furthermore, each country's national and local strategies, including emission reduction targets and social protection mechanisms, are analysed to highlight best practices and persistent gaps.

2.1. Indicators released by the EPAH

EPAH is the leading EU initiative on local action against energy poverty [22]. EPAH is a key resource for communities facing energy poverty. It does not just offer advice, it supports local governments and organisations with the tools, knowledge, and funding they need to address local challenges. Whether it is helping a small village access European Union grants for energy-efficient housing or training city officials to develop affordable renewable energy projects, EPAH provides targeted assistance. EPAH collects data, shares success stories, and brings people together to learn from one another. That is the kind of collaboration EPAH promotes. At its core, EPAH is about justice and fairness, ensuring that no one is left behind in Europe's transition to clean energy. To effectively contribute to these goals, EPAH provides indicators within a structured framework to assess and address energy poverty across the EU. The latest updates refined previous indicators, eliminated redundancies, and introduced new dimensions to broaden and deepen energy poverty measurement. These indicators help

policymakers, researchers, and practitioners develop evidence-based strategies to combat energy poverty. The refined 21 indicators, which encompass various dimensions of energy poverty, including economic factors (such as arrears on utility bills and energy expenses), housing conditions (like the presence of damp or lack of heating), and health-related aspects, are classified into four main topics with multiple subtopics, as follows:

Climate Factors

Climate plays a crucial role in determining household energy needs, influencing heating and cooling demands. Two key indicators help assess climate-driven energy consumption:

- **Heating Degree Days (HDD)**: This metric measures the extent to which outdoor temperatures fall below a certain baseline (e.g., 18°C), requiring heating to maintain indoor comfort. Higher HDD values indicate greater heating demand, which can significantly increase energy expenses for households in colder regions [23].
- **Cooling Degree Days (CDD)**: This indicator assesses the number of days when outdoor temperatures exceed a certain threshold (e.g., 22°C), leading to a need for cooling. In warmer climates, high CDD values correlate with increased electricity consumption for air conditioning, impacting affordability and energy security [23].

By analysing HDD and CDD, policymakers can better understand regional energy needs and allocate resources accordingly, such as through subsidies for heating costs in colder areas or incentives for energy-efficient cooling systems in warmer regions.

Housing and Building Stock

The energy efficiency status and quality of residential buildings are key factors in determining energy vulnerability. Poor housing quality often leads to higher energy consumption and

inefficient heating or cooling, resulting in increased energy costs for residents (energy bills expenditure). This category includes:

- **Building Stock Characteristics**:
  - Percentage of energy-efficient homes: Identifies the proportion of dwellings with proper insulation, double-glazing, and other efficiency measures.
  - Presence of heating and cooling equipment: Evaluates whether households have access to adequate heating systems in winter and cooling options in summer.
  - Type of buildings: Differentiates between single-family homes, apartment buildings, and social housing, as energy vulnerability varies across housing types.

- **Energy Consumption and Equipment:**
  - Energy use by household appliances: Examines the energy demand of everyday household items like heaters, refrigerators, and lighting.
  - Reliance on different fuel types: Analyses the proportion of households using electricity, gas, oil, coal, or biomass, highlighting regions that depend on expensive or polluting fuels.
  - Smart meters and energy monitoring: Assesses the adoption of modern energy management tools, which can help households track and optimise their energy use.

- **Housing conditions:**
  - Leaks, dampness, and structural issues: Measures the percentage of homes experiencing roof leaks, water damage, and damp conditions, both energy efficiency and the health of inhabitants.
  - Lighting and ventilation: Identifies dwellings that lack adequate natural light and airflow, contributing to higher energy use and poor indoor air quality.
  - Overcrowding and living space constraints: Highlights cases where multiple families share a single dwelling, increasing energy demand and reducing comfort levels.

By designing targeted policies and funding schemes to improve building quality and energy efficiency, policymakers can effectively reduce energy poverty and enhance the living conditions of vulnerable populations.

Mobility and Transport Energy Poverty

Energy poverty is not limited to housing: it also affects transportation, which is essential for accessing jobs, education, and vital services. This category evaluates:

- **Affordability of Public Transport:**
  - Measures the cost of public transport to household income, identifying communities where transport expenses are a significant financial burden.
  - Highlights areas where low-income households may struggle to afford regular commuting costs, leading to social and economic exclusion.

- **Transport Energy Expenditure:**
  - Assesses the percentage of household income spent on fuel and transportation costs.
  - Identifies households' dependent on personal vehicles due to a lack of public transport options, which increases vulnerability to fuel price fluctuations.
  - Examines regional differences in transport accessibility, helping to develop policies that improve mobility for disadvantaged groups.

Recognising transport-related energy poverty is essential for promoting affordable and sustainable mobility solutions, such as subsidised public transport, shared mobility programs, and cycling and pedestrian infrastructure investments.

Socioeconomic Aspects

Energy poverty is deeply connected to income levels, employment status, and living conditions. This category examines:

- **Household Income and Affordability**
  - Disposable income levels: Determine whether households have sufficient income to cover energy expenses without compromising other essential needs.
  - Rent and housing cost burdens: Identifies households spending an excessive portion of income on rent and utilities, signalling financial stress.
  - Inability to keep homes warm or cool: Tracks the percentage of residents who cannot afford proper heating in winter or summer cooling, highlighting regions needing urgent assistance.

- **Energy Expenses and Market Dynamics:**
  - Percentage of income spent on energy: Measures the financial impact of energy costs on household budgets.
  - Energy price fluctuations: Assesses the volatility of energy prices and their effects on low-income families.
  - Access to affordable energy providers: Examines whether households have options to choose lower-cost energy suppliers.

- **Health-Related Impacts:**
  - Chronic diseases linked to poor housing: Evaluates the prevalence of respiratory conditions, cardiovascular diseases, and other illnesses caused by cold, damp, or poorly ventilated homes.
  - Excess winter mortality: Tracks deaths linked to inadequate heating and extreme cold conditions.
  - Mental health effects of energy poverty: Examines how stress and anxiety related to unaffordable energy bills impact overall well-being.

Understanding socioeconomic aspects of energy poverty enables policymakers to design targeted support mechanisms, such as subsidies, financial assistance, and public health programs. To expand the scope of energy poverty tracking, EPAH has introduced 11 new indicators [22] aiming to provide a more comprehensive understanding of energy poverty and to better equip policymakers and researchers with detailed tools for analysis, including:

- **Final energy consumption in households**: Provides a detailed breakdown of energy use by fuel type to identify efficiency gaps.
- **Disposable annual household income**: A key affordability metric, ensuring that energy policies align with income realities.
- **Housing cost overburden rate**: Identifies households spending an excessive share of income on rent and utilities.
- **Population unable to afford public transport**: Highlights mobility-related energy poverty risks.
- **Chronic disease prevalence and mortality data**: Offers insights into health risks related to poor energy access.

To make these insights more actionable, EPAH has updated its online dashboard, improving data organisation and usability. The indicators are now aligned with the Covenant of Mayors framework, which is a European initiative launched by the EC in 2008 aimed at supporting local and regional authorities in their efforts to achieve and exceed the EU's climate and energy targets [24]. This ensures consistent local, national, and EU-wide analyses. Additionally, new data disaggregated allow policymakers to assess energy poverty risks based on:

- **Income level** (quantiles).
- **Household type** (single-parent, elderly, etc.).
- **Tenure status** (owners vs. renters).

By expanding the understanding of energy poverty, these enhanced indicators empower policymakers to develop targeted interventions, such as:

- Renovation programs for inefficient buildings.
- Subsidies and financial aid for vulnerable households.
- Improved public transport access.

This comprehensive framework ensures that energy poverty is addressed holistically, improving living conditions and promoting social and economic fairness across Europe.

2.2. Indicators Selected in the POWERINGCITIZENS Project

The POWERINGCITIZENS project has used key indicators from EPAH to assess energy poverty and its impact on households, besides providing new ones. These indicators provide a comprehensive framework for evaluating economic vulnerability, housing conditions, and access to essential energy services.

Arrears on Utility Bills

The late payment of utility bills (e.g., electricity, gas, water, etc.) is a critical indicator of household economic vulnerability. Arrears suggest that a household is experiencing financial difficulties that may compromise its ability to maintain access to essential energy services. Persistent arrears can increase the risk of disconnection or reduced service quality, further exacerbating vulnerability. Monitoring arrears is essential for identifying households at risk and evaluating whether current social support measures effectively reach those in need. This indicator also helps assess the effectiveness of policies aimed at ensuring continuous access to basic energy services and protecting vulnerable consumers.

Inability to Keep the Home Adequately Warm

The ability to keep a home warm during cold months is essential for maintaining health and comfort. Several factors influence this ability, including the quality of thermal insulation, the

age and design of the building, the efficiency of heating systems, energy prices, and household income levels. Poor insulation, outdated heating systems, and high energy costs can force households to spend excessive amounts to maintain a comfortable indoor temperature. Additionally, low income can limit access to energy-efficient solutions or necessary heating, exacerbating the challenges of staying warm. Inadequate warmth during the winter months can result in serious health issues, particularly for vulnerable groups such as the elderly, children, and individuals with pre-existing medical conditions. Health risks include respiratory diseases and cardiovascular issues. By tracking this data, policymakers can better understand the complex link between energy poverty and health, prioritising efforts to improve building insulation, reduce energy costs, provide energy-efficient heating solutions, and implement support programs for vulnerable populations.

High Share of Energy Expenditure in Income

When a household spends a significant portion of its income on energy costs, it signals that energy is becoming an economic burden. A high ratio of energy expenditure to income suggests that the household may have to make difficult choices, such as cutting back on other essentials like food, medicine, or transportation. This is a clear indicator of energy poverty and highlights the affordability gap for many households, especially those with low incomes. The percentage of income spent on energy is a useful benchmark for identifying households that are most vulnerable to energy price fluctuations or changes in energy policy. It can also be used to assess the effectiveness of energy subsidies and determine whether they are targeted appropriately to support the financially distressed.

Population Living in Dwellings Comfortably Cool During Summer

As global temperatures rise due to climate change, maintaining a cool indoor environment during the summer months is becoming increasingly important. Households without adequate cooling systems or measures may face significant health risks during extreme heat events. Prolonged exposure to high temperatures can lead to heat exhaustion, heatstroke, and worsen existing respiratory and cardiovascular conditions. This indicator examines the proportion of the population living in homes with adequate indoor cooling during hot summer months. It includes factors such as access to cooling equipment, the effectiveness of insulation, shading, ventilation, and the overall ability to maintain a comfortable indoor temperature. This

approach to cooling adequacy goes beyond just air conditioning, recognising the importance of a holistic set of cooling strategies. Ensuring that homes remain adequately cool not only improves health outcomes but also helps reduce energy dependency, especially as electricity demands rise in the summer months. By analysing this indicator, policymakers can prioritise investments in energy-efficient cooling systems, promote passive cooling strategies, and support affordable energy solutions for vulnerable populations.

Population Living in Dwellings Comfortably Warm During Winter

Similar to the summer cooling indicator, this metric measures whether households can maintain a comfortable temperature during the winter months. Cold indoor temperatures can lead to serious health complications, including respiratory illnesses and heart disease, particularly for vulnerable groups such as children, the elderly, and people with chronic illnesses. The thermal comfort of a dwelling is influenced by various factors, including the quality of insulation, the efficiency and access to heating systems, indoor air quality, and the household's ability to afford energy costs. This indicator tracks the percentage of households unable to maintain adequate indoor temperatures during the winter, providing insight into the prevalence of energy poverty and inadequate housing conditions. By understanding these dynamics, policymakers can design more effective interventions, such as energy-efficient home renovations, subsidies for heating costs, support for affordable energy access, and public health programs aimed at reducing winter-related morbidity and mortality.

Population Living in Dwellings Equipped with Heating and Air Conditioning

Having adequate heating and cooling systems is essential for maintaining a healthy living environment, especially in regions with extreme seasonal temperatures. This indicator assesses whether households have access to these systems and examines the types of energy sources used for heating and cooling. Heating systems include central heating, electric heaters, and biomass systems, while cooling systems typically involve air conditioners or fans. The lack of appropriate heating and cooling systems indicates energy poverty, as households may be forced to rely on less efficient or costlier alternatives to maintain a livable indoor temperature. This indicator is particularly important for understanding the economic hardship experienced by households with no access to reliable energy for heating and cooling.

By analysing this data, policymakers can develop strategies to improve energy access and efficiency, such as subsidies for energy-efficient appliances and improved housing conditions.

Population Living in Dwellings with Leaks, Dampness, and Rot

The presence of leaks, dampness, and rot is a clear sign of poor housing conditions, which contribute to higher energy consumption and increased costs. Water leaks and damp walls affect the thermal performance of homes, requiring additional energy to heat or cool the space. Furthermore, mould and mildew resulting from dampness can contribute to respiratory issues, making these households more vulnerable to health problems. This indicator helps identify homes that urgently need repair or energy-efficient upgrades. It also serves as a warning that vulnerable groups, especially those with preexisting medical issues, may be living in unhealthy and unsafe conditions. Addressing these issues can have a significant impact on both health outcomes and energy efficiency by reducing energy consumption and improving living conditions.

Household Electricity and Natural Gas Prices

The affordability of electricity and natural gas is a crucial aspect of energy poverty. High energy prices can force households to reduce energy use, even at the cost of comfort, safety, or health. Energy affordability is not just about the absolute price of energy but also how these costs relate to household income. Monitoring energy prices in relation to income levels provides critical insights into whether rising costs are disproportionately impacting vulnerable populations. This indicator helps assess the need for price support mechanisms and other interventions to alleviate the financial burden on households facing high energy expenses. By analysing this data, policymakers can develop policies that promote fair energy pricing and offer financial relief to households struggling to afford basic energy services.

Vulnerability to Economic Difficulties

This indicator assesses households' overall financial stability and the degree to which energy costs contribute to their economic challenges. For example, households may experience difficulty paying for other essential services, such as healthcare, education, and food, due to high energy costs. Some households may even have to sacrifice social activities or basic well-being to meet their energy needs. By identifying households that face economic

difficulties due to high energy expenditure, policymakers can design targeted economic assistance programs to reduce the financial burden of energy costs, help reduce social exclusion, and improve the overall standard of living.

Number of Rooms per Person and Ownership Status

The number of rooms per person and ownership status are important indicators of a household's housing wealth, living conditions, and economic stability. Overcrowded households are more likely to face financial challenges that prevent them from upgrading energy systems or improving insulation. Additionally, renters often have less control over property upgrades and may live in older buildings with poor energy efficiency. This indicator helps policymakers identify areas with high housing density or poor living conditions and assess the need for affordable housing policies, renovation programs, or energy-efficient housing solutions.

Type of Energy Carrier

The type of energy carrier used for heating, cooling, cooking, and lighting determines a household's energy consumption and efficiency. Using non-renewable energy sources like coal, heating oil, or natural gas can increase energy costs and carbon emissions. Conversely, households that rely on renewable energy sources, like solar, wind, or geothermal, may enjoy lower energy bills and a more sustainable living environment. By examining the types of energy used, this indicator helps assess whether households are exposed to volatile energy prices or environmentally harmful energy sources. It also highlights the potential for transitioning to more sustainable energy solutions, such as solar panels, district heating, or biomass systems, which can reduce long-term energy costs and improve energy security.

Finally, these indicators, adapted and selected based on the EPAH repository, offer a holistic understanding of energy poverty and its impact on households. By examining factors like energy expenditure, housing conditions, and economic vulnerability, policymakers can develop effective solutions to reduce energy poverty, improve living conditions, and ensure access to affordable and sustainable energy for all.

2.3. Assessing Energy Poverty in the Western Balkans: Approaches and Strategies

To assess energy poverty in the Western Balkans, this study adopts a survey-based approach, supported by statistical data and policy document analysis. A questionnaire to measure potential energy poverty issues among the respondents, which will be available in the Training Guide report belonging to the POWERINGCITIZENS project, will be administered to residents as the core method, complemented by a review of relevant statistical data and policy documents to provide a more holistic understanding of the issue. The questionnaire is designed based on selected indicators, with each set of questions addressing specific dimensions of energy poverty. The answers will provide quantitative and qualitative indications of the extent of energy deprivation, allowing for a comprehensive assessment of the problem.

Demographic data

The demographic section collects basic information on gender, age, education and country of residence. These variables help to analyse energy poverty trends in different socio-economic and geographical groups.

Arrears on Utility Bills

Respondents are asked about their history of late energy bill payments. Frequent delays indicate financial strain and an increased likelihood of energy poverty.

Inability to Keep the Home Adequately Warm

The questions assess energy efficiency, insulation, and the age of the building. Dissatisfaction with insulation and heating efficiency, along with self-reported discomfort in maintaining a warm indoor environment, serve as important risk indicators for fuel poverty. The real risk of energy poverty arises not only from dissatisfaction with these factors but also from the actual inability to keep warm, which is reflected in both objective conditions and subjective experiences of discomfort.

High Share of Energy Expenditure in Income

This section investigates household income and energy costs to determine the percentage of income devoted to energy expenditures. A ratio above 30%, which is a project-defined threshold, indicates a significant burden.

Population Living in Dwellings Comfortably Cool During Summer and Warm During Winter

Questions on indoor temperatures and overall comfort levels in summer and winter help assess whether respondents experience seasonal energy poverty.

Population Living in Dwellings Equipped with Heating and Air Conditioning

Questions on heating and cooling systems highlight disparities in access to essential temperature control mechanisms.

Population Living in Dwellings with Leaks, Dampness, and Rot

Questions on leaks, damp, and mold highlight how poor housing conditions contribute to increased energy needs and exacerbate energy poverty.

Household Electricity and Natural Gas Prices

Subjective assessments of electricity and gas prices provide valuable insights into perceived affordability and economic pressure. While these subjective perceptions are important, they should ideally be cross-checked with actual billing data to improve the reliability and accuracy of the findings. Combining both subjective assessments and objective cost data provides a more comprehensive understanding of energy affordability.

Vulnerability to Economic Difficulties:

Questions on financial hardship, such as sacrificing social activities to pay energy bills, provide a broader understanding of economic vulnerability.

Number of Rooms per Person by Ownership Status:

Data on home ownership, housing type and household size will help identify the relationship between housing conditions and energy poverty.

Type of Energy Carrier:

Understanding the energy sources used for heating, cooking and other services will help identify high-cost energy dependencies.

This questionnaire-based strategy enables a systematic evaluation of energy poverty indicators, facilitating both quantitative (numerical) and qualitative (perceptions) analysis. The data collected will provide a comprehensive understanding of energy poverty, allowing for the formulation of targeted recommendations and interventions to effectively address the issue in the Western Balkans.

3. Country-Level Analysis of Energy Poverty in the Western Balkans: Challenges and Opportunities

Energy poverty in the Western Balkans presents unique challenges, driven by a combination of economic, social, and infrastructural factors. The region's energy systems are often characterised by inefficient buildings, outdated energy infrastructure, and high reliance on non-renewable energy sources, all contributing to increased vulnerability to energy poverty. Evaluating energy poverty in the Western Balkans requires a multi-dimensional approach that considers not only the economic affordability of energy, but also the condition of housing, health impacts, and climate-related vulnerabilities that shape energy needs.

The POWERINGCITIZENS project offers a framework for analysing energy poverty, drawing on a set of indicators that reflect key aspects of energy vulnerability. For the Western Balkan countries, these indicators serve as a basis for identifying the most vulnerable populations and designing targeted interventions to alleviate the impacts of energy poverty. This analysis provides an overview of the key factors contributing to energy poverty in the region, while emphasising the importance of tailored solutions to address specific national and local challenges. Understanding these dynamics is crucial for developing policies that can drive energy efficiency improvements, reduce reliance on expensive and polluting energy sources, and enhance the overall well-being of citizens in the Western Balkans.

3.1. Albania

Albania is a small country in Southeastern Europe, bordered by Montenegro to the northwest, Kosovo to the north, North Macedonia to the east, and Greece to the south. It also boasts a beautiful coastline along the Adriatic and Ionian Seas to the west and southwest. With a population of approximately 2.8 million, Albania has a rich cultural heritage marked by its ancient history, unique traditions, and diverse influences from the Roman, Bysantine, and Ottoman periods. Albania has made significant progress in economic development and infrastructure improvements in recent decades, particularly following the fall of its communist regime in the early 1990s. However, despite these advancements, the country still faces

challenges, including poverty, high unemployment rates, and issues related to energy poverty, especially in rural areas.

Albania's energy sector relies heavily on hydropower, with most of its electricity coming from hydropower plants. However, the country's energy infrastructure remains underdeveloped in certain areas, and energy inefficiency in homes, outdated systems, and poor insulation contribute to the ongoing energy poverty issue. The government has made efforts to modernise the energy sector, but high energy costs and climate-related risks continue to affect vulnerable populations, particularly during the winter months. Albania's journey towards a sustainable energy future and addressing energy poverty remains essential to its broader economic and social development goals.

3.1.1. National Energy Policy and Climate Action Plan: Strategies for a Sustainable Future

Albania's NECP outlines the country's strategic framework for achieving its energy and climate objectives from 2021 to 2030 [25]. The plan is aligned with the EU's energy and climate framework, ensuring that Albania's energy transition contributes to a secure, sustainable, and affordable energy system while reducing greenhouse gas emissions and increasing renewable energy sources [26]. The country has made significant strides in prioritising renewable energy, enhancing energy efficiency, and reducing its carbon footprint. These efforts reflect Albania's commitment to building a more environmentally friendly future and achieving the ambitious climate targets set for this decade. The NECP serves as a strategic roadmap, guiding the country towards achieving key goals, such as reducing greenhouse gas emissions, increasing investment in renewable energy, lowering energy costs, and enhancing the security and sustainability of the energy sector. Albania has introduced several key legislative actions to support the objectives outlined in the NECP. In 2023, Law No. 24/2023 was enacted to promote renewable energy, aligning the country's policies with EU Directive 2018/2001. This law aims to accelerate the transition to a more renewable-based energy system and increase energy security by expanding the integration of renewable sources. Additionally, Albania implemented the National Action Plan for Renewable Energy Resources (NAPRER) in 2018-2020, which is central to enhancing energy security and

integrating wind, solar, and hydropower projects into the national energy mix. Albania's NECP sets clear and ambitious targets for 2030, which include:

- An 18.7% decrease in greenhouse gas emissions.
- An 8.4% reduction in final energy consumption.
- Achieving 54.4% of total final energy consumption from renewable sources.

One of Albania's most notable achievements is its zero-emission electricity generation, positioning the country as a leader in decarbonising the energy sector. The country's reliance on hydropower makes it a leader in renewable electricity production, with substantial progress towards renewable energy integration. Albania's government officially approved the initial version of the NECP on December 29, 2021, signalling the country's proactive approach to sustainable energy. The draft plan was submitted to the Energy Community Secretariat (ECS), which provided detailed recommendations to refine the plan further [27]. As Albania continues to evolve its NECP, the government will incorporate the Secretariat's guidance to ensure the plan remains relevant and in line with the European Union's climate-neutral objectives for 2050. The NECP is a critical tool that helps Albania demonstrate its commitment to achieving climate neutrality and fostering a greener transition. It offers a clear framework for transparent action, enabling the country to showcase its dedication to energy transition and climate goals to both its citizens and international stakeholders. The targets set in the NECP are influenced by various factors, which are explained in greater detail in Chapters 4 and 5 of the plan. These include:

- The operational efficiency of renewable energy plants.
- The reduction of fossil fuel use in the transport and industrial sectors through fuel switching and energy efficiency measures.
- The significant role of forestry management in carbon sequestration and in contributing to climate goals.

These areas will be key to ensuring that Albania not only meets its energy transition goals but also strengthens its energy resilience and enhances its climate sustainability over this decade. The NECP is Albania's central framework for driving forward its energy transition and meeting climate objectives for 2021-2030 (see Table 1). Albania is taking meaningful steps toward creating a cleaner, more sustainable energy future, and it is on track to achieve its

ambitious targets and contribute to the broader European commitment to climate neutrality by 2050.

Table 1: Albania's 2030 Targets as Part of the NECP

Target (2030)	***Sector Contribution***
Greenhouse Gas (GHG) Emission Savings (Reduction relative to (World Energy Model (WEM) Scenario)	*-18.7%*
Greenhouse Gas Emissions [kt CO_{2eq}] as projected With Additional Measures (WAMs) for 2030	
Demand	*4,833.0 kt CO_{2eq}*
Transformation	*250.8 kt CO_{2eq}*
Non-Energy	*5,139.0 kt CO_{2eq}*
Energy Efficiency (Final Energy Consumption reduction relative to WEM Scenario)	*-8.4%*
Final Energy Consumption [kTOE] as projected WAMs for 2030	
Residential	*348.9 kTOE*
Services	*195.2 kTOE*
Industry	*542.4 kTOE*
Transport	*1,003.4 kTOE*
Agriculture & Forestry	*110.5 kTOE*
Fisheries	*56.0 kTOE*
Non-Energy	*70.6 kTOE*
Renewable Energy Share in Final Energy Demand	*54.4%*
Renewable Energy Share of Final Energy Demand as projected WAMs for 2030	
Electricity	*178.1%**
Transport	*34.6%*
Heating & Cooling	*16.6%*

Target (2030)	*Sector Contribution*
** Values over 100% are due to electricity exports*	

3.1.2. National

3.1.3. Political Context

Albania has developed a comprehensive set of policies and legislation, which are in accession process, that address each dimension of the EU, reflecting the country's commitment to

aligning with EU standards and objectives. These policies are designed to create a robust framework for Albania's energy sector, enabling it to transition towards a more sustainable and secure energy future. The country is focused on fostering a supportive domestic energy market that not only promotes energy security but also drives energy efficiency, environmental protection, and a significant reduction in greenhouse gas emissions. Key strategic documents, such as the national energy strategy, energy efficiency action plans, and the renewable energy action Plan, provide clear targets and a roadmap for achieving these goals. These plans focus on enhancing energy security by increasing the share of renewable energy in the energy mix, reducing energy consumption, and cutting emissions. The climate change Law (155/2020), a landmark piece of legislation, aligns Albania's climate goals with European Union regulations, further strengthening the country's commitment to tackling climate change and ensuring compliance with EU climate and energy policies. In parallel, Albania is actively developing secondary legislation that will complement the primary laws related to energy efficiency and renewable energy. These regulations will help facilitate the practical implementation of energy policies, create a regulatory framework for clean energy investments, and encourage technological innovation in the energy sector. Institutions such as the renewable energy agency and energy service companies are also in the process of being established to oversee and support the implementation of these policies. These institutions will play a critical role in driving Albania's green transition by providing the necessary expertise, resources, and coordination to ensure that the country meets its renewable energy targets and enhances its energy efficiency measures. By building these institutional capacities and ensuring strong governance, Albania is positioning itself as a leader in sustainable energy development in the Western Balkans.

3.1.4. National Economic and Legislative Context

The development and implementation of energy policies, particularly the NECP, are expected to have a transformative impact on Albania's economic growth. By prioritising sustainable energy development, Albania can stimulate significant long-term economic benefits. Strategic investments in the energy sector, such as renewable energy projects, energy efficiency measures, and infrastructure upgrades, will not only boost Gross Domestic Product (GDP) but also generate new revenue streams. These investments will create a diverse range of

employment opportunities, from construction and installation to maintenance and management of renewable energy systems. In particular, policies aimed at building renovations, the retrofitting of homes and commercial buildings, and the expansion of photovoltaic systems will stimulate the green job sector, contributing to both environmental and economic goals. These green jobs are expected to become a cornerstone of the country's labor market, helping to meet the increasing demand for skilled workers in the renewable energy industry. Furthermore, reducing Albania's reliance on energy imports will play a pivotal role in enhancing energy security, making the country less vulnerable to fluctuations in global energy prices and geopolitical tensions. This shift towards domestic renewable energy production will also help stabilise the country's energy supply, reducing the risk of energy shortages. By cutting down on energy imports, Albania can strengthen its political and macroeconomic stability, as the reduction in foreign energy dependency will decrease the national budget deficit and improve fiscal balance. These combined effects will not only boost Albania's economic resilience but also position the country as a leader in sustainable development within the region.

3.1.5. National Environmental Context

Albania's energy policies are strategically designed to foster economic development, enhance energy security, and protect the environment. A key focus of these policies is promoting renewable energy, with a particular emphasis on non-hydro sources such as wind and solar power. Indeed, the shift towards renewable energy is a critical component in Albania's commitment to mitigating climate change impacts, aligning with national and European Union climate goals. However, as Albania pursues this green transition, some challenges need to be carefully navigated. One of the key concerns is balancing the expansion of renewable energy projects with the preservation of environmental protection standards. Some renewable energy projects, e.g., wind farms and large-scale solar installations, may pose potential risks to local ecosystems and biodiversity. Additionally, hydropower projects, especially dams, can significantly affect river ecosystems, water quality, and biodiversity, posing risks to local habitats. This is particularly relevant in Albania, where the energy sector is highly dependent on hydropower. It is important to thoroughly consider and mitigate these environmental impacts as part of the renewable energy transition. Nowadays, there is a need for careful

planning to ensure that renewable energy development does not undermine efforts to protect natural habitats, forests, and landscapes. To manage these conflicts, Albania needs to adopt a holistic approach that integrates environmental assessments, stakeholder engagement, and sustainable planning into the energy policy framework. By doing so, the country can advance its energy goals while safeguarding its rich natural heritage for future generations.

3.1.6. National Social Context

Investments in the energy and building sectors have proven to catalyse positive economic and social outcomes in Albania. Job creation in these sectors provides long-term economic stability and helps reduce unemployment, particularly in rural and underdeveloped regions. Beyond individual financial benefits, these investments contribute significantly to municipal and government revenues. The funds generated through energy sector investments, whether from renewable energy projects, energy efficiency programs, or building renovations, can be reinvested in public services such as healthcare, education, and infrastructure development. This cyclical flow of investment ensures that the growth in one sector positively impacts other areas of public life, fostering broader societal benefits and reducing inequalities. Furthermore, Albania's energy efficiency targets are critical in reducing overall energy consumption, which is key to making energy more affordable for households. As energy costs are a significant burden for many low-income families, especially during harsh winters or hot summers, improving energy efficiency can lead to substantial savings in household energy bills. By focusing on energy-saving measures, such as better insulation, the use of energy-efficient appliances, and the adoption of renewable energy sources, Albania is helping to alleviate the financial strain on its citizens and reduce energy poverty.

3.1.7. Energy Poverty Situation in Albania

Energy poverty in Albania is currently not clearly defined or systematically monitored. Although the Law on power sector No. 43/2015 defines a ‘vulnerable customer’ as someone entitled to special rights concerning electricity and gas supply based on social status (Article 95), no specific policies directly address the root causes of energy poverty. The existing measures are limited to compensation schemes, which are offered as cash benefits to

households in need. Looking forward, Albania has set key objectives for addressing energy poverty by 2030, which include:

- Defining what constitutes energy poverty in the country.
- Establishing a national system for the systematic monitoring of energy poverty.
- Recommending measures aimed at eliminating energy poverty.
- Conducting a comprehensive study to estimate the number of people experiencing energy poverty, along with identifying the underlying causes.

Currently, Albania's residential sector is the largest consumer of electricity. Historically, before the 1990s, household electricity consumption accounted for only 8-10% of total national consumption, with the industrial sector consuming a larger share. However, in the years following Albania's transition, residential electricity consumption increased steadily. This growth slowed down after 2006 due to factors such as rising energy prices, the introduction of new energy sources (e.g., natural gas), and the growth of new industries and services. These changes have not eased the burden on consumers, as Albanian households continue to face relatively high electricity costs by paying 11.4 ALL/kWh (0.09 €/kWh), the second-highest rate in the Western Balkans [28]. Energy consumption patterns vary significantly across different socio-economic groups. For example, households where the head of the family has no formal education tend to consume less energy, not because their needs are lower, but because limited income constrains their ability to afford adequate heating, cooling, or appliances. As a result, they often spend a disproportionately high share of their income on electricity, sometimes twice the national average. According to the country's energy balance data, Albanian households rely on three primary energy sources: electricity (53%), biomass (26%), and Liquefied Petroleum Gas (LPG) (21%). Heating remains a significant issue for many households. Electric heaters are used by 14.3% of poor households, compared to 19.0% of households that do not face with energy poverty. Similarly, electricity for heating is used by 19.5% of poor households, compared to 28.0% of non-poor households. The use of central heating is rare, with only 3.2% of private households having access to it, while 4.4% rely on a fireplace. Even in households with central heating systems, issues like a lack of metering and temperature control persist. In rural areas, 85% of households depend on wood for heating. Regarding financial assistance, a proposed subsidy for electricity up to 210 kWh per month per household could cost approximately 2394 ALL

(19.70 €) per month. This would be nearly double the existing benefit of 1288 ALL (10.42 €), highlighting the gap between the current assistance offered and what is needed to support households in energy poverty adequately. Albania's housing stock presents further challenges. The total surface area of residential buildings is 84,927,085 m², with the average dwelling size being 117.58 m², based on the 2011 Census data. A large portion of the housing stock was built between 1991 and 2011 (56%), but only 35% of buildings constructed after 2000 are considered energy efficient. Additionally, while 50% of the population cannot afford heating services for their entire home, the distribution of heating access varies significantly by region. For example, only 35% of buildings along the coast have access to heating, compared to 70% in mountainous regions [29]. In sum, energy poverty in Albania is a complex issue that involves not only high energy prices and inefficient housing stock but also limited access to heating services for many households. Addressing these challenges will require clear definitions, systematic monitoring, and targeted policies that focus on both improving energy efficiency and making energy more affordable for vulnerable populations.

3.1.8. Local Targets for CO_2 Reduction and Combating Energy Poverty: Pathways to a Sustainable Future

Locally, several municipalities have taken measures and initiatives to improve the quality of life of their citizens from different perspectives. By 2030, the Municipality of Shkodra is focused on advancing sustainable energy management, reducing its carbon footprint, and enhancing climate resilience. The municipality is committed to a transition that promotes fairness, inclusivity, and environmental sustainability across public services. This shift will lead to increased green investments, job creation, and improvements in healthcare and education, ultimately contributing to a healthier environment and improved quality of life for residents.

Shkodra's energy efficiency, renewable energy, and CO_2 reduction objectives are aligned with the NECP, targeting a reduction of greenhouse gas emissions by 18.7%, an 8.4% decrease in final energy consumption, and achieving a 54.4% renewable energy share in final energy demand by 2030. The municipality has the flexibility to develop tailored strategies to meet these targets, with specific actions for various sectors. Between 2010 and 2021, the share of petroleum by-products in the energy mix decreased slightly from 60.40% to 58.93%, while

the contribution of hydropower and net imported electricity grew from 26.69% to 28.53%. Fuelwood consumption has also declined, from 10.04% in 2010 to 7.96% in 2021. In Shkodra, CO_2 emissions from primary energy use (electricity, wood, and gasoline) reached 352,000 t in 2021. The commercial and residential sectors are the largest contributors, accounting for 50% of all emissions. However, there is significant potential for emission reductions, with the municipality estimating a potential reduction of up to 42 kt of CO_{2eq} per year through targeted actions and investments (Fig. 4).

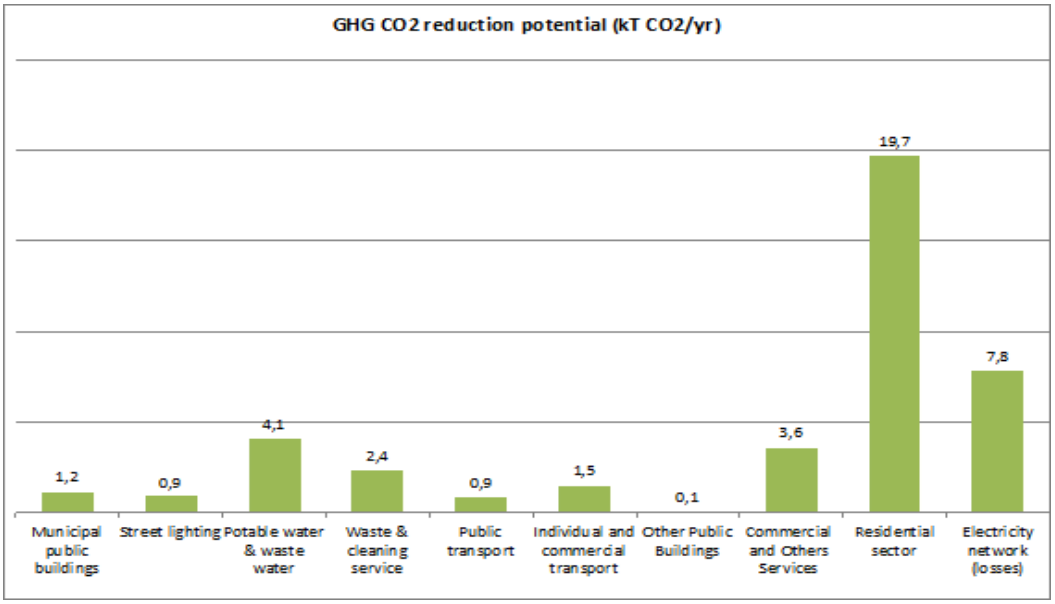


Figure 4: Potential GHG Emission Reductions in kt per year [30]

As outlined in the Energy Efficiency Law, the Municipal Energy Efficiency Plan (PBVEK) must align with the National Energy Efficiency Action Plan (PKEK) and set specific targets for energy savings, renewable energy contributions, and CO_2 reductions across various sectors. These sectors include direct municipal services such as public buildings, public street lighting, solid waste management, water supply, wastewater treatment, public transportation, and other municipal services. In addition, the PBVEK must also encompass indirect sectors within the municipality's jurisdiction, such as residential, industrial, agricultural, private services, and other relevant sectors. The residential sector in Shkodra is the second-largest

energy consumer in Albania, accounting for 25% of the country's total final energy consumption. Energy consumption in this sector is divided into five categories: space heating, cooling, hot water and cooking, lighting, and household appliances. Currently, households in Shkodra typically heat around 27-30% of their total living space (mainly the dining room), with heating typically lasting between 8-10 hours per day. However, as per the energy strategy document, it is expected that in the future, Shkodran households will increase the heated area to 60-70% of their total space, with heating durations extending to 16-18 hours per day [31]. Consequently, the energy demand forecast for the Business-As-Usual (BAU) scenario for the entire residential building stock is based on this assumption. Figure 5 illustrates the projected total annual energy demand for the baseline scenario from 2021 to 2040, while Figure 6 presents the forecasted GHG emissions scenario, expressed in CO_{2eq}, for the entire residential building stock during the same period. These projections offer a comprehensive outlook on the energy needs and emissions reduction potential in Shkodra, helping to guide future energy efficiency measures and sustainable development strategies.

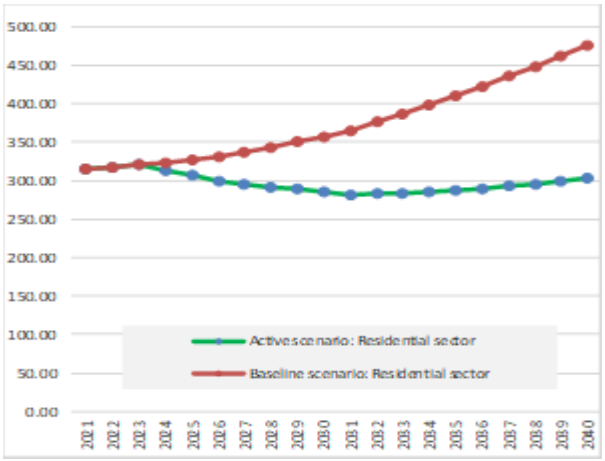


Figure 5: BAU Energy Demand Forecast for Residential Buildings (2021-2040, GWh/year)

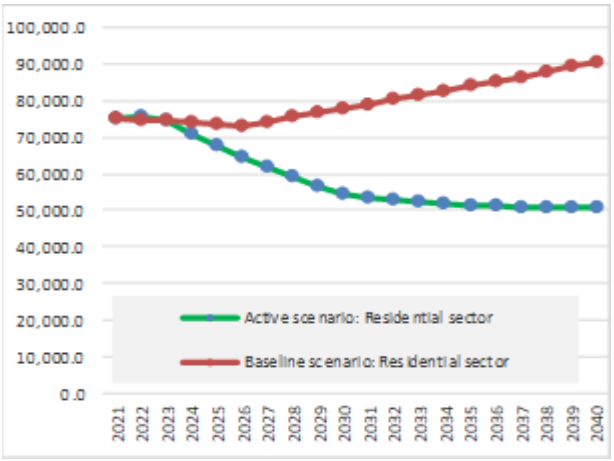


Figure 6: BAU & Active Greenhouse Gas Emissions Forecast for Residential Buildings (2021-2040, t CO_{2eq}/year)

In detail, Figure 5 illustrates a BAU demand forecast for the residential buildings sector from 2021 to 2040. It compares two scenarios: a baseline scenario and an active scenario that

includes measures to manage demand. In the baseline scenario, demand steadily increases, rising from around 330 units in 2021 to nearly 480 units by 2040. In contrast, the active scenario shows a slight decline in demand through the late 2020s, followed by a modest rise, ending around 340 units. Along the same line, Figure 6 shows the BAU & Active GHG emissions forecast for the residential sector from 2021 to 2040, now in absolute values. In the baseline scenario, GHG emissions gradually increases from just over 70,000 units to nearly 95,000 by 2040. Meanwhile, the active scenario shows a steady decline of GHG emissions through the late 2020s, stabilising around 60,000 units in the following decade.

3.1.9. Obstacles and Key Challenges

Energy poverty remains a pressing issue in Albania, affecting at least 37% of the population. This rate far exceeds the European average of 5% according to a study conducted by Society for Sustainable Development Design / Drustvo za Oblikovanje Odrzivog Razvoja (DOOR) and Energy Institute Hrvoje Požar (EIHP) on energy poverty in energy community contracting parties [29]. This widespread energy poverty forces many households to rely on wood for heating, which not only exacerbates environmental concerns but also poses significant health risks due to indoor air pollution and inefficient combustion methods. Despite the severity of the issue, Albania's legal framework lacks a specific definition of energy poverty or a formal classification of households vulnerable to it. Instead, the legal system recognises specific categories of socially vulnerable customers based on criteria such as health, disability, and income level. These groups are identified under Law No. 9355 (2005) on Social Assistance and Services and its subsequent amendments (Laws No. 9602/2006, No. 10252/2010).

3.1.10. Case Study

This study presents a comprehensive analysis of the energy poverty situation in five areas of the city of Shkodra [32], where the main ones are the Administrative Unit of Rrethina, Livadhe, and the Mark Lula neighborhood (Fig. 7). The Administrative Unit "Rrethina" surrounds the city of Shkodra from all sides, except for its western part, which is bordered by the waters of Shkodra Lake and the Buna River. The Rrethina Administrative Unit covers an

area of 41.7 km² with a population of 23,292 inhabitants and consists of 8 villages: Bardhaj, Bleran, Dobraç, Golem, Grudë e Re, Hot i Ri, Shtoj i Ri, and Shtoj i Vjetër. The two villages with the highest population numbers are Dobraç and Grudë e Re, while the villages with the lowest population are Bardhaj and Shtoj i Vjetër. Over the last 30 years, the population in the territory of the Rrethina Administrative Unit has more than doubled. This phenomenon is linked to the massive arrival of people from the mountainous areas of Shkodra who settled in the unit's territory after the 1990s, as a result of changes in the political and economic systems and the opportunities that arose for people to move freely. The area of Livadhe, also known by residents as "Livade," is located in the western part of the city of Shkodra, along the shore of Lake Shkodra. Characterised by flat terrain and natural value, the area is one of the largest green spaces on the city's outskirts, with a typical meadow landscape and a long history of agricultural and livestock use. Its close proximity to the lake makes it highly susceptible to flooding, especially during the rainy season or when water levels rise. Without protective infrastructure and functional drainage systems, flooding remains a recurring concern for residents. After 1990, as a result of internal migration and the growing demand for housing, the Livadhe area experienced rapid demographic expansion. Spontaneous settlement mainly outside the framework of urban planning led to the development of an area with informal constructions, lacking building permits and not included in the city's official urban development plans. This situation has directly impacted the quality of life of the community, with evident shortcomings in basic infrastructure, limited access to public services, high social vulnerability, and a large portion of residents facing unemployment, housing insecurity, and economic hardship. The Mark Lula neighborhood is located in the northern part of the city of Shkodra, near the neighborhoods "Neighborhood 5" and "Arra e Madhe." This area is primarily residential, with individual houses and low-rise buildings. Over the past 25 years, the Mark Lula neighborhood has experienced rapid population growth, mainly as a result of the migration of families from mountainous areas to the city. This sudden increase has brought a range of infrastructural and social challenges, making the neighborhood an area in urgent need of urban planning interventions and public investments, to improve living conditions and meet the growing demands of the community.

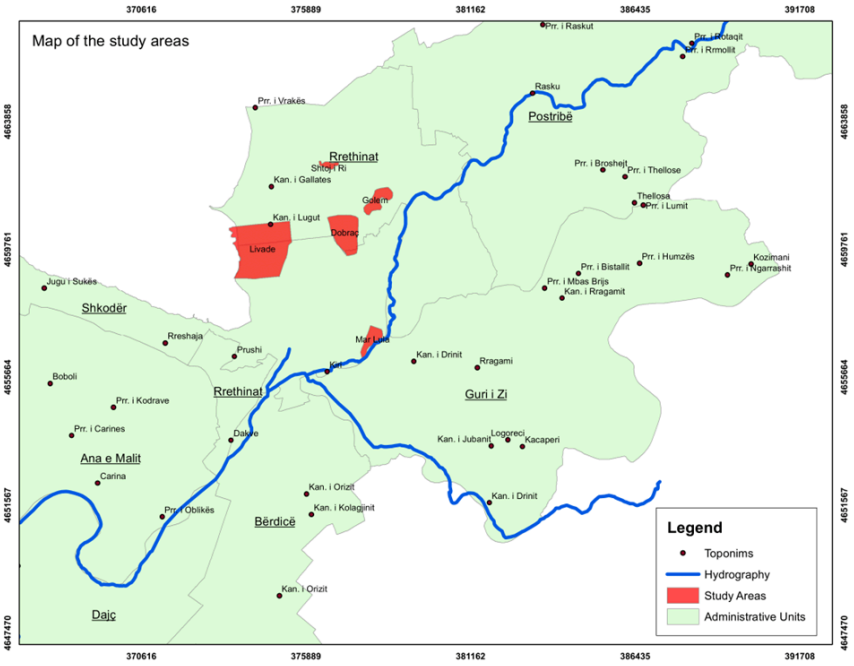


Figure 7: Study area in Albania (city of Shkodër)

Although geographically different, these areas share common characteristics of energy vulnerability due to their isolation, limited infrastructure, and socio-economic disparities. The study was conducted through questionnaires with residents, aiming to assess the energy efficiency of households, comfort levels, economic conditions, and the quality of housing, generating both quantitative and qualitative data.

Results from the energy poverty investigation:

This study on energy poverty was conducted with the participation of 50 households from five different areas in the city of Shkodër, and in particular from the Administrative Unit of Rrethina, the Livadhes area, and the Mark Lula neighborhood. As already reported in the previous section, all the details regarding the questionnaire provided to people living in Western Balkans will be made available in the Training Guide document of the POWERINGICITZENS project.

Key Demographic and Socio-economic Insights

The survey aimed to collect information on the challenges these communities face concerning access and the ability to pay for energy, examining how energy poverty impacts their daily

lives. Among the respondents, 55.1% were women and 44.9% were men. This balanced representation enables a more comprehensive understanding of the issue through different local contexts, offering a clearer picture of the varying experiences within these areas. The populations surveyed across three areas display varying levels of vulnerability, especially regarding energy conditions. Despite more than 85% of respondents in these areas owning their homes, primarily family houses, this has not led to improved energy efficiency. Interestingly, many of these homes are relatively new. Approximately 64.5% of the houses in the Administrative Unit of Rrethina were constructed within the last 25 years, compared to 54.5% in the Livadhe area. In contrast, the homes in the Mark Lula neighborhood are older, with roughly 50% being 25 to 35 years old. The age of these buildings plays a significant role in their thermal efficiency, which is a major concern for respondents. It has been found that 66.7% of homes lack thermal insulation. The situation is somewhat uncertain in Livadhe, where 54.5% of respondents are unsure whether their homes have thermal insulation, and 18.2% report that they do not. In the Mark Lula neighborhood, 50% of the respondents state that their homes are not insulated, while 12.5% are unsure about the presence of thermal insulation (Fig. 8). This lack of insulation in many homes is directly tied to the energy challenges faced by these communities.

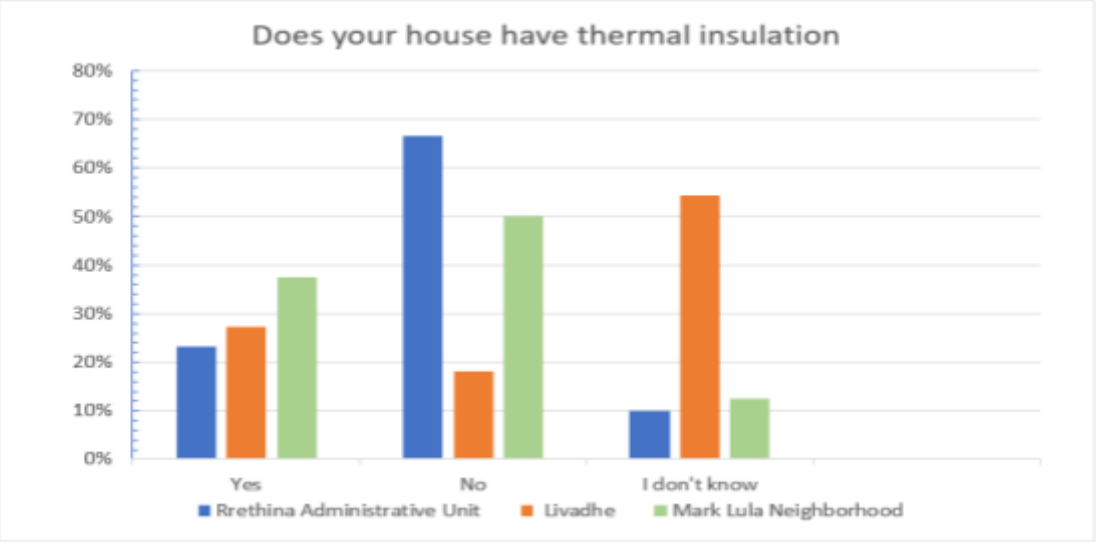


Figure 8: Feedback on house thermal insulation (city of Shkodër)

Economic Stress and Ability to Pay for Energy

The ability to pay for energy is a critical concern. In the Rrethina Administrative Unit, 69% of respondents consider the price of electricity to be "expensive". In the Livadhe area, 90% of respondents say that the price of electricity is "expensive". Similar situation is observed in the Mark Lula neighborhood, where 75.5% of respondents state that the price of electricity is "expensive" (Fig. 9).

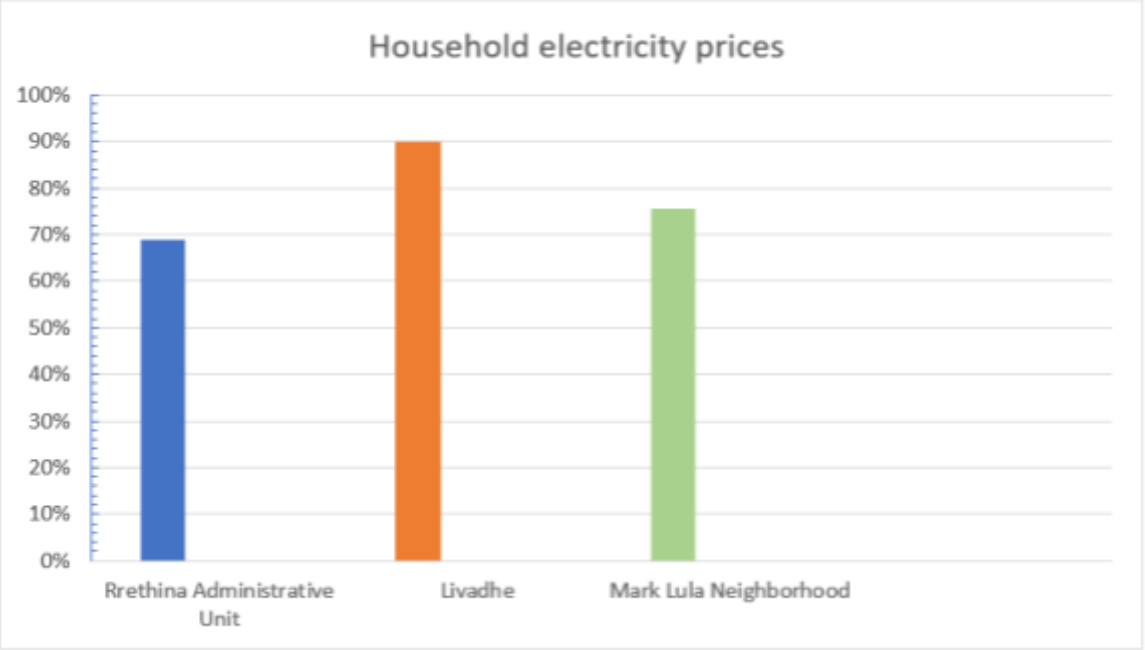


Figure 9: Feedback on households' electricity prices (city of Shkodër)

Due to the high price of electricity and the economic difficulties faced by families in these areas, along with the lack of government initiatives to forgive delays in paying electricity bills, respondents report difficulty covering basic expenses. In the Rrethina Administrative Unit, 48.4% of respondents stated that they have "sometimes" faced difficulties covering basic expenses over the past five years. In the Livadhe area, 41.7% expressed that they have "sometimes" faced difficulties covering basic expenses. Similar to the other two surveyed areas, many respondents in the Mark Lula neighborhood reported "sometimes" facing

difficulties, but a notably higher share, 12.5%, also reported experiencing them “often” (Fig. 10).

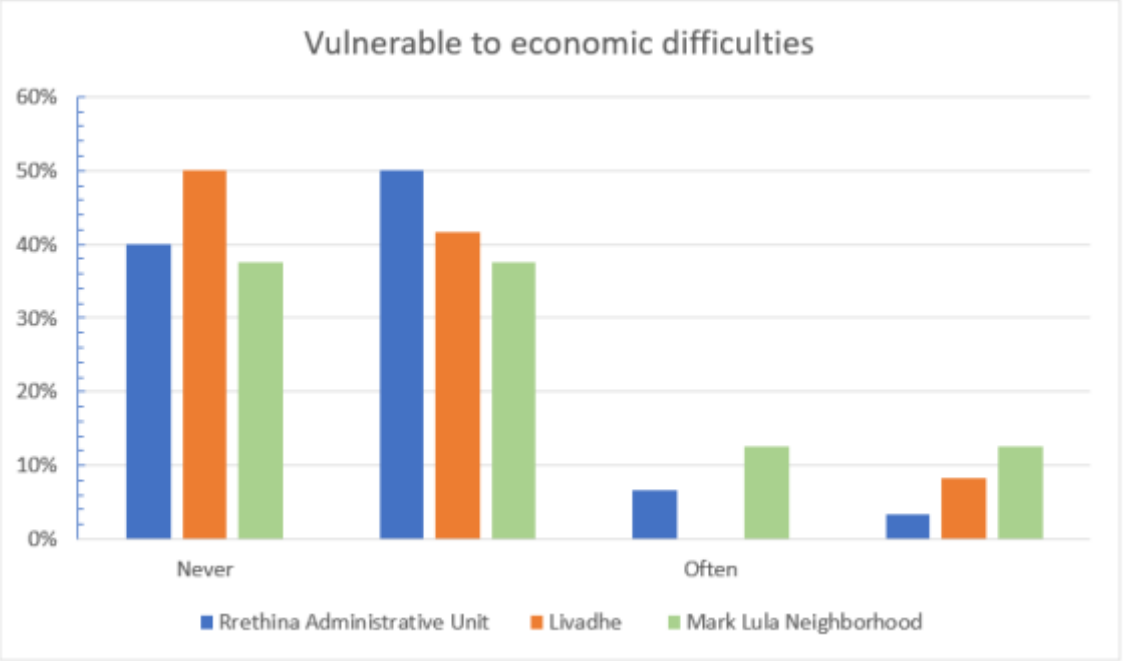


Figure 10: Feedback on vulnerability to economic difficulties – challenges covering basic expenses over the past five years *(city of Shkodër)*

The respondents reported the percentage of their monthly household income spent on electricity bills. In all three surveyed areas, the average monthly income ranges from 300 to 700 €, and in some cases, it exceeds 700 €. In the Rrethina Administrative Unit, the Livadhe area, and the Mark Lula neighborhood, 90% of the respondents stated that 10-30% of their monthly income is spent on covering electricity bills. Only 10% reported spending less than 10% of their monthly income on electricity bills.

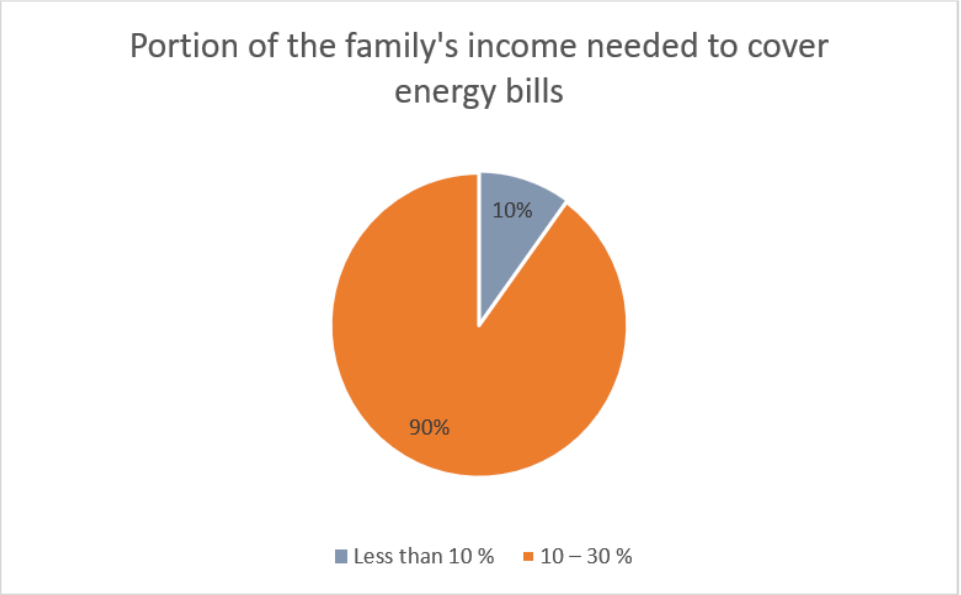


Figure 11: Feedback on portion of the family's income needed to cover energy bills (city of Shkodër)

Satisfaction and Living Conditions

Inadequate indoor temperatures are directly linked to health conditions. Residents in homes that are not properly heated or cooled often report allergies and chronic illnesses related to mold and poor air quality. In the areas covered in the study, most families report that the main issues in their homes are mold and humidity. Specifically, in the Rrethina Administrative Unit, 36.7% of respondents' report problems with mold on window frames, and 23.3% report humidity on walls. In the Livadhe area, the primary concern is humidity on walls, cited by 41.7% of respondents. In the Mark Lula neighborhood, 25.5% of respondents' report mold on window frames (Fig. 12).

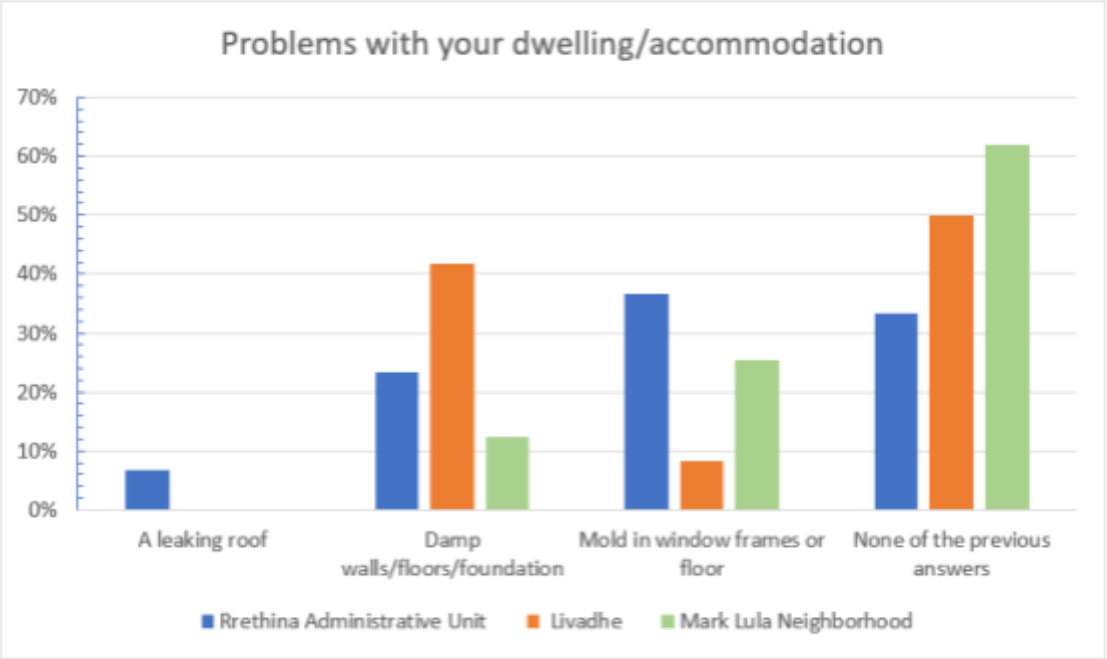


Figure 12: Feedback on problems with dwellings/accommodations (city of Shkodër)

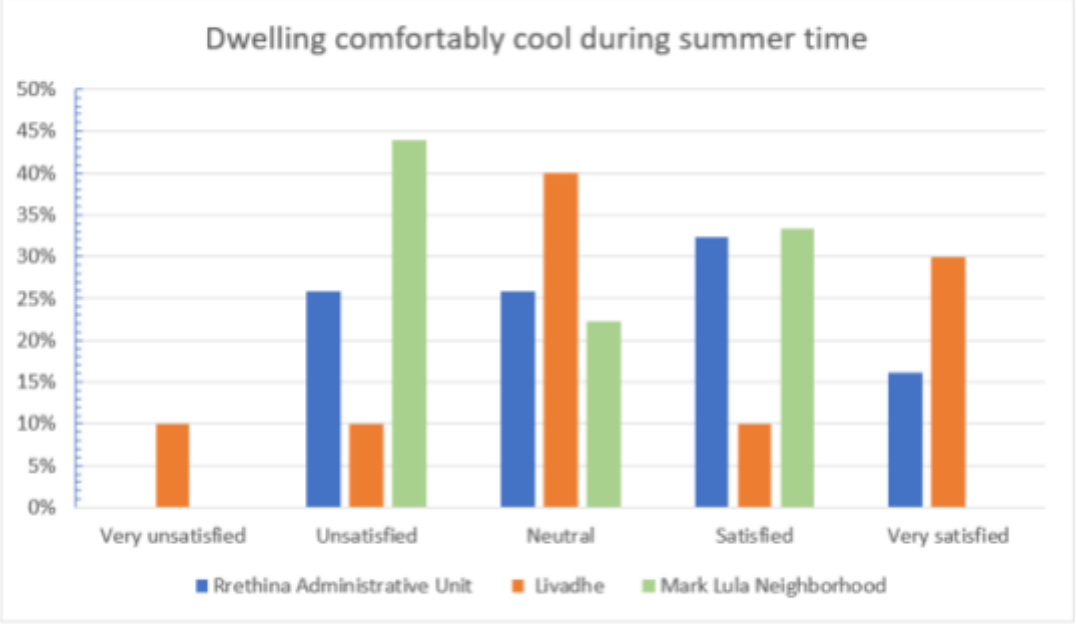


Figure 13: Feedback on comfortable dwellings in the summer time (city of Shkodër)

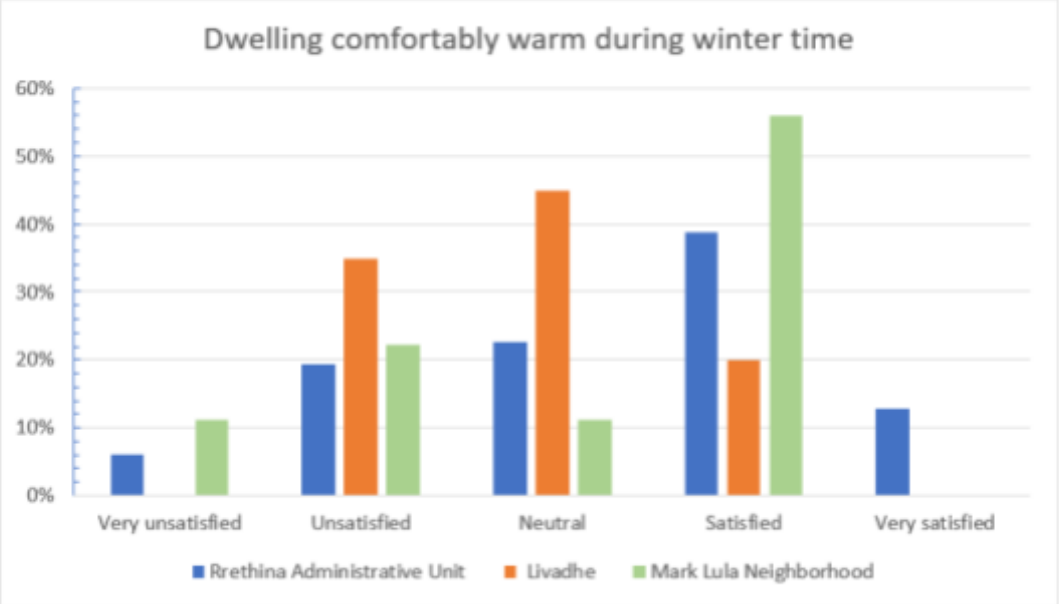


Figure 14: Feedback on comfortable dwellings in the wintertime (city of Shkodër)

When asked how satisfied they are with the energy efficiency in their homes, the majority of respondents, 45.2%, in the Rrethina Administrative Unit reported being “unsatisfied” and 9.7% “very unsatisfied”. In the Livadhe area, 40% of the respondents expressed being “unsatisfied” with the energy efficiency in their homes, 20% expressed being 'neutral' on this issue. In the Mark Lula neighborhood, the situation is different, as the majority of respondents expressed being “satisfied” with the energy efficiency in their homes (Fig. 15).

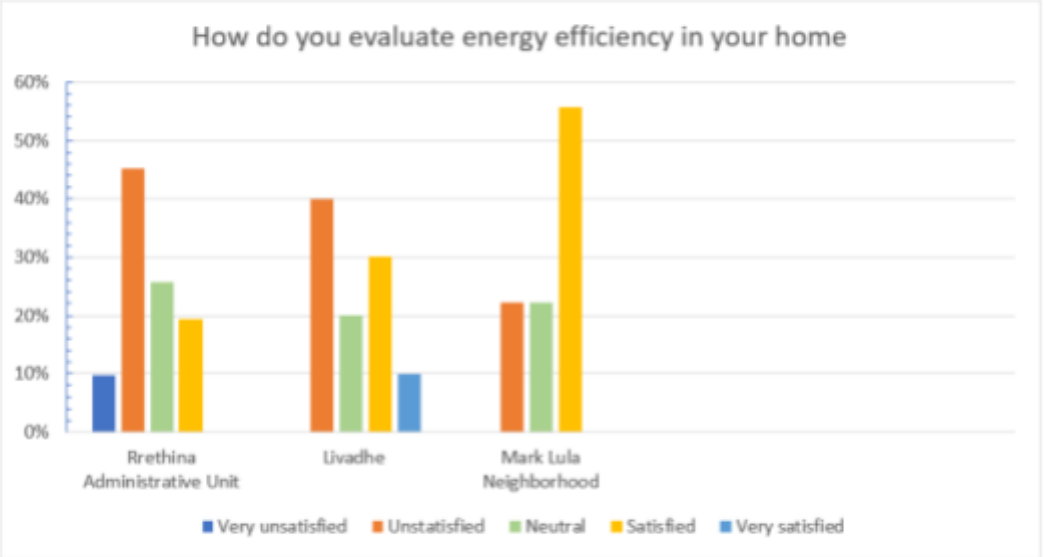


Figure 15: Feedback on energy efficiency at home (city of Shkodër)

3.2. Kosovo

Kosovo is located in southeastern Europe, in the heart of the Balkan Peninsula, and shares borders with Albania, Montenegro, Serbia, and North Macedonia. Covering approximately 10,900 km², it features diverse terrain with an average altitude of 800 meters above sea level, ranging from 297 meters in the Drini i Bardhe valley to 2,565 meters at Gjeravicë, its highest peak. The country experiences a continental climate, marked by hot summers and cold winters, with regional variations in temperature and precipitation due to its varied elevations. As of 2019, Kosovo had a population of around 1.8 million, predominantly ethnic Albanians. Prishtina, the capital, is the most populous city. The country's youthful population and workforce contribute significantly to its economy, which is driven by trade, services, agriculture, and substantial remittances from the Kosovo diaspora [33].

3.2.1. National Energy Policy and Climate Action Plan: Strategies for a Sustainable Future

Kosovo's energy sector stands at a critical juncture, grappling with the dual challenges of transitioning towards decarbonisation while addressing the deep-rooted issue of energy

poverty [34]. As the country seeks to align itself with European energy and climate frameworks, its journey is fraught with difficulties that stem from a long history of reliance on coal, institutional inefficiencies, and significant financial constraints. While Kosovo has set ambitious targets to reduce its carbon footprint and improve energy accessibility, the path to achieving these goals remains unclear, primarily due to the outdated infrastructure, reliance on fossil fuels, and the reality of energy poverty affecting a large portion of the population. The energy consumption patterns underscore an urgent need for change, transitioning away from fossil fuels to cleaner, more sustainable energy alternatives are essential.

In 2021, Kosovo's primary energy sources were largely dominated by coal (1,564 kTOE), with oil products (789 kTOE) and biomass (363 kTOE) also playing a significant role. Smaller contributions came from hydropower (26 kTOE), wind (7 kTOE), and solar energy (4 kTOE) [35]. Despite a 2.91% increase in total energy consumption from the previous year, the country continues to struggle with high energy intensity —meaning that its economy is not efficiently utilising energy. This high energy intensity reflects the inefficiencies that persist across sectors and indicates the need for a comprehensive strategy to improve energy use and reduce waste. Improving energy efficiency holds multiple benefits for Kosovo: not only would it decrease overall energy consumption, but it would also improve the country's economic productivity. There are clear opportunities for efficiency improvements in the industrial sector, transport, and residential buildings, areas that could yield significant cost savings and boost Kosovo's global competitiveness. Additionally, reducing energy consumption per capita and improving energy intensity are essential indicators of economic development and sustainability. Moreover, Kosovo must work towards aligning its policies with European directives and strengthening institutional capacity to implement these strategies. Without this alignment, Kosovo risks falling short of its energy transition goals, thus limiting its ability to integrate into the European energy market and meet the broader commitments outlined in the energy community treaty. In conclusion, Kosovo's energy future depends on a careful balancing act: tackling energy poverty, promoting renewable energy development, and enhancing energy efficiency while navigating the economic and institutional challenges at hand. Only through strong, coordinated efforts, supported by both national and international stakeholders, can Kosovo achieve a just and sustainable energy

transition. This transition must be inclusive, ensuring that no one is left behind and that the country can meet both its energy and climate goals for a more sustainable future.

3.2.2. National Political Context

Kosovo's governance is shaped by a relatively young institutional framework built in the aftermath of war and international supervision. The Ministry of Economy oversees energy policy, while the Energy Regulatory Office (ERO) acts as the sector's independent regulator. KOSTT, the transmission system operator, became fully integrated into the European grid only in 2020 - an important milestone for regional cooperation [36]. However, political volatility, overlapping mandates, and limited technical capacity within public institutions have slowed reform implementation. The legacy of contested statehood, especially in the context of north Kosovo, further complicates institutional coherence on long-term infrastructure planning and investment.

While the country holds some of Europe's largest lignite reserves, the sector suffers from chronically outdated infrastructure, underinvestment, and significant inefficiencies across generation, transmission, and distribution. The two main thermal power plants, Kosovo A and Kosovo B, operate below optimal capacity, frequently experience unplanned outages, and are among the most polluting in Europe. These plants are significant contributors to greenhouse gas emissions and local air pollution, making Kosovo one of the most emissions-intensive energy producers in the region. The environmental impact is severe, but the public health consequences are equally alarming. The pollution from these plants contributes to respiratory and cardiovascular diseases, leading to a serious health burden for the population. This includes increased rates of asthma, lung disease, and heart conditions, disproportionately affecting vulnerable groups such as children, the elderly, and those with pre-existing health conditions. The combination of energy inefficiency and poor air quality underscores the urgent need for cleaner, more sustainable energy solutions to safeguard both the environment and public health.

3.2.3. National Economic and Legislative Context

Kosovo's legal and policy framework for the energy sector remains fragmented and overly focused on formal alignment with the energy community treaty and the EU acquis. This

external orientation often masks domestic shortcomings, such as inconsistent implementation, regulatory gaps, and a lack of strategic coherence tailored to Kosovo's specific energy challenges and institutional capacities. Key laws, including the Law on energy (No. 05/L-081), the Law on electricity (No. 05/L-085), the Law on the energy regulator (No. 05/L-084), and the Law on energy efficiency (No. 06/L-079), provide the formal foundation for a liberalised and market-oriented energy system [37]. These are complemented by the Law on energy performance of buildings, the energy strategy 2022–2031, and its implementation program (IPESK 2022–2025), which aim to support decarbonisation, diversification, and energy security. However, while these laws establish a strong theoretical framework, their operationalisation remains uneven.

The tension between Kosovo's market liberalisation goals and the realities of widespread energy poverty remains a significant issue. Many households, particularly those in rural areas, informal settlements, or low-income brackets, struggle to afford adequate heating and electricity (Tab. 2), reflecting structural socio-economic disparities that the current regulatory regime does not adequately address. According to the Kosovo household budget survey (2017) [33], this reality highlights a gap in the existing framework, which has yet to address equity, affordability, and environmental justice effectively.

Table 2: Key information depending on the household type [38]

Household Type	***Primary Energy Source***	***Efficiency Level***	***Average Energy Consumption [€/Year]***
Urban	*Electric Heating Systems*	*High*	*1200*
Rural	*Wood-burning Stoves*	*Low*	*1500*

Although the Law on energy efficiency and associated strategies aim to reduce consumption and improve energy performance, practical implementation, particularly in the residential sector, has been limited. A major gap is the lack of targeted incentives for household-level renewable energy integration and retrofitting. Energy efficiency is often treated as a technical concern rather than a socially embedded issue tied to inequality and exclusion. Kosovo's legal framework requires a more inclusive approach, incorporating explicit protections for vulnerable consumers and a clear recognition of energy poverty. Currently, the absence of a legal definition of energy poverty limits the ability of public institutions to design targeted

interventions. Without legal obligations or social-energy instruments, such as subsidised tariffs or direct financial assistance, households most in need remain vulnerable to price volatility and market fluctuations, especially in the context of regional energy market integration. Furthermore, the implementation of energy performance certificates for buildings remains underdeveloped. While EPCs are essential for promoting energy transparency, improving construction practices, and enabling better decision-making for homeowners, tenants, and investors, Kosovo lacks a robust system for their issuance and monitoring. Stricter oversight of energy auditors is necessary to ensure quality assurance and avoid greenwashing. Additionally, Kosovo must fully implement its building renovation strategy and plan for nearly zero-energy buildings, which are vital for meeting climate and EU targets and improving the thermal comfort and well-being of residents. However, both initiatives remain largely aspirational unless supported by enforceable regulations, public funding, and cross-sectoral implementation. Ultimately, Kosovo's energy policy trajectory risks exacerbating socio-technical inequalities unless it adopts a rights-based, justice-oriented approach to energy transition.

3.2.4. National Environmental Context

Kosovo's energy sector is heavily dependent on coal, particularly lignite, which accounts for the vast majority of its electricity generation. The country possesses some of the largest lignite reserves in Europe, making coal a historically dominant energy source. However, this reliance presents significant environmental and health challenges due to high greenhouse gas emissions and air pollution [39]. In recent years, Kosovo has been working to diversify its energy mix by integrating renewable energy sources, such as hydropower, wind, and solar, while also enhancing energy efficiency and modernising its outdated infrastructure [40]. However, energy security remains a crucial issue, with frequent power shortages and aging power plants requiring significant investment. To address these challenges, Kosovo has been aligning its energy policies with EU directives and regional energy market regulations, aiming to improve sustainability, reduce dependency on coal, and enhance regional cooperation.

Despite progress, challenges persist in ensuring a stable and affordable energy supply, attracting foreign investment, and implementing structural reforms that support a greener and more resilient energy sector. In recent years, modest steps have been taken to diversify the

energy mix, largely driven by commitments under the energy community treaty and Kosovo's stated goal of closer alignment with EU energy and climate policy. Wind projects such as Bajgora and Kitka represent the initial phase of utility-scale renewable energy deployment in Kosovo, and solar development is beginning to gain momentum. However, a key challenge that has emerged alongside this development is the issue of grid bottlenecks. The existing grid infrastructure is often unable to handle the influx of renewable energy, resulting in transmission constraints that limit the potential of these projects. Addressing these grid bottlenecks is critical to fully harness the benefits of renewable energy and ensure that new projects can contribute effectively to Kosovo's energy mix. Yet progress remains constrained: integration of renewables is limited by insufficient grid capacity, lack of storage infrastructure, and a regulatory framework that has yet to fully enable market liberalisation and private investment. Energy security remains a core vulnerability. Seasonal imbalances, particularly during winter, require significant imports, often procured on short notice at high and volatile prices. Compounding this is institutional fragmentation, especially in northern Kosovo, where energy governance remains contested due to the presence of parallel Serbian-backed administrative structures. This undermines revenue collection, grid stability, and the extension of regulatory oversight.

3.2.5. National Social Context

Kosovo's social fabric is marked by resilience, adaptability, and a strong sense of collective agency shaped by its recent history and ongoing transformation. With a notably young population, and while this demographic profile is often cited as a structural challenge, it is also a source of social dynamism and political engagement. Civil society remains active, particularly around issues of governance, environmental protection, and energy justice, often filling the accountability gaps left by state institutions [41]. Persistent structural issues, such as uneven access to services and labor market issues, are compounded by patterns of emigration and remittance dependency. These are not merely symptoms of economic vulnerability, but also reflections of rational strategies for mobility, autonomy, and transnational engagement. Energy insecurity, especially in the form of fluctuating supply and rising costs, is experienced not as a passive burden but as a point of contention—fueling demands for transparency, equity, and a just transition. Public trust in institutions remains

cautious, shaped by a legacy of politicisation and stalled reforms. Yet this has not translated into disengagement. On the contrary, there is growing public scrutiny over how energy decisions are made, who benefits, and at what social and environmental cost. Any future energy transition in Kosovo must therefore be understood not just as a technical or financial undertaking, but as a deeply political and social process—one in which citizens are already asserting their stake.

3.2.6. Energy Poverty Situation in Kosovo

Kosovo's energy sector stands at a defining moment, caught between the urgent need for decarbonisation and the persistent realities of energy poverty and economic limitations. As a country seeking integration into European energy and climate frameworks, Kosovo has set ambitious targets to reduce its carbon footprint and improve energy accessibility. However, these aspirations are challenged by a historically coal-dependent energy infrastructure, institutional inefficiencies, and financial constraints. This analysis critically evaluates Kosovo's national and local energy policies, the feasibility of its CO_2 reduction goals, and the persistent issue of energy poverty. By examining challenges, barriers, and a case study, this research aims to provide an informed perspective on the country's energy transition.

The energy strategy of Kosovo (2017-2026, replaced by 2022-2031) acknowledges the existence of vulnerable consumers, including social assistance beneficiaries, low-income households, female-headed families, and elderly residents, implicitly recognising the energy poverty crisis that disproportionately affects these groups. However, despite this recognition, the strategy lacks a concrete framework or actionable measures to systematically address the structural drivers of energy poverty. While the strategy briefly mentions the need for a government intervention program, particularly in response to rising energy prices due to investments in so-called "clean coal" technology, it falls short of offering a targeted, long-term approach to protecting vulnerable consumers. This lack of strategic depth and alignment with broader energy community requirements suggests a superficial policy commitment, where the issue is acknowledged in principle but remains neglected in actual institutional implementation [42].

According to data from the Kosovo agency of statistics [43], 43% of households in Kosovo struggled to pay their utility bills at least twice a year, and an equal percentage could not afford to sufficiently heat their homes during the cold season. This situation was exacerbated in February 2022 when energy tariffs were increased for households consuming more than 800 kWh per month, impacting over 22% of Kosovar electricity consumers [44]. A more recent policy document, the draft NECP 2025-2030, attempts to bridge some of the policy gaps. The NECP refers to Article 49 of the Law on Electricity, which mandates protection for vulnerable consumers. It outlines an inter-institutional working group established in 2019 to develop a government program for mitigating the socio-economic impact of rising energy tariffs. However, despite these efforts, the document admits that Kosovo still lacks a legal definition of energy poverty and has no comprehensive strategy for mitigating its effects. The absence of systematic data collection on energy poverty and vulnerable consumers has severely limited the government's ability to quantify the scope of the problem and design effective interventions.

Table 3: Kosovo's Energy and Climate Targets (2025-2030) - Based on NECP

Category	***Value to be achieved***
GHG Emission Reduction Target (relative to WEM Scenario)	-32%
Total Greenhouse Gas Emissions Projection (2030) - WAMs	10.5 $MtCO_{2eq}$
Final Energy Consumption Reduction Target	-8.2%
Final Energy Consumption Projection (2030) - WAMs	2,400 kTOE
Renewable Energy Share in Final Energy Consumption (2030)	38.0%
Renewable Electricity Share (2030)	45.2%
Renewable Energy in Transport (2030)	22.5%
Renewable Energy in Heating & Cooling (2030)	18.3%

Kosovo has pledged to reduce its greenhouse gas emissions by 32% by 2030 (Tab. 3), aligning itself with broader European climate policies [44]. Yet, the feasibility of this target remains uncertain given the country's overwhelming reliance on lignite, which continues to generate over 90% of its electricity. The scale of the decarbonisation challenge is immense. The existing power plants, particularly Kosovo A and Kosovo B, not only contribute to substantial CO_2 emissions but also rank among the most polluting in Europe. While the government has committed to transitioning towards cleaner energy sources, tangible progress remains slow, primarily due to the economic infeasibility of rapidly phasing out coal without a

clear alternative energy framework. Beyond emission reductions, Kosovo faces the pressing issue of energy poverty, which disproportionately affects vulnerable communities. Households struggle with inadequate heating during the winter months due to high energy costs. The government has introduced targeted subsidies and efficiency measures to mitigate this crisis, yet these initiatives often fall short of addressing the structural inequalities that perpetuate energy poverty. The reliance on outdated heating systems, the lack of energy-efficient housing, and fluctuating electricity prices further exacerbate this issue, leaving many households in precarious conditions. The challenge is not simply to provide financial relief but to implement sustainable long-term solutions that ensure equitable energy access without deepening the country's dependence on fossil fuels.

3.2.7. Local Targets for CO_2 Reduction and Combating Energy Poverty: Pathways to a Sustainable Future

The recent European energy crisis has highlighted the vulnerabilities within Kosovo's energy sector, particularly the limitations of the current support mechanisms for vulnerable populations. The energy price shocks caused by the crisis have exposed the deep inadequacy of Kosovo's protection framework for vulnerable consumers. At present, the existing support system is restricted to only two groups: beneficiaries of the social assistance scheme and recipients of war-related benefits. These criteria are narrowly defined, leaving a significant portion of the population without any support. Many low-income families, working-class households, informal workers, and pensioners, groups who are facing extreme energy insecurity, remain unprotected under the current system. This gap in support mechanisms underscores the urgent need for a more inclusive and comprehensive approach to addressing energy poverty.

Kosovo's energy landscape also presents a stark contrast between urban and rural areas, with varying access to energy resources and significant differences in environmental impacts [45]. In Pristina, the capital city, significant strides have been made in improving energy access and reducing emissions. The expansion of the district heating system has played a crucial role in reducing household air pollution, providing cleaner and more affordable heating to urban residents. However, this success is largely confined to Pristina, as smaller cities and rural municipalities struggle with outdated energy infrastructure and limited capacity to implement similar initiatives. Local governments in cities like Mitrovica and Gjilan have begun

exploring renewable energy options, with pilot projects focused on solar and wind energy [46]. Despite these efforts, these projects are still in their infancy and face numerous challenges. Regulatory inconsistencies, a lack of robust financial support, and limited technical expertise have hindered their full implementation. Consequently, while there is enthusiasm for renewable energy solutions, progress remains slow and fragmented.

The situation in rural areas is even more dire [47]. In these regions, energy poverty is not just an economic issue; it is a deeply ingrained structural challenge. The inefficiency of local energy grids exacerbates these problems, with frequent outages disrupting daily life and economic activities. The lack of reliable and consistent energy access places rural populations at a severe disadvantage, particularly in terms of economic development, health, and overall quality of life.

Efforts by local governments to address these challenges and promote renewable energy solutions have largely faltered. Financial constraints, insufficient technical knowledge, and poor institutional coordination have all contributed to the slow pace of change. Despite some pilot initiatives, the energy inefficiencies and disparities between urban and rural areas remain pronounced, revealing the deep-rooted socio-economic inequalities that persist within Kosovo. The lack of a cohesive and comprehensive strategy to bridge the gap between these two realities highlights the urgent need for more coordinated action at both the local and national levels. Kosovo must prioritise a more equitable approach to energy access, ensuring that rural areas, in particular, are not left behind in the country's energy transition. Without these efforts, Kosovo risks exacerbating existing socio-economic disparities and failing to build a truly sustainable and resilient energy system for all its citizens.

3.2.8. Obstacles and Key Challenges

Kosovo's transition to a cleaner and more equitable energy system is impeded by a range of systemic challenges, deeply rooted in both structural and institutional obstacles. One of the most significant barriers to decarbonisation is the country's overwhelming reliance on lignite coal, which remains the most affordable and readily available energy source. This heavy dependence on coal creates a significant structural impediment to the shift toward cleaner energy alternatives. The cost of transitioning away from coal is substantial, involving

extensive investments in renewable energy infrastructure, grid modernisation, and the capacity-building necessary to support a sustainable energy future. However, due to Kosovo's budgetary constraints, and a lack of investor confidence, these efforts have yet to gain significant traction. The financial burden of decarbonisation, coupled with limited access to capital, presents a major roadblock in moving toward a greener energy system. In addition to financial challenges, Kosovo's institutional framework presents significant barriers to effective energy transition.

The country's regulatory environment for renewable energy investment is still underdeveloped, which deters private sector engagement and slows the adoption of alternative energy solutions. Despite the growing recognition of renewable energy's potential, Kosovo's regulatory policies are often inconsistent and lack the clarity and stability necessary to attract long-term investments. Political instability further compounds these issues, as shifts in government priorities result in delays, policy reversals, and uncertainty surrounding energy reforms. Energy policies are often subject to abrupt changes, undermining confidence in their long-term viability. Furthermore, widespread corruption and bureaucratic inefficiencies exacerbate the situation, preventing meaningful reforms and eroding trust in the energy sector. These challenges create an environment where short-term political considerations take precedence over long-term strategic planning, which ultimately hampers the effectiveness of Kosovo's energy transition.

Another critical challenge facing Kosovo is the pervasive issue of energy poverty, which remains a significant barrier to the country's energy transition. Energy poverty exacerbates existing social inequalities, creating a vicious cycle where disadvantaged communities are unable to access modern energy services. Policies intended to alleviate energy poverty in Kosovo are often fragmented, with initiatives failing to address the root causes of the crisis. This lack of coordination and integration between energy policy, social welfare, and environmental sustainability further deepens the crisis, leaving marginalised groups without effective support. Without a comprehensive energy strategy that aligns social policies with economic and environmental considerations, Kosovo risks perpetuating a situation where energy poverty and environmental degradation reinforce each other. The failure to address the structural drivers of energy poverty can leave these vulnerable communities trapped in a cycle of disadvantage, while the country's broader goals of decarbonisation and economic growth

are also undermined. For Kosovo to achieve a just and equitable energy transition, it must take a more holistic approach, one that integrates energy access with social equity and environmental sustainability. By building a coordinated framework that addresses the root causes of energy poverty while simultaneously promoting renewable energy solutions, Kosovo can break the cycle of inequality and environmental harm. However, this will require robust, long-term investments, political stability, and a commitment to transparent governance to ensure that all citizens have access to affordable, clean, and reliable energy.

3.2.9. Case Study

This analysis engages with survey findings documenting household experiences with energy affordability, housing infrastructure, and related dimensions of socioeconomic vulnerability over the past five years. The data reveals not merely individual episodes of hardship, but rather enduring patterns of structural exclusion, infrastructural neglect, and unequal access to energy-secure housing. These findings require a situated understanding of energy poverty as a multidimensional issue embedded within broader socioeconomic and political conditions.

To gain a deeper understanding of these issues, a case study was conducted involving 26 family respondents in Kamenica. This survey aimed to identify and address energy poverty by exploring their socioeconomic conditions, evaluating the state of home insulation, and assessing their satisfaction with energy efficiency. The findings underscore the necessity for continued investment in energy infrastructure and targeted interventions to alleviate energy poverty in the region.

Description of the area:

Kamenica, a municipality in eastern Kosovo, has been actively involved in initiatives aimed at enhancing its energy infrastructure and addressing energy poverty among its residents. In 2018, the Ministry of Economic Development announced that Kamenica would benefit from significant projects in energy, water, and digital economy. This includes the integration of villages into water supply systems and the implementation of energy efficiency measures in public buildings. Furthermore, in 2021, citizens of Kamenica actively participated in municipal budget planning, leading to the allocation of funds for public lighting in three

villages, among other infrastructure projects. Despite these efforts, Kosovo, including municipalities like Kamenica, faced significant power outages in December 2024 due to soaring energy demand during cold weather, highlighting ongoing challenges in the energy sector.

Results from energy poverty investigation:

The data on late energy bill payments offers insight into the pervasiveness of economic precariat and its entanglement with energy consumption. Among those who reported delays (excluding those who never experienced them), the majority (54.5%) were late three or more times, with 31.8% indicating delays on more than five occasions. This recurrence suggests not episodic mismanagement or temporary shocks, but rather sustained financial instability that impedes the ability to meet essential energy needs. Such repetition of arrears signals the inadequacy of prevailing economic and welfare infrastructures to buffer households from recurring deprivation. This challenges the dominant policy paradigm that frames energy poverty in behavioral or individualistic terms. Instead, the data directs attention to systemic affordability failures and underlines the need for income-sensitive energy policies, such as progressive tariff systems, energy debt relief programs, or comprehensive social assistance that accounts for energy as a non-negotiable component of dignified living.

Living with energy insecurity:

The prevalence of structural housing issues, mold (27.3%), damp walls or foundations (18.2%), and leaky roofs (9.1%) (Fig. 16), reflects an entrenched condition of housing precariat that is both spatial and physiological. These physical deficiencies are not incidental; they are symptomatic of disinvestment in housing infrastructure, inadequate building standards, and the absence of systematic maintenance protocols, particularly in low-income or marginalised communities.

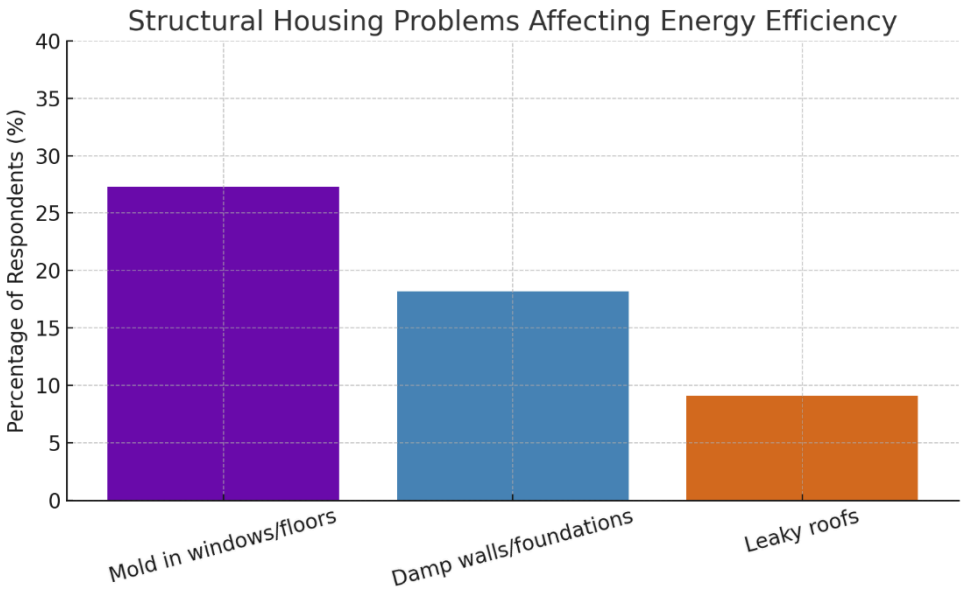


Figure 16: Results on structural housing problems affecting energy efficiency in Kamenica

Moreover, these conditions exacerbate thermal inefficiency, contributing to higher energy consumption and reinforcing cycles of energy poverty. This coupling of poor housing quality with energy hardship foregrounds the ecological injustice embedded in the built environment. The failure to ensure adequate insulation, ventilation, and waterproofing constitutes a form of infrastructural violence that disproportionately burdens economically vulnerable populations and intensifies winter-time deprivation. The data calls for a recalibration of housing policy frameworks to foreground energy-efficient retrofitting, enforce accountability mechanisms for landlords, and reframe housing as a public health issue, recognising the cascading effects of substandard dwellings on physical well-being and economic resilience.

Poor Housing and Living Conditions:

Respondents' perceptions of their homes' energy efficiency further illuminate the limitations of narrowly technocratic approaches to energy poverty. While 31.8% reported a neutral stance, another 31.8% expressed dissatisfaction or strong dissatisfaction with their home's energy performance. Only 9.1% reported high satisfaction. These figures underscore a critical perception gap, where technical interventions, such as insulation or new windows, may be present but fail to achieve meaningful improvements in lived thermal comfort.

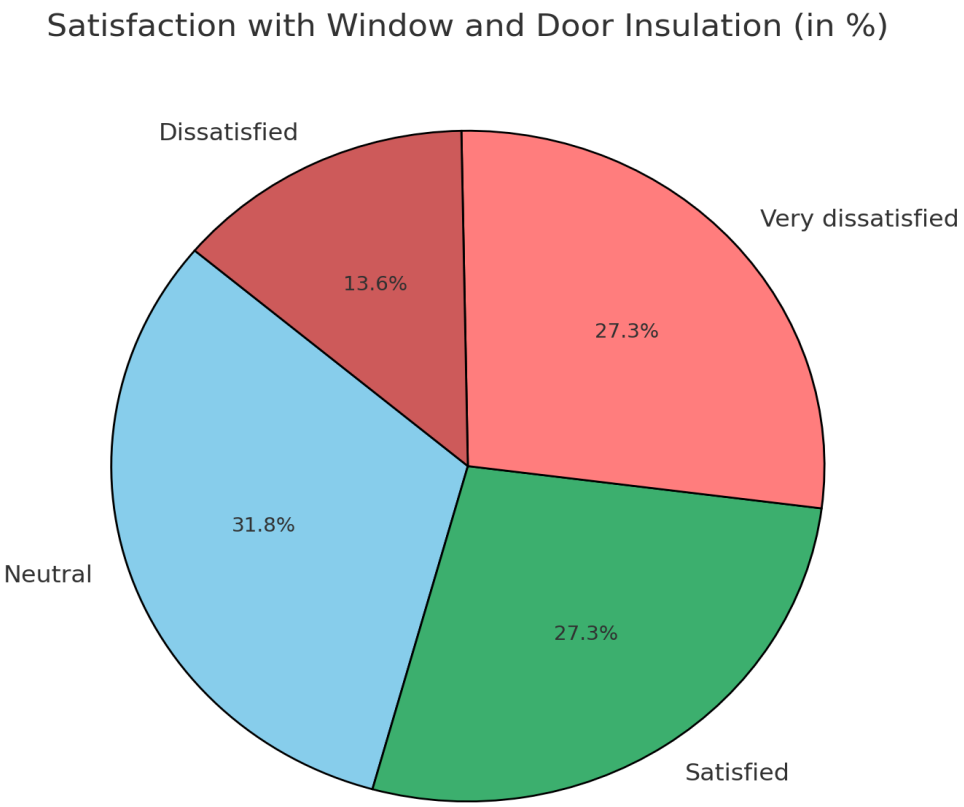


Figure 17: Results on satisfaction with window and door insulation in Kamenica [48]

This suggests that energy efficiency cannot be understood solely in terms of material inputs or isolated retrofitting. Instead, it must be approached as a relational concept, mediated by housing typologies, occupancy patterns, household needs, and socioeconomic context. A critical energy justice lens would thus interrogate how energy interventions are distributed, who benefits, and whose discomfort remains systematically invisible within policy frameworks.

Perceptions on Energy Efficiency:

The winter season emerges as a temporality of heightened vulnerability. High levels of dissatisfaction regarding home conditions during colder months reflect not only infrastructural deficits but also institutional negligence in preparing for and mitigating seasonal hardship. With just 4.5% expressing strong satisfaction with their home's winter conditions, the data

reveals a normalised condition of cold exposure, inadequacy, and discomfort that contradicts the assumption of universal access to basic warmth.

Energy Poverty as a Living Condition

The economic toll of energy poverty extends beyond housing into the realm of daily life and social participation. Nearly half of respondents (45.5%) reported intermittent difficulty meeting basic needs such as food or rent, and another 18.1% described frequent or constant struggle. These patterns indicate not isolated vulnerabilities but a stratified landscape of material insecurity wherein essential needs are routinely negotiated and, at times, sacrificed. Moreover, with total of 77.3% of respondents reported forgoing social or cultural activities due to the cost of energy - either sometimes, often, or always. This form of deprivation is less visible but equally significant. It reveals the extent to which energy poverty functions as a mechanism of social exclusion, curtailing not only physiological well-being but also emotional, cultural, and relational dimensions of life.

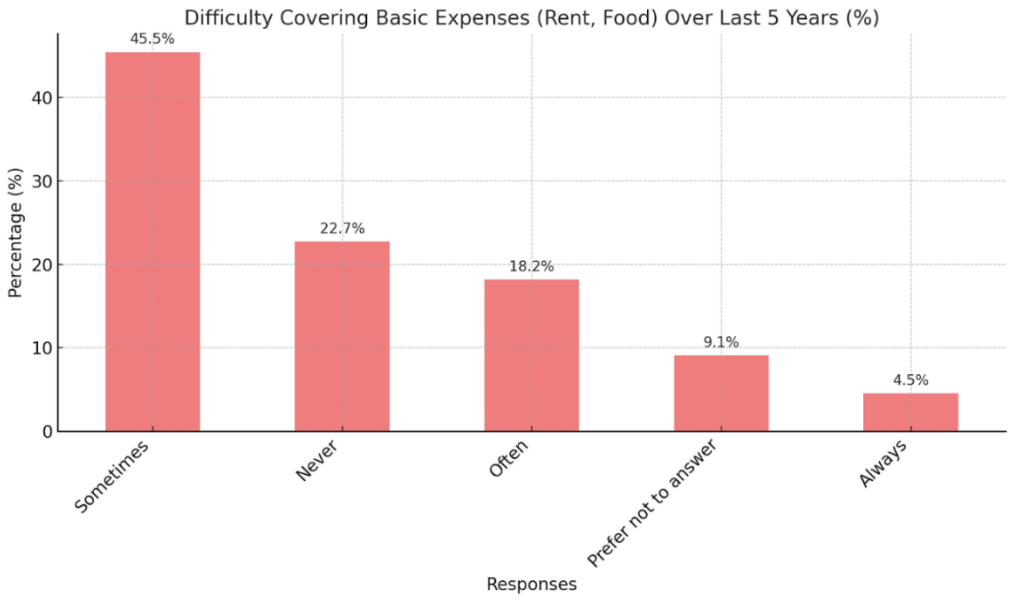


Figure 18: Results on difficulty covering basic expenses over the last 5 years in Kamenica [48]

Towards Sustainable Solutions

The cumulative evidence calls for a paradigm shift in how energy poverty and housing deprivation are understood and addressed in Kosovo. Rather than framing these issues as isolated challenges of affordability or energy use, the data makes visible the complex interplay of inequality, infrastructural neglect, and social exclusion. However, here an intersectional analysis is crucial. Although the present data set does not disaggregate by ethnicity or disability, these dimensions likely mediate the intensity and consequences of energy poverty. For instance, women and the elderly, alongside marginalised communities face compounding barriers to accessing assistance, live in lower-quality housing stock, and may be excluded from policy consultation processes. Ultimately, these data compel a reframing of energy poverty as a structural injustice rather than a technical failure. It is produced and sustained through uneven development, and systemic neglect of low-income communities. Addressing it requires moving beyond energy efficiency metrics and towards a justice-centered approach that foregrounds lived experience, redistributive policy, and the right to warmth, shelter, and participation.

3.3. Germany

Germany is a country in Central Europe known for its rich history, strong economy, and cultural influence. It is bordered by nine countries: Denmark to the north; Poland and the Czech Republic to the east; Austria and Switzerland to the south; and France, Luxembourg, Belgium, and the Netherlands to the west. It has coastlines along both the North Sea and the Baltic Sea. The country's terrain is diverse, featuring the flat North European Plain in the north, forested uplands in the central region, and the Bavarian Alps in the south. Major rivers such as the Rhine, Elbe, and Danube traverse the country, contributing to its varied landscapes and ecosystems.

Germany is the most populous country in the EU and has a federal parliamentary republic system. The capital is Berlin, and other major cities include Munich, Frankfurt, and Hamburg. Germany is renowned for its engineering, automotive industry, classical music, and contributions to philosophy and science. It is also a founding member of the EU and a key player in global politics and economics [49].

3.3.1. National Energy Policy and Climate Action Plan: Strategies for a Sustainable Future

Germany's energy and climate policies are guided by its commitment to achieving climate neutrality by 2045. The country has implemented a comprehensive legal and policy framework to transition towards a low-carbon economy while ensuring energy security and economic stability. The climate action Law, first enacted in December 2019, provides the legal foundation for Germany's GHG reduction targets. It was developed in response to growing public and political pressure, fueled by climate protests and extreme weather events in 2018–2019. The law aligns national policies with EU regulations, including the effort sharing regulation, and ensures compliance with international agreements such as the Paris Agreement [50]. The climate action Law establishes legally binding emission reduction targets, requiring Germany to cut GHG emissions by 65% by 2030 (compared to 1990 levels), 88% by 2040, and to achieve net-zero emissions by 2045. Beyond 2050, it introduces targets for negative emissions, emphasising carbon removal technologies such as Direct Air Capture and Carbon Storage (DACCS). The law assigns annual emissions budgets for key economic sectors, including energy, buildings, transport, industry, agriculture, and waste, to guide sectoral reductions. If a sector exceeds its allocated budget, the responsible ministry must implement corrective measures to compensate for the overage. In 2023, Germany introduced a set of reforms to make the law more flexible by shifting from sector-specific targets to a cross-sectoral approach, allowing sectors to offset emissions through over performance in others [51].

The climate action programme 2023 was introduced to accelerate emissions reductions, particularly in sectors that have struggled to meet their targets, such as transport. The program emphasises a rapid expansion of renewable energy, to supply 80% of electricity from renewables by 2030. It also includes measures to decarbonise industry, such as the introduction of Carbon Contracts for Difference (CCfD) to promote low-carbon industrial processes and the expansion of hydrogen electrolysis capacity to 10 GW by 2030. In the agricultural sector, Germany is investing in forest restoration, moorland renaturation, and improved emissions monitoring to enhance carbon sequestration [52]. Germany's carbon pricing system, launched in 2021, plays a critical role in its climate strategy. This system applies to emissions from the transport and building sectors, initially setting a price of €25 per

ton of CO_2, which increased to €45 in 2024 and is expected to rise to €55 in 2025. From 2026, the system will transition to an auction-based model, integrating with the EU Emissions Trading System II (EU ETS II) in 2027, where market forces will determine carbon prices. Between 2021 and 2024, carbon pricing generated €40 billion in revenue, funding initiatives such as energy-efficient renovations, renewable energy projects, and citizen relief measures. The system is projected to reduce CO_2 emissions by 3.1 million tons by 2025 and 12.4 million tons by 2035 [52].

Despite significant progress, Germany faces challenges in meeting its climate commitments. While the country is projected to reduce GHG emissions by 64% by 2030, it is expected to fall short of its EU targets, particularly in the transport, buildings, and agriculture sectors. A shortfall of 126 million tons of CO_2-equivalent under the EU Effort Sharing Regulation may require Germany to purchase emissions allowances from other EU nations. In 2023, emissions fell by 10.1% to 673 Mt CO_2-equivalent, primarily due to reduced fossil fuel use, a mild winter, and economic slowdowns affecting energy-intensive industries. However, transport emissions exceeded their 2023 cap by 13 million tons of CO_2, making it one of the most critical areas for policy intervention [52]. To address these challenges, Germany is reforming its Climate Action Law to move from annual sector-specific targets to cumulative emissions monitoring, allowing for greater flexibility across sectors. However, environmental organisations have criticized these changes, arguing that they weaken accountability, particularly in sectors struggling to reduce emissions. Balancing emissions reductions with economic stability remains a key challenge, and experts warn that while the 2023 emissions drop appears promising, it was largely driven by external factors rather than sustained climate policies. As a result, stronger long-term measures are needed to ensure that Germany remains on track to meet its climate commitments [52].

3.3.2. National Political Context

Germany has a multi-party parliamentary democracy, with its political system structured around the basic Law (Grundgesetz), which serves as the country's constitution. The Bundestag (Federal Parliament) and the Bundesrat (Federal Council) shape legislation, while

the Chancellor (Bundeskanzler) as head of government, holds significant executive power. Germany is divided into 16 federal states (Länder) and is currently governed by a coalition government, a common feature of its politics due to proportional representation in elections. The ruling coalition typically includes multiple parties, requiring compromise and negotiations. The major political parties include: the center-right, conservative parties: Christian Democratic Union (CDU) and its Bavarian counterpart, the Christian Social Union (CSU), the center-left, historically linked to labor movements, the Social Democratic Party (SPD). The Alliance 90/The Greens (Die Grünen) party, focused on environmental policies and social justice, Free Democratic Party (FDP), a pro-business party, advocating for free markets and individual liberties, Alternative for Germany (AfD), far-right and nationalist party critical of immigration and EU policies and finally the Left (Die Linke), a socialist party advocating wealth redistribution and social justice. Germany is Europe's largest economy but still faces key challenges such as industrial slowdowns, energy price fluctuations and inflation concerns. Current debates revolve around the push for renewable energy and the "Energiewende" (energy transition), immigration policies, the increased investment in defense spending and the rising rents and housing shortages [53, 54].

Figure *19: Regional Divisions within the Federal Republic of Germany [55]*

3.3.3. National Economic and Legislative Context

Germany, as Europe's largest economy, operates within a social market economy (Soziale Marktwirtschaft), which combines free-market principles with a strong welfare state. Its legal system is based on civil law and heavily influenced by the Grundgesetz (basic Law), which outlines fundamental rights and the division of power between federal and state governments. As the fourth-largest world economy, Germany has a GDP of around €4.5 trillion, driven by industry, exports, and services. Indeed, it is a major global exporter, with key sectors including automotive, machinery, chemicals, and pharmaceuticals [56]. As mentioned, Germany has a federal system, meaning legislative power is divided between the Bundestag (Federal Parliament) and Bundesrat (Federal Council). Laws are proposed by the government, debated in parliament, and often require approval from state representatives in the Bundesrat. The key areas of legislation are as follows:

- Corporate tax policies, investment incentives, and wage regulations, i.e., Supply Chain Due Diligence Act (Lieferkettengesetz), that requires companies to ensure ethical labor practices in global supply chains.
- Labor & employment laws: Germany has strong workers' rights, including collective bargaining, co-determination (Mitbestimmung), and strict labor protections.
- Environmental laws, with ambitious climate targets and green policies, influence industries, including emissions regulations and renewable energy laws.
- New immigration policies, aimed at attracting skilled workers to address labor shortages while managing asylum applications. For example, the Skilled Immigration Act (Fachkräfteeinwanderungsgesetz) was recently voted on, which facilitates the entry of skilled foreign workers, as well as the Citizenship Law Reform (2024), which makes it easier for immigrants to obtain German citizenship and allows dual citizenship.

3.3.4. National Environmental Context

Energy and Climate Policy

Germany's Energiewende (energy transition) aims to shift the country toward a low-carbon, renewable energy system while ensuring energy security and economic stability. The nation is targeting 80% renewable electricity by 2030 and climate neutrality by 2045. Wind and solar power are the cornerstones of this transition, with coal and nuclear energy being phased out. However, challenges such as grid stability, storage capacity, and industry decarbonization remain pressing issues [57]. The 2022 energy crisis following Russia's invasion of Ukraine accelerated Germany's efforts to diversify energy sources, develop LNG infrastructure, and boost renewable energy investment [58].

Air Quality and Emissions

Germany has made significant progress in reducing air pollution, largely due to stricter emissions standards, cleaner industrial processes, and the promotion of electric mobility. However, transportation remains a major source of CO_2 emissions, and urban areas still struggle with NO_2 pollution from diesel vehicles [59]. Policies like low-emission zones, public transport expansion, and incentives for electric vehicles aim to address this challenge.

Water Resources and Conservation

Water availability has become an increasing concern, especially due to rising temperatures and prolonged droughts. Germany is implementing water management strategies to protect drinking water supplies, support agriculture, and safeguard aquatic ecosystems. River pollution from agricultural runoff and industrial activity remains an issue, despite strict environmental regulations [60].

Biodiversity and Land Use

Germany's commitment to biodiversity conservation is evident in its national parks, nature reserves, and EU Natura 2000 sites. However, urban expansion, intensive agriculture, and infrastructure projects threaten wildlife habitats. Policies promoting reforestation, sustainable farming, and green urban planning are being implemented to mitigate biodiversity loss [61].

Waste Management and Circular Economy

Germany has one of the world's most advanced recycling systems, with strong policies on waste reduction, extended producer responsibility, and circular economy initiatives. The country is reducing single-use plastics, increasing composting, and promoting repair and reuse systems to minimise environmental impact [62].

3.3.5. National Social Context

Germany is a highly developed, multicultural society (around 27% of the population has a migration background, with large Turkish, Polish, Syrian, and Romanian communities) with a strong welfare state, progressive social policies, and an aging population. While Germany maintains a high standard of living, social challenges such as integration, housing shortages, and demographic shifts continue to shape national debates. These factors are closely linked to energy poverty risks, particularly for vulnerable groups such as migrants. Migrants, who are more likely to live in substandard housing or overcrowded conditions, face heightened exposure to energy poverty due to poor insulation, inefficient heating systems, and higher energy costs. Addressing these social issues and ensuring equitable access to energy are critical steps in reducing the risk of energy poverty and improving living conditions for these groups. Cities like Berlin, Hamburg, and Munich are growing, while rural areas face depopulation. Its population is approximately 84 million, making Germany the most populated EU country. the median age is around 45, and the birth rate is 1.5 children per person capable of pregnancy, below replacement level [63]. While historically Christian (Catholic and Protestant), Germany is increasingly secular, with growing Muslim and non-religious communities.

3.3.6. Energy Poverty Situation in Germany

Germany prioritises affordable energy as a core pillar of its energy transition, recognising it as essential for social stability and economic well-being. The government does not treat energy poverty as an isolated issue but integrates it into a broader social welfare framework. Under Germany’s constitution, all individuals have a right to a minimum standard of living, which includes access to energy as part of basic welfare [64]. Heating and hot water costs are fully covered for those receiving social benefits under social code Volumes II and XII, ensuring

households are not forced to go without essential heating. Household electricity expenses, excluding decentralised hot water production, are included in a standardised welfare allowance that is periodically adjusted for inflation and wage trends [65]. For decentralised hot water systems, additional financial support is provided. Electricity disconnections are permitted only if the outstanding debt exceeds €100 and there is no feasible repayment plan. Disputed debts or those from unresolved pricing conflicts cannot be used as grounds for disconnection. Gas disconnections follow similar regulations, though with no minimum arrears threshold [66]. As a result, only 6% of households that received disconnection warnings for electricity and 3% for gas in 2018 actually lost supply, indicating the effectiveness of protective measures [57]. Beyond emergency financial aid, Germany promotes long-term affordability through initiatives like the energy savings check, which offers free consultations and energy-saving tools. Caritas Germany, for instance, provides tailored energy advice, including in-home consultations and efficiency tips [67].

Germany lacks a singular definition of energy poverty. The most common method considers households spending more than 10% of their income on energy. A more nuanced measure includes both energy expenses and relative income levels to avoid misclassifying high-income households with high usage [68]. Despite support programs, energy poverty has intensified, particularly since the 2022 energy crisis. According to the 2024 European Union Statistics on Income and Living Conditions (EU-SILC) survey, 6.2% of German households couldn't sufficiently heat their homes, and 4.7% fell behind on payments. A study by the Öko-Institut for the German Environment Agency (UBA) found that 10% of households were highly vulnerable to energy price shocks [69]. The report "Gefahr der Energiearmut wächst" ("The Risk of Energy Poverty is Growing") details how rising prices disproportionately burden low-income groups. Between March 2022 and June 2023, median household energy costs rose by €52/month. For low-income households, energy costs rose from 12% to 16% of income, while higher-income groups remained around 4%. Energy poverty increased from 14.5% in 2021 to 25.2% in May 2022, excluding relief measures (Fig. 20) [68].

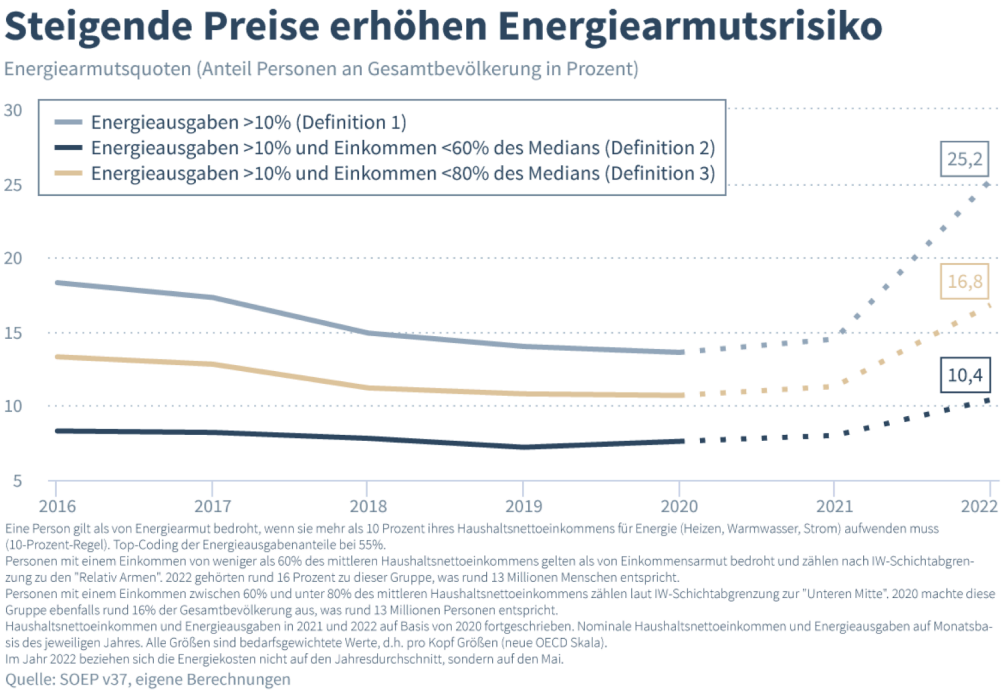


Figure 20: Increase in Energy Poverty Risk Due to Rising Prices [70]

Vulnerable groups include the unemployed, retirees, single parents, and those in poorly insulated homes. Even middle-income households (earning 60–80% of the median) were increasingly affected, with 40% experiencing energy poverty in 2022, double the rate of prior years' [68]. Among households below the poverty line, the rate rose from 49% to 65% [68]. To mitigate this, the German government expanded housing benefits in 2023 to include permanent heating and climate components, increasing the average monthly payment from €180 to €370 and covering 5% of all households. The benefit includes a €0.40/m² supplement for energy-efficient housing [71]. However, structural reforms are still needed. A joint report by the Öko-Institut and The Federation of German Consumer Organisations (Verbraucherzentrale Bundesverband e.V. - VZBV) recommends allocating €17 billion over two years for energy efficiency upgrades in low-income homes. This investment could cut 9.5 TWh of energy demand and reduce emissions by 2.6 million tons, with potential lifetime energy savings of €20 billion [69]. Municipalities are also affected: 46% report that energy prices are difficult to manage, and 5% say they are unsustainable without service cuts or debt [72]. Public surveys reveal behavioral shifts: 55% of Germans changed heating habits after Russia's invasion of Ukraine, motivated by rising costs (55%), energy independence (27%),

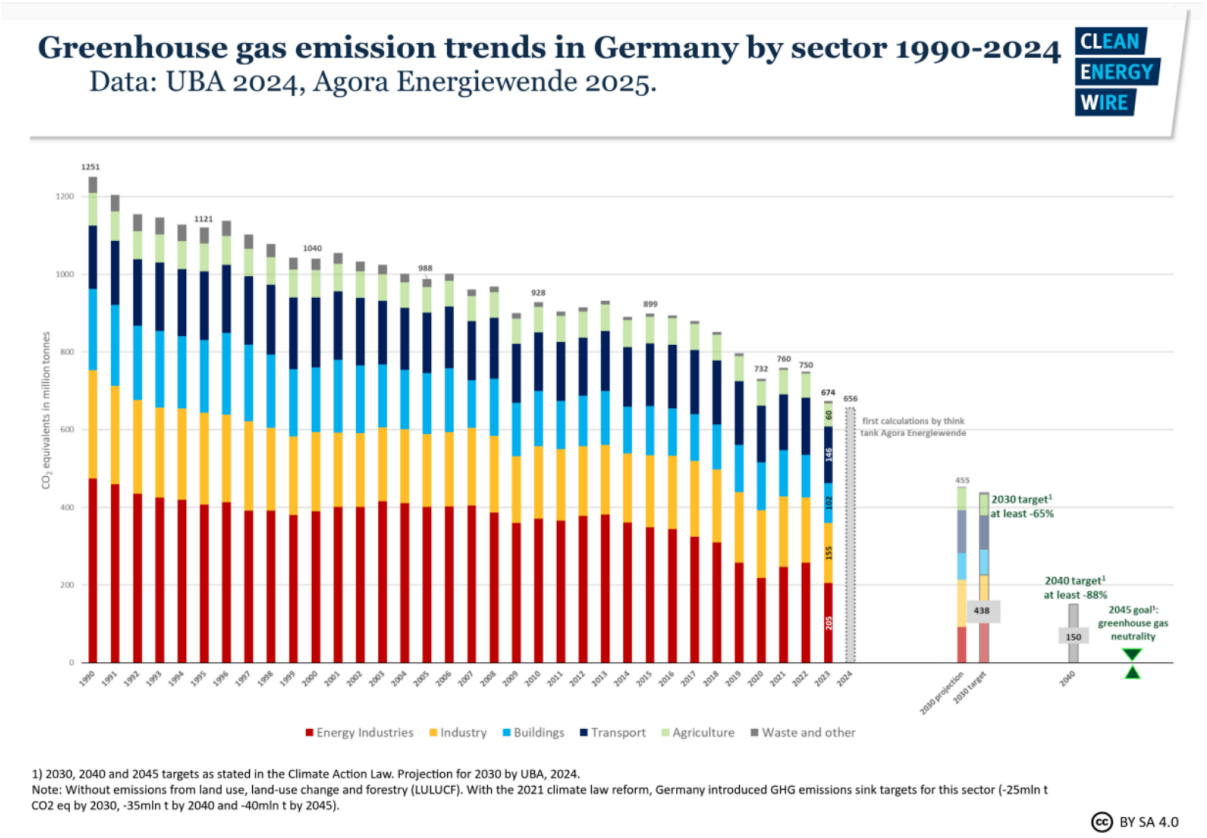
and environmental concerns (18%). Yet, in 2022, 5.5 million Germans still reported being unable to keep their homes warm [73, 74]. While energy prices have stabilised somewhat, the burden on lower-income households remains high. Experts call for targeted subsidies, social housing reforms, and better data collection to inform future policy [68].

3.3.7. Local Targets for CO_2 Reduction and Combating Energy Poverty: Pathways to a Sustainable Future

Germany's climate strategy is centered on rapid decarbonisation, expansion of renewable energy, and modernisation of infrastructure. The country has set ambitious targets to transition to renewable energy, enhance energy efficiency, and secure energy supply, ensuring a sustainable future. By 2030, at least 80% of Germany's electricity consumption should come from renewables, supported by capacity expansion targets of 215 GW for solar Photovoltaics (PV), 115 GW for onshore wind, and 30 GW for offshore wind. To achieve these goals, the government is accelerating renewable energy deployment, streamlining regulations, and investing in innovative solutions such as agrivoltaics and floating solar farms [75]. Energy security is a top priority for Germany, which maintains one of the most reliable electricity grids in Europe. The country has significantly reduced power outages, with the average power interruption per user falling to 12.2 minutes in 2022, down from 21.5 minutes in 2006 [76]. To support the increasing share of renewables, Germany is expanding its electricity grid, investing in High-Voltage Direct Current (HVDC) transmission lines to efficiently transport electricity across the country. By the third quarter of 2023, 509 km of new grid projects had been completed, with over 3,000 km currently in planning [77]. Additional measures, such as the 2022 Act on the maintenance of substitute power stations, aim to reduce dependence on natural gas while maintaining energy security [78].

Decarbonisation of the building and heating sectors is also a key priority. The government is promoting climate-friendly heating solutions and energy-efficient buildings through financial incentives, including grants covering up to 70% of investment costs for heating system upgrades. A major initiative is the installation of 500,000 heat pumps annually starting in 2024, while the heat planning act mandates that all German states develop greenhouse

gas-neutral heating plans by 2045. To support these efforts, Germany has allocated over €670 million for modernising heating networks and infrastructure [78]. The transport sector is undergoing major transformations to reduce emissions. Germany is expanding public transport, introducing the Deutschlandticket, which makes public transit more affordable and attractive. A CO_2-based toll for Heavy Goods Vehicles (HGVs) has been introduced, incentivising cleaner transport solutions, with new regulations mandating a 45% reduction in CO_2 emissions from new HGVs by 2030. By the same year, 90% of city buses must be emissions-free, with full electrification planned by 2035 [78]. Germany's long-term strategy extends beyond 2045, with initiatives such as the National Biomass Strategy (NABIS), which aims to ensure sustainable biomass use for energy, industry, and ecological needs. Additionally, the long-term strategy on negative emissions will integrate carbon removal technologies into Germany's climate policies, with goals extending to 2060 [78]. These initiatives highlight Germany's commitment to achieving a sustainable, carbon-neutral future while maintaining energy security and economic resilience (Fig. 21).



1) 2030, 2040 and 2045 targets as stated in the Climate Action Law. Projection for 2030 by UBA, 2024.
Note: Without emissions from land use, land-use change and forestry (LULUCF). With the 2021 climate law reform, Germany introduced GHG emissions sink targets for this sector (-25mln t CO2 eq by 2030, -35mln t by 2040 and -40mln t by 2045).

Figure 21: GHG emission trends in Germany by sector (1990-2024) [75]

Berlin and Brandenburg:

The Berlin-Brandenburg region is actively working on climate policies. Both Berlin and Brandenburg have their own plans to reach carbon neutrality, but they are connected and follow Germany's overall goal of becoming climate-neutral by 2045.

Berlin:

Berlin has long been at the forefront of urban climate action. Initially targeting carbon neutrality by 2050, the city now aligns with the national target of reaching climate neutrality by 2045. It has set interim goals to reduce CO_2 emissions by 70% by 2030 and at least 90% by 2040, relative to 1990 levels [79]. The city's primary policy instrument, the Berlin Energy and Climate Protection Programme (BEK), outlines 95 measures across sectors such as energy supply, buildings, and transportation. Major focus areas include transitioning away from coal and oil for heating and power generation, increasing the use of renewables, enhancing energy efficiency in buildings, and promoting electric mobility. Although a 2023 referendum proposed accelerating climate neutrality to 2030, it failed to meet the required quorum, despite a majority vote in favor. Nonetheless, the city continues to strengthen its climate policy in light of national challenges as recent reports warn that Germany is likely to miss its 2030 climate targets without significant policy adjustments [80]. To support decarbonisation, the federal government has allocated €3 billion in subsidies for industry, with further funding planned in 2025 to support emissions reduction in sectors such as energy and manufacturing [80].

Energy poverty, when households cannot afford essential energy services such as heating, lighting, or cooling, remains a pressing issue in Germany, including the Berlin-Brandenburg region. The recent surge in energy prices, driven by the energy crisis and geopolitical instability, has worsened this situation. In Berlin and Brandenburg, low-income households, renters, and people living in poorly insulated buildings have been affected the hardest. The crisis has exposed structural weaknesses in the energy system, including outdated housing

stock and dependency on fossil fuels. In Berlin, the Senate has responded with targeted measures such as subsidies for energy-efficient building renovations and emergency financial aid for utility costs. These programs aim to reduce household energy consumption while protecting vulnerable groups from disconnection. The city also supports community energy initiatives that allow residents to co-own renewable energy systems, helping them lower costs and participate in the energy transition [81].

Brandenburg:

The state of Brandenburg, surrounding Berlin, complements the capital's ambitions by focusing on renewable energy expansion and cross-sectoral cooperation. While its climate targets have historically been less prominent, the adoption of the Brandenburg climate plan in March 2024 marks a significant step toward achieving climate neutrality by 2045. The plan outlines 103 measures, covering renewable energy, energy efficiency, and climate adaptation [82]. The Ministry of Agriculture, Environment, and Climate Protection coordinates the implementation of the plan with contributions from all relevant ministries. Scientific oversight is provided by the Scientific Climate Council of Brandenburg (WKB), chaired by Hermann Lotze-Campen of the Potsdam Institute for Climate Impact Research (PIK), ensuring that the measures are evidence-based [83]. Further regional support comes from the Climate Change Center Berlin Brandenburg (CCC), an interdisciplinary hub for climate research and knowledge transfer. The CCC plays a vital role in engaging stakeholders and developing innovative solutions for mitigation and adaptation across the region [84].

Regarding the energy poverty issue in Brandenburg, it has taken a similar approach. The state's climate plan includes actions to address energy poverty through better energy efficiency standards in housing and support for renewable energy in rural areas [84]. Special attention is paid to socially just climate measures, guided by the scientific climate council of Brandenburg, which stresses equity and resilience in its recommendations [83].

3.3.8. Obstacles and Key Challenges

Achieving targets for CO_2 reduction and combating energy poverty in Berlin and Brandenburg involves a range of interconnected challenges. These include outdated energy infrastructure, political resistance to renewable energy projects, economic challenges related to financing the

transition, and social resistance to changing consumption habits. Additionally, the region's dependence on coal, particularly in Brandenburg, the slow adoption of electric vehicles, and the high emissions from heavy industries such as cement and steel contribute to the complexity of achieving rapid decarbonization.

Located in Brandenburg and part of the historically coal-dependent Lausitz region, the Dahme-Spreewald district (Landkreis Dahme-Spreewald, LDS) is currently undergoing a structural transformation toward renewable energy and sustainable development. We focus on the obstacles faced by LDS in more detail because it includes the town of Luckau (the site of our case study, see chapter 3.9.9.), offering a concrete example of how a rural district is navigating the path toward climate neutrality and energy justice.

One of the main barriers to rapid CO_2 reduction in LDS is the lack of necessary infrastructure for large-scale renewable energy deployment. Challenges include:

- Limited grid capacity to handle increased electricity from renewable sources, requiring investment in grid expansion and modernisation.
- High initial costs for energy-efficient building renovations and smart grid technology, which may be difficult for municipalities and private homeowners to afford.
- Need for storage solutions, as wind and solar energy generation fluctuates. Investment in battery storage and hydrogen technology is critical but currently underdeveloped in LDS.

Additionally, the economic development of the LDS, particularly around the Berlin Brandenburg Airport (BER), creates tension between economic expansion and climate protection. A major challenge is the increased land consumption for housing, industry, and transportation, which leads to higher CO_2 emissions from construction and energy use. Additionally, high traffic emissions from the airport and logistics hubs make reducing CO_2 in transport particularly difficult. Furthermore, local businesses express resistance to the transition to renewable energy due to concerns over rising energy costs, adding another layer of complexity to balancing growth with sustainability. Public resistance to certain climate measures is another major obstacle. Opposition to wind energy projects is common, driven by concerns over landscape changes, noise pollution, and potential impacts on biodiversity.

Additionally, limited awareness among citizens and businesses about energy efficiency programs and climate policies hampers broader participation in sustainability efforts. Affordability concerns also play a crucial role, particularly for low-income households that may struggle with the rising costs associated with green energy transition investments. Beyond mitigation, LDS must also adapt to the effects of climate change, as rising temperatures, extreme weather events, and water shortages are already impacting the region. Declining water resources pose a challenge for agriculture and tourism, requiring new water management strategies. Additionally, increased energy demand for cooling during heat waves puts strain on power grids, while flood risks from extreme weather events necessitate investments in resilient infrastructure to protect communities and businesses [85].

3.3.9. Case Study

Description of the area:

At the project's initial input seminar, Comparative Research Network (CRN) invited Jerome R. Haßler, Climate Adaptation Manager of Luckau, Germany, to provide insights into the city's energy landscape and energy poverty challenges. His talk played a key role in shaping this part of the report, offering a detailed account of Luckau's participatory strategies for climate adaptation. In his presentation, he outlined the critical planning challenges the city faces, particularly in balancing land-use priorities for renewable energy expansion and ensuring the feasibility of district heating networks. He emphasised the need for innovative solutions that integrate both technical and social considerations while securing public acceptance. His presentation highlighted the critical role of inclusive decision-making in the energy transition, stressing the need to actively involve local communities, policymakers, and stakeholders to effectively address the challenges of climate adaptation and sustainable energy planning.

Figure 22: Location of Luckau, Germany

Luckau is a town in the state of Brandenburg, one of Germany's 16 federal states (Bundesländer). Administratively, it falls within the Dahme-Spreewald district (Landkreis Dahme-Spreewald), which is responsible for regional governance, infrastructure, and public services. At the local level, Luckau functions as a municipality (Gemeinde), managing urban planning, public transportation, and waste management. While it has its own municipal government, it operates under the broader authority of the Dahme-Spreewald district and the state of Brandenburg. Luckau is located within the historical region of Lusatia, which spans across Brandenburg and Saxony. The region combines urban and rural communities, maintaining a distinctive cultural identity while undergoing economic and environmental transitions. Luckau has a population of approximately 9,501 residents (as of December 2022). The town consists of 21 districts, including one urban center and 20 former villages. Geographically, Luckau lies about 80 km south of Berlin, along the northern side of the Lusatian border wall, with the Berste and Wudritz rivers flowing into the Spree. The highest

point in the area is Mühlenberg (120 meters above sea level). The southern half of the town's territory is part of the Niederlausitzer Landrücken Nature Park, featuring unique landscapes shaped by the region's historical connection to lignite mining, particularly the former Schlabendorf-Süd lignite mine in the Lusatian coalfield [86].

One of the most pressing challenges for Luckau is its changing demographic structure, characterised by an increasingly older population. Over the past decades, Luckau, like many other towns in Brandenburg, has experienced a decline in birth rates and an out-migration of young people, particularly those in their late teens and early twenties who leave for education or employment opportunities in larger cities like Berlin, Cottbus, or Dresden. As a result, the proportion of elderly residents (aged 65 and above) is steadily increasing, leading to greater demand for healthcare, social services, and age-friendly urban infrastructure. The infrastructure and housing stock must be adapted to meet the needs of an aging population. This includes making public spaces more accessible, expanding barrier-free housing options, and improving transportation systems to ensure that elderly residents can move around the city safely and independently. The strategy emphasises the importance of developing intergenerational urban spaces, where both younger and older residents can interact and benefit from shared facilities. Despite the overall trend of population aging, Luckau has also experienced a rise in migration from Berlin and its surrounding metropolitan area, driven by increasing housing costs in the capital and the search for a better quality of life in smaller towns. As Berlin continues to expand, more families are choosing to move to places like Luckau, where housing is more affordable, and the natural environment offers a better living experience. This has led to an unexpected increase in demand for school and kindergarten places, particularly in the younger age groups. The need for additional school and childcare services also aligns with Luckau's broader goal of attracting and retaining young families [87].

Luckau faces significant environmental challenges, including increasing heat waves, prolonged droughts, and heavy rainfall events, which threaten vegetation and urban ecosystems. Additionally, the legacy of coal mining has caused severe groundwater imbalances, sedimentation, acidification, and the accumulation of iron hydroxide in local water bodies. To address these issues, Luckau is implementing a comprehensive climate

adaptation and modernisation plan focused on restoring natural water systems, expanding green spaces, and strengthening climate resilience. Some of the measures include the revitalisation of the Stadtgraben and Berste river, where eco-friendly dredging, riverbank stabilisation, and native vegetation replanting will improve water retention and reduce sedimentation from former mining activities. In the city park, irrigation systems are being upgraded, pathways are made more permeable to enhance water absorption, and the Weiher pond is being restored with improved public access. In the historic city center and promenade, greening initiatives such as tree planting, improved park areas, and expanded shaded zones aim to regulate urban temperatures and enhance public spaces. Meanwhile, residential districts, especially those near the Schanze, are undergoing ecological improvements, including biodiversity-friendly landscaping, controlled visitor access to forests, and the planting of climate-resilient tree species. Luckau is also committed to reducing carbon emissions, improving energy efficiency, and increasing renewable energy use. Efforts include retrofitting buildings for energy efficiency, promoting solar and wind power, and encouraging responsible waste management and circular economy initiatives, encouraging responsible consumption and local recycling programs [87].

Luckau is undergoing a comprehensive energy transition to reduce carbon emissions, increase energy efficiency, and integrate renewable energy sources. The city's strategy focuses on district heating networks, solar thermal energy, photovoltaic installations, hydrogen production, and seasonal energy storage. A core component of Luckau's energy transformation is the establishment of a district heating network that will primarily serve residential buildings, schools, and healthcare facilities. This network will operate with a two-tiered temperature system, where a low-temperature network (up to 60°C) will supply most residential and institutional buildings, while a high-temperature network (up to 95°C) will meet the needs of hospitals and other facilities requiring higher heat levels. The heating network will be powered by a combination of solar thermal energy, hydrogen-based Combined Heat and Power (CHP) plants, and seasonal energy storage systems. The integration of 5,000 m^2 of solar thermal collectors will allow excess heat to be stored in an aquifer storage system, ensuring a stable heat supply during winter months. One of the most innovative solutions in Luckau's energy strategy is aquifer heat storage, which will allow excess solar thermal energy from summer to be retained and used in winter. This system

significantly reduces reliance on fossil fuels and enhances the overall efficiency of the heating network. Additionally, high-temperature storage units will serve as backup systems to maintain uninterrupted heating for critical infrastructure. Hydrogen also plays a crucial role in Luckau's decarbonisation efforts. The plan includes using excess wind energy to produce hydrogen through electrolysis. This hydrogen will then be utilised in CHP plants, generating both electricity and heat. Moreover, waste heat from the electrolysis process will be recovered to further enhance system efficiency. However, challenges such as hydrogen storage, cost, and availability need to be addressed to ensure long-term feasibility. The strategy also prioritises energy efficiency improvements in existing buildings. Measures include: retrofitting older buildings with improved insulation and heating systems, installing solar thermal systems on rooftops to supplement heating needs and implementing smart energy management systems to optimise energy consumption in public and private buildings. The city's energy plan emphasises a mixed approach, where both centralised and decentralised solutions work together. While the district heating network serves major institutions and housing blocks, individual households and smaller buildings are encouraged to adopt decentralised solutions like solar thermal systems and heat pumps [88].

Luckau is expanding its PV energy capacity as part of its shift to renewable energy. Ground-mounted PV systems are a key part of this effort, helping the city meet climate goals, improve energy security, and support the local economy. To achieve this, a structured plan is in place to find suitable locations, use innovative technology, and address environmental, social, and technical challenges. Finding the right land for solar installations is crucial since not all areas are suitable due to environmental regulations, agricultural use, or infrastructure limitations. In a selection process, land is categorised based on factors such as sunlight availability, proximity to the power grid, and potential conflicts with other land uses. Priority is given to areas that do not interfere with protected natural spaces or high-value farmland, ensuring minimal environmental impact while maximising energy production. Two types of PV systems are being considered: traditional ground-mounted solar farms and Agri-PV. Traditional solar farms place large panels on open land, typically in unused fields, former industrial sites, or lower-quality farmland. Agri-PV, a more innovative approach, allows solar panels to be installed above crops, enabling both farming and energy generation on the same land. Integrating new solar systems into Luckau's energy infrastructure presents challenges,

such as grid connection, energy storage, and distribution. Battery storage and smart grid technologies are needed to maintain a stable energy supply. Public acceptance is another concern. Some residents worry about land use changes, economic impacts, or how solar farms might affect the landscape. To address this, transparent communication, community involvement, and fair benefit-sharing are essential. Offering lower energy costs or co-ownership options to local communities can help increase support for solar projects [88].

Despite its ambitious plans, Luckau faces several challenges in expanding renewable energy. Financial constraints pose a major hurdle, as large-scale projects require significant investment, making funding a key priority. Public acceptance is also crucial, as engaging residents and ensuring fair pricing for heating services can help prevent opposition. Additionally, land use and infrastructure must be carefully planned to identify suitable sites for solar farms, hydrogen production, and aquifer storage. To address these challenges, Luckau is pursuing public-private partnerships, securing national and EU funding, and actively involving local communities in decision-making [88].

3.4. Greece

Greece, which also stands as the Hellenic Republic, is a Southeast European country. Greece sits at the southernmost point of the Balkan peninsula and borders Albania to its northwest. At the same time, it shares borders with North Macedonia and Bulgaria in the north and Turkey in the east. The mainland of Greece faces east towards the Aegean Sea, while the Ionian Sea stretches to its west, and to the south lies the Sea of Crete alongside the Mediterranean Sea. Greece boasts the longest Mediterranean coastline, which includes thousands of islands. Nine traditional geographic regions make up the country, supporting a population greater than 10 million. Record economic growth from 1950 to the 1970s advanced Greece into a developed nation with an advanced high-income economy. In 1981, Greece became the tenth state to join the European Union and participated in several international organisations and forums. Greece demonstrates a distinctive cultural heritage alongside its extensive tourism industry and significant shipping sector. The nation possesses a wealthy historical heritage represented by its 19 designated United Nations Educational, Scientific and Cultural Organisation

(UNESCO) World Heritage Sites. In 2023, international travel statistics placed Greece as the ninth most popular destination worldwide.

3.4.1. National Energy Policy and Climate Action Plan: Strategies for a Sustainable Future

The revised NECP was published in the Official Gazette in December 2024. This NECP is, in principle, Greece's strategic plan for achieving its GHG emission reduction targets. It is based on current data and reasonable projections for the evolution of the maturity and cost of "green" technologies. It has been prepared with the basic principle of minimising the cost of the energy transition to achieve the desired outcome. This principle is reflected in the prioritisation of interventions according to the following scheme so that, where there are equivalent alternatives, the most mature and cost-effective interventions are prioritised to achieve the objectives.

The following have also been taken into account in the preparation of the NECP:

- The macroeconomic projections and the evolution of prices of energy products set on international markets and GHG emission allowances align with the European Commission's projections. According to these, wholesale gas prices will be relatively stable at the level of 38 €/MWh until 2050, but CO_2 emission allowance prices will fluctuate at the level of 80 €/tons until 2030 and then increase drastically up to 290 €/tons until 2040 and 490 €/tons until 2050, while from 2027 onwards other sectors (buildings, transport, etc.) will be included in the emissions market system. etc.), initially with transitional (reduced) prices and entirely from 2031 onwards. The escalation of emission allowance prices is an essential way of motivating the energy transition and financing the measures to achieve it.
- A realistic representation of the potential of renewable energy sources according to existing studies (e.g., biomethane, hydro, pumped storage, offshore wind).
- The ongoing decarbonisation projects in specific industrial sectors, some of which have been included in Community programmes for co-financing (e.g., refineries, cement industries).
- The pursuit of solutions that are as sustainable as possible in the long term. This calls for a strategy leading to the eventual decarbonisation of fossil fuels, as solutions such

as fossil fuel conservation with Carbon Capture and Storage (CCS) or capture and storage of carbon dioxide from the air (DAC) are not sustainable in perpetuity due to the finite storage potential. Thus, carbon capture and storage is primarily (and without prejudice to the next point) preferred as a transitional solution for sectors with no other visible alternative (such as the cement industry and refineries) until alternative products are developed. At the same time, to achieve the net zero target in the shortest possible timeframe by 2050, the use of carbon capture from air (DAC) is introduced after 2050. This choice is combined with the reasonable expectation that DAC costs will be decoupled by then.

- The need to maintain a high level of energy security and adequacy of supply. The complexity of the energy transition and the replacement of fossil fuels with renewable fuels must be reconciled with maintaining and increasing uninterrupted access to energy resources. This necessity calls for a number of transitional options, which, depending on progress towards individual decarbonisation targets, will be kept under constant review for the period covered by the NECP.

The NECP was developed using the International Energy Agency (IEA)'s TIMES energy system simulation model and a simulation model of the operation of the National Technical University of Athens (NTUA) 's power system [89].

Greece's path towards the goal of climate neutrality in 2050 is divided into three main periods of energy transition, each of which focuses successively on a different key parameter of the energy transition: first, the decarbonisation of electricity generation, then the electrification of as much of the final energy use as possible and, finally, the widespread decarbonisation of the so-called hard to abate sectors, through alternative fuels. Although the boundaries between these periods are not entirely distinct, this gradual evolution emerges from the energy system modelling as the most rational and cost-effective solution in terms of transition costs, as it takes optimal advantage of the (already occurring in some and expected in others) decoupling of transition costs per technology. Priority has also been given to the required climate change adaptation actions in line with the United Nations Framework Convention on Climate Change (UNFCCC) requirements. Targeted climate change adaptation measures have been foreseen within the updated NECP, which address both natural and human systems and are based on

vulnerability assessments for ecosystems, economic sectors and population groups. The planned policies and measures aim to reduce climate vulnerability for each dimension of the updated NECP separately. The implementation of these policies and measures is imperative because climate change will have a significant impact on the entire energy system. For example, reduced water availability jeopardises the operation of thermal power plants. In addition, electricity transmission and distribution networks, high-voltage power plants, and other energy networks and facilities are vulnerable to extreme weather events. At the same time, rising sea levels threaten coastal energy infrastructure. Rising average temperatures are expected to reduce energy needs for heating in the winter period and increase energy needs for cooling in the summer. Finally, climate change is expected to affect the performance of renewable energy systems, creating uncertainty in achieving the targets set.

Table 4: Quantification of NECP targets and indicators [90]

TARGET ACHIEVEMENTS	***YEAR 2030***		***YEAR 2035***	***YEAR 2040***	***YEAR 2045***	
	EU TARGET	***NECP PROJECTION***	***NECP PROJECTION***	***NECP PROJECTION***	***EU TARGET***	***NECP PROJECTION***
*Reduction of GHG emissions compared to 1990 (with LULUCF)**	*-55%*	*-58%*	*-69%*	*-80%*	*-100%*	*-98%*
*Renewable Energy Source (RES) in gross final energy consumption***	*42.5%*	*43.0%*	*60.6%*	*77.2%*		*95.8%*

*RES in gross electricity consumption****	*69.0%*	*75.7%*	*96.2%*	*102.8%*	*100.0%*	*100.8%*
*RES in heating and cooling***		*52.6%*	*60.6%*	*75.2%*		*84.1%*
*RES in buildings***	*49.0%*	*72.2%*	*86.0%*	*93.3%*		*95.1%*
*RES in industry***		*34.0%*	*43.0%*	*57.3%*		*65.8%*
*RES in transport***	*29.0%*	*13.4%*	*43.2%*	*69.0%*		*96.1%*
*Advanced biofuels + RFNBO (% of transport fuels)***	*5.5%*	*4.6%*	*11.2%*	*14.2%*		*13.2%*
*RFNBO (% of transport fuels)***	*1.0%*	*0.9%*	*5.4%*	*11.5%*		*30.9%*
SAF (Sustainable Aviation Fuel) of biological origin	*6%*	*5.0%*	*16.2%*	*25.3%*		*38.0%*
SAF (Sustainable Aviation Fuel) of non-biological origin		*1.0%*	*4.1%*	*8.1%*		*43.9%*
Final energy consumption (kTOE)	*14.6%*	*15.2%*	*14.1%*	*13.4%*		*12.2%*
Primary energy consumption (kTOE)	*17.1%*	*17.8%*	*16.8%*	*16.3%*		*16.9%*

*Domestic energy consumption and international air transport.

**Calculation according to the provisions of RED III, using the tool "Eurostat Sharestool Draft_version 5".

***(RES injection - Storage losses) / (Net production + Net imports + Own use of production).

3.4.2. National Political Context

Greece operates as a parliamentary constitutional republic, where the Prime Minister leads the government within a multi-party political system. Legislative authority lies with the Greek Parliament, while the judiciary functions independently from both the executive and legislative branches. Since 2011, Greece has implemented the “Kallikratis” Programme (Law 3852/2010), which restructured the country's administrative organisation. This reform redefined the boundaries and responsibilities of local self-government units, altered the election processes of local authorities, and clarified their roles and powers. Additional reforms

followed with Law 4555/2018 and subsequent amendments under the "Kleisthenis" programme. These aimed to deepen democratic governance, enhance citizen participation, and improve both funding mechanisms and the developmental capacity of local authorities.

3.4.3. National Economic and Legislative Context

According to Note on the Greek Economy, the Bank of Greece (Feb. 2025) in January 2025 [91], Greece's Economic Sentiment Indicator (ESI) rose to 108.6 (from 106.4 in December 2024), driven by improved business expectations in the manufacturing sector, which offset declines in other sectors. Consumer confidence also showed positive momentum. The Purchasing Managers' Index (PMI) recorded 52.8 in January (slightly down from 53.2 in December), indicating ongoing expansion in manufacturing for the 24th consecutive month. Input and output prices continued their upward trend. Industrial production increased by 5.8% year-on-year (y-o-y) in December, supported by a 3.6% rise in manufacturing and a notable 16.4% increase in electricity production. For 2024, industrial output rose by 5.2%, with manufacturing up by 3.7%. Building activity remained strong, with building permits surging 46.7% y-o-y in October and posting a 14.7% increase over the January–October 2024 period. Retail sales volume edged up 1.1% y-o-y in November, though it declined by 1.2% y-o-y for the January–November period. Household nominal disposable income rose by 7.3% y-o-y in Q3 2024, largely due to increases in compensation for employees and self-employed individuals. However, due to continued inflationary pressures, real disposable income grew more modestly, up 3.0% y-o-y. Headline Inflation (HICP) rose to 3.1% in January 2025, up from 2.9% in December 2024. This was driven mainly by increases in volatile components such as energy (up to 2.6% from 0.7%) and unprocessed food (up to 0.8% from 0%). Lower inflation in non-energy industrial goods partially offset these, which declined to 1.4% from 1.7%. Employment rose by 0.8% y-o-y in December 2024, while the seasonally adjusted unemployment rate decreased to 9.4%. However, net flows of dependent employment in the private sector fell by 14,218 jobs in December 2024 compared to an increase of 18,496 jobs during the same month in 2023.

The general government's primary cash surplus reached 5.1% of GDP in 2024, significantly higher than the 2.4% recorded in 2023, largely thanks to increased tax revenues. Private sector

bank deposits rose by €5.7 billion in December 2024, reaching €204 billion, largely reflecting seasonal trends. Credit growth to non-financial corporations slowed to 13.8% y-o-y (from 16% in November), while the contraction in housing loans eased slightly to -2.6 % (from -2.7 %). Lending rates for both corporate and housing loans declined, standing at 4.93% and 3.65%, respectively. Long-term Greek government bond yields fell slightly, aligning with broader euro area trends due to lowered expectations for future policy rates. In contrast, short-term Greek government bond yields rose marginally. Though accompanied by increased volatility, equity markets in Greece saw gains in line with other European bourses. Greek corporate bond yields declined, echoing trends in lower-rated euro area corporate bonds. Standard & Poor's upgraded the credit ratings of three systemic Greek banks, citing improvements in the regulatory environment, the implementation of borrower-based macro prudential measures, and stronger capital quality due to the accelerated amortisation of Deferred Tax Credits (DTCs). Yields on Greek senior bank bonds declined in line with those of euro area peers. On February 7, 2025, Eurobank issued an 11-year, €350 million senior preferred bond (callable in 10 years) with a coupon rate of 4%.

3.4.4. National Environmental Context

Based on the findings presented in Sustainable Governance Indicator (SGI), 2024 [91], Greece ranks in the lower-middle tier among Organisation for Economic Cooperation and Development (OECD) countries for environmental sustainability (19th place), reflecting a mixed record. While the country passed a binding national climate law in 2022 and aims to phase out coal-powered electricity by 2028 and reduce GHG emissions by 55% by 2030, it performed poorly in key areas during the 2010s. These include GHG intensity growth and carbon emissions from land cover, where Greece ranked near the bottom among OECD nations (Fig. 23).

Environmental challenges remain significant. The country continues to struggle with waste and water management, air pollution, and the environmental impact of natural disasters like the 2023 wildfires and floods. Over the past decade, Greece has lost substantial areas of forest, wetlands, and grasslands. Despite this, the country has implemented a biodiversity strategy (2014–2029), which sets 13 national goals and 39 targets, and established the Natura 2000 network, covering over a quarter of its land area.

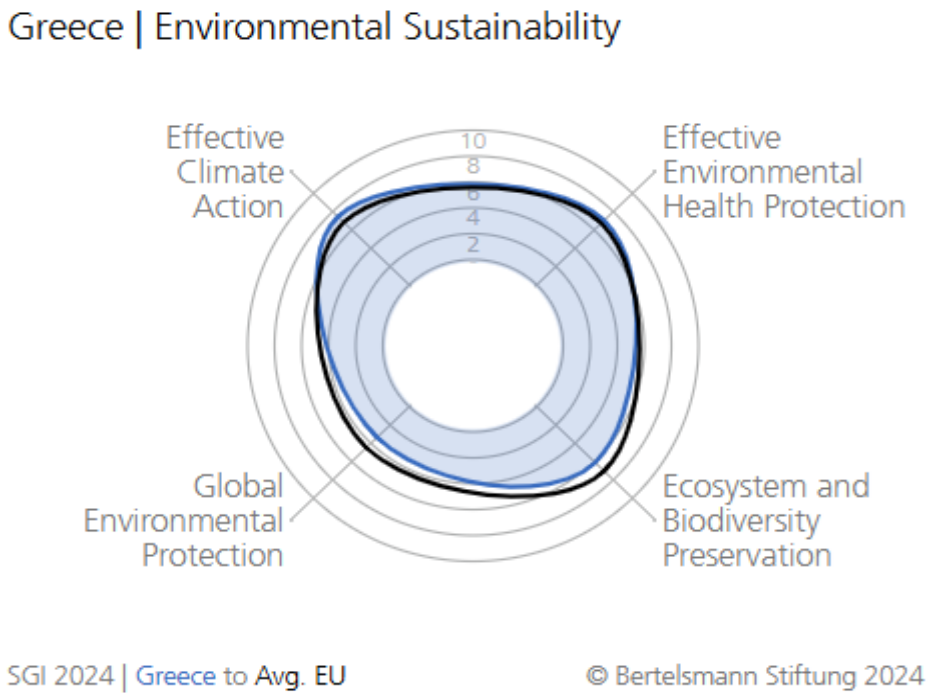


Figure 23: Environmental Sustainability in Greece (blue) compared to average EU countries (black) [92]

Greece's environmental policies are backed by legal structures, including Article 24 of the constitution and the NECP, which outlines sector-specific targets through 2030. The "Greece 2.0" Recovery and Resilience Plan dedicates 37.5% of its resources to green initiatives. While policy implementation is often delegated to the country's 13 self-governed regions, the central government retains oversight and frequently intervenes when needed. Monitoring is led by the Ministry of Environment and Energy, with additional oversight from parliamentary committees and legal institutions. Although Greece lacks an independent climate council, it actively participates in global and regional environmental efforts. Since recovering from its economic crisis, the country has prioritised Mediterranean cooperation. It launched the "Addressing Climate Change Impacts on Cultural and Natural Heritage" initiative at the United Nations (UN) Climate Action Summit. It plays a central role in the Barcelona Convention, hosting its secretariat in Athens.

3.4.5. National Social Context

Greece has implemented a broad range of social welfare policies and support schemes to protect vulnerable households and address social inequality, focusing on energy affordability, housing, and poverty alleviation:

- The Ministry of Finance offers an annual heating allowance to assist households with heating expenses, especially in the face of rising fuel prices. This support ranges from €80 to €650, depending on geographic and meteorological factors, and is available to those using heating oil, natural gas, or biomass.
- The Social Solidarity Income (KEA) is a comprehensive safety net for vulnerable populations. Administered by multiple ministries, including Labour and Social Affairs and Finance, it provides:
- A minimum income of €200/month for single-person households.
- Access to complementary services such as free healthcare, subsidised municipal services (e.g., electricity and water), and integration into social support programs.
- Activation measures, including vocational training, educational re-entry opportunities, and community service initiatives aimed at labour market reintegration.
- The Ministry of Labour and Social Affairs offers a housing allowance ranging from €70 to €210/month to support low-income renters. Eligibility is determined by income level, property value, and a valid rental contract.
- Under the Ministry of Environment and Energy, vulnerable consumers are eligible for significantly reduced electricity rates. Those also receiving KEA pay €75/MWh and are exempt from distribution and network charges. Others pay €45/MWh. These tariffs aim to shield low-income households from energy cost burdens.
- Special regulatory protections are in place for registered vulnerable customers. These include extended bill payment deadlines, interest-free instalment options, and protection from disconnection during winter and summer extremes. Consumers with health issues are further protected under gas safety provisions, and eligibility extends to seniors and households requiring life-support devices.
- As part of Greece's strategy to improve energy efficiency, suppliers must meet national savings targets using their funds without passing costs onto consumers. Notably, these schemes prioritise vulnerable households by offering a premium (1.4x

credit) for energy-saving measures targeting energy-poor homes. These schemes are key in achieving 20% of Greece's cumulative energy savings target for 2021–2030.

3.4.6. Energy Poverty Situation in Greece

In Greece, energy poverty is a significant problem, especially after 2011, due to the economic recession. As a result, in the context of the NECP, the fight against this phenomenon is a priority and a major challenge until 2030. The objective of tackling energy poverty is maintained, aiming at a reduction of 50% in 2025 and 75% in 2030 compared to 2016 levels. According to NECP 2024, achieving this objective requires implementing a coherent and effective strategy to combat energy poverty permanently and in the long term, not temporarily mitigating it through temporary and short-term measures. However, it is also imperative to provide immediate support to the most vulnerable households that experience the inability to access essential energy services. To this end, the action plan to combat energy poverty was developed in September 2021, which includes the definition of households affected by energy poverty through specific quantitative criteria. At the same time, emphasis was placed on exploring targeted policy measures to address energy poverty, either through existing or new ones, using both available financial programmes and market mechanisms. In addition, a monitoring and control mechanism was established to continuously evaluate the implemented policies, ensuring their smooth and effective implementation following the NECP's requirements and objectives until 2030. The monitoring and control mechanism foresees preparing a progress report on a yearly basis, which reflects the evolution of the energy poverty phenomenon through the implementation of the proposed monitoring procedures, both "top-down" through the EPOV and "bottom-up." The progress report aims to assess the achievement of the target for reducing energy poverty levels compared to the previous year, specify policy measures in cooperation with the relevant actors for their design and implementation and formulate proposals in case of significant deviations. As the main indicator for measuring and monitoring the energy poverty phenomenon, the I & IIeq indicator has been defined, which calculates the number of households that simultaneously meet the following two conditions:

1. The annual cost of total energy consumption of each household is lower than 80% of its annual cost of meeting the minimum required energy consumption (Condition I).

2. Each household's net income on an annual basis is less than 60% of the median of the corresponding adjusted income based on the equivalent number of persons belonging to each household according to the OECD scale for all households according to the definition of relative poverty (Condition II).

This indicator is determined annually using the data collected in the Family Budget Survey, which the Hellenic Statistical Authority conducts.

Table 5: Calculation of Energy Poverty Levels [91]

Year	*Condition I*	*Condition II*	*Condition IIeq*	*Indicator I & IIeq*
2016	*59%*	*21%*	*19%*	*13.8%*
2017	*57%*	*22%*	*18%*	*12.5%*
2018	*57%*	*21%*	*16%*	*11.1%*
2019	*55%*	*21%*	*17%*	*11.2%*
2020	*55%*	*23%*	*18%*	*12.0%*
2021	*62%*	*23%*	*18%*	*12.4%*

According to the Index I & IIeq, the percentage of households affected by energy poverty in 2021 is 12.4%, an increase compared to 2020 (12%). The value of the I & IIeq indicator for the year 2016, which is the reference year for monitoring the target, was 13.8%, leading to the conclusion that the level of energy poverty has decreased by 10% in the period 2016-2021. According to NECP 2024, the number of households affected by energy poverty in 2021 is 513,000 based on the performance of the I & IIeq Index. It should be noted that the number of affected households in 2016 was 573,000.

3.4.7. Local Targets for CO_2 Reduction and Combating Energy Poverty: Pathways to a Sustainable Future

The climate strategy by the Municipality of Athens (2024) [93] outlines its key commitments toward achieving climate neutrality. The document was co-created through a participatory process involving citizens, civil society organisations, experts, and local stakeholders. It reflects a shared vision for a greener, more resilient, and socially just city, integrating

environmental goals with public health, economic opportunity, and urban well-being. The list of commitments includes:

- 88% of the Municipality's electricity demand will be met by renewable energy sources, with 16% directly covered through municipal projects and active participation.
- Energy upgrades will ensure that at least 34% of buildings within the Municipality achieve energy class B or higher. This target increases to 90% for municipal buildings, 50% for tertiary sector buildings, and 30% for residential properties. To achieve these goals, innovative and accessible financial tools and structures will be developed with the involvement of the Municipality and relevant bodies to support households and businesses.
- A 50% reduction in car and motorcycle traffic within the city compared to 2019. Active support will be given to walking, cycling, clean public transportation, and municipal transit, creating spaces for play and social interaction. The goal is to create neighbourhoods where citizens can meet most of their daily needs within 15 minutes by walking, cycling, or using clean, efficient public transport.
- Increase recycling and composting rates to 80–85%, reduce food waste by 30% compared to 2019, and vigorously promote the circular economy.
- In collaboration with citizens and organisations, more than 35,000 trees will be planted within the city by 2030. A firm policy will support green and blue infrastructure, nature-based solutions, and the restoration of 20% of natural areas in the city. All trees will be digitally recorded and managed based on data and their condition, in compliance with a new green infrastructure regulation.
- A comprehensive water management strategy will be implemented to prevent flooding and cool the city. This includes green infrastructure for water reuse and soil absorption, revitalisation of water pathways, reduction in network water consumption, and energy savings. Given drought conditions and rising water demand due to high temperatures, water-saving measures, such as rainwater, groundwater, greywater, and even treated wastewater, will support climate adaptation and reduce energy consumption for water processing. It is also essential to protect water sources and ecosystems in the wider Attica region that are currently or potentially utilised due to declining reserves.

- Create ventilation and cooling corridors across the city to restore the microclimate and combat the urban heat island effect.
- Develop municipal housing stock with nearly zero-energy buildings and actively support the energy renovation of apartment buildings and neighborhoods affected by overheating.
- Boost the green, sustainable, and circular economy and support job creation, research, education, and training. All actions will place special emphasis on social and cooperative economy models.

The climate plan is a tool for social cohesion and for addressing climate, environmental, social, and economic challenges in an integrated and equitable manner. It will significantly improve public health and reduce premature deaths caused by pollution and extreme temperatures. All measures aim to create a green, clean, sustainable, resilient, and beautiful Athens for the benefit of citizens, the environment, social cohesion, and justice in every neighborhood, without exception.

3.4.8. Obstacles and Key Challenges

Many of Greece's residential buildings were constructed before the introduction of energy efficiency regulations. Many homes lack insulation, modern heating or cooling systems, and basic structural adequacy. In the island case studies, over 60% of homes either lacked energy performance certificates or residents were unaware of them. Without proper certification and renovation, these buildings contribute directly to energy waste and thermal discomfort. While Greece has developed comprehensive plans such as the NECP, implementation responsibilities are often fragmented across different levels of government. Although a monitoring mechanism exists, its effectiveness depends on consistent data collection and enforcement, which has historically been limited or inconsistent [94].

Despite subsidy schemes (e.g., heating allowance, social tariff), many low-income households lack access to sustainable long-term financial instruments needed for home energy renovations. Financial insecurity prevents participation in energy upgrade programmes, especially in remote or underserved areas [90]. The correlation between poor indoor conditions (e.g., cold, mold, air quality) and health issues is strong. Inadequately heated or

cooled homes contribute to respiratory problems, allergies, and deterioration of general well-being. Therefore, tackling energy poverty must also be seen as a public health priority, requiring cross-sectoral coordination between energy, housing, and health services, as the technical assistance. While national targets are ambitious, implementation must reflect local realities. The energy poverty diagnosis of nine small islands revealed unique barriers such as geographic isolation, outdated infrastructure, and seasonal economies. National strategies must empower municipalities with resources and flexibility to design tailored solutions that reflect local socio-economic and climatic contexts.

3.4.9. Case Study

Description of the area:

This case study presents a comprehensive analysis of the energy poverty landscape in nine small Greek islands: Antiparos, Astypalea, Ikaria, Kasos, Lemnos, Mykonos, Psara, Sifnos, and Skiathos based on the results of the technical assistance provided by Initialising Energy Balance Towards Zero (INZEB) within the frame of the EPAH Technical Assistance 2022. Though geographically diverse, the islands share common energy vulnerability characteristics due to their isolation, limited infrastructure, and socio-economic disparities. The diagnosis utilised resident surveys to evaluate household energy efficiency, comfort, economic conditions, and housing quality, generating quantitative and qualitative insights.

The surveyed populations across the islands display varying degrees of vulnerability. For example, in Antiparos, 25% of households benefit from the social residential tariff, while in Astypalea, this figure drops to 6.7%, despite 53.4% of residents reporting that their income is insufficient to meet basic needs. Education levels are generally moderate, and full-time employment is not universally dominant, seasonal work and self-employment are significant. In many cases, unemployment figures reported by respondents contrast sharply with outdated official statistics, highlighting changes in local economic conditions not yet reflected in national data. Homeownership is relatively high, with more than 70% of residents in Antiparos and over 68% in Astypalea living in owner-occupied homes. However, ownership does not translate into better energy conditions, as many homes are old and lack thermal efficiency. Notably, many homes were built before insulation regulations were introduced

(e.g., 23.5% in Astypalea before 1979). Most homes are standalone buildings with little structural adjacency, making heating and cooling less efficient.

Across all islands, energy performance certificates are either unknown or absent in most homes. In Antiparos, 60.4% of residents do not know if they have an energy performance certificate or confirm not having one. Astypalea fares slightly better, but 64.99% are unaware or lack energy performance certificates documentation. This lack of data reflects poor monitoring infrastructure and complicates policy targeting. Heating systems are generally present, with over 89% of households in Antiparos and 95% in Astypalea reporting some form of heating. However, adequacy is a significant issue; 60.4% of Antiparos residents and 63.3% in Astypalea do not heat the entire home. Winter indoor temperatures in these islands are frequently below the comfort threshold of 18°C, highlighting widespread thermal discomfort. In Astypalea, 13.3% of respondents reported winter indoor temperatures below 15°C. Cooling systems are more limited. In Astypalea, 40% of respondents report having no cooling system. Those that do mainly rely on fans or air conditioning, though efficiency is unclear. During summer, discomfort remains an issue; 48% of residents in Antiparos report feeling uncomfortable due to high temperatures. Electricity reliability is also a concern, especially in Antiparos, where 47.9% report frequent power quality issues. These disturbances sometimes damage appliances. Such instability further stresses household budgets and underscores infrastructural weaknesses typical in island settings.

Energy affordability is a critical concern. While most respondents report being consistent with bill payments, this does not necessarily reflect financial ease. In Antiparos, 45.8% of respondents state that their annual income does not meet household needs. About 39.5% consider their energy bills "high," and 29.2% consider them "too high." In Astypalea, 73.3% strongly disagree that energy costs are low. These perceptions align with actual energy expenditure data, where nearly half of respondents report monthly bills between €151 and €300, significant amounts relative to reported incomes. Utility bill arrears strongly correlate with thermal discomfort, mold, and other indicators of poor housing quality. Pearson correlation analysis across all islands (from the indicators correlation report) shows statistically significant relationships between energy poverty indicators: insufficient insulation, heating/cooling inadequacy, arrears, and indoor environmental quality (e.g., mold, air quality, noise).

Thermal discomfort is directly tied to health conditions. Residents in inadequately heated or cooled homes often report allergies and chronic illnesses linked to mold and poor air quality. In Antiparos, 56.3% of households have mold issues, and 45.8% report cold indoor temperatures. In Astypalea, 38.3% report mold problems, and nearly half state they are uncomfortable in the summer. These indicators suggest a direct link between energy poverty and health degradation. Correlations drawn from the entire dataset further validate these links. Living conditions correlate with healthcare needs, self-reported disabilities, and thermal comfort metrics. Social variables such as household income and education levels also affect energy affordability and comfort perceptions. The diagnosis in the nine islands revealed systemic issues related to housing quality, energy affordability, and infrastructure in small island communities. Key recommendations include:

- **Infrastructure investment:** Upgrade housing stock through energy-efficient renovations, especially targeting buildings constructed before 1990.
- **Monitoring and certification:** Mandate and facilitate the issuance of energy performance certificates to improve data collection and policy precision.
- **Targeted subsidies:** Expand access to social energy tariffs and increase public awareness, especially in under-covered islands.
- **Local capacity building:** Empower municipalities and local authorities to develop tailored energy assistance programs with national support.
- **Health-centric interventions:** Address the health implications of energy poverty with integrated support that includes medical and housing solutions.

In conclusion, tackling energy poverty in the Greek islands requires a multidimensional approach that blends technical, social, and economic measures. Recognising the diverse yet interconnected challenges each island faces will be key to building resilient, energy-secure communities.

3.5. Italy

Italy, located in Southern Europe, is renowned for its rich history, diverse culture, and stunning landscapes. Bordered by France, Switzerland, Austria, and Slovenia to the north, it is also surrounded by the Mediterranean Sea to the south, offering a vast coastline along the

Adriatic, Ionian, and Tyrrhenian Seas. With a population of approximately 60 million, Italy is one of Europe's largest and most influential countries, known for its significant cultural contributions, ranging from art and literature to fashion and cuisine. Italy's economic development has evolved over centuries, and it is today considered one of the world's largest economies. It is an industrialised nation with a highly developed infrastructure, but it still faces challenges, particularly in the southern regions. These areas often experience higher levels of unemployment, economic disparity, and social issues, which contribute to the ongoing economic gap between the northern and southern parts of the country.

Italy's energy sector is diverse, relying on a mix of domestic and imported energy sources. While Italy has a moderate amount of renewable energy production, particularly solar, wind, and hydroelectric power, it remains heavily dependent on natural gas and oil imports to meet its energy demands. The country has been making significant strides in increasing its renewable energy capacity, particularly solar power, as part of its commitment to reducing greenhouse gas emissions and combating climate change. However, Italy also faces challenges in terms of energy inefficiency and energy poverty, particularly in its southern regions. Many households, especially those in rural or economically disadvantaged areas, struggle with high energy costs, inadequate insulation, and inefficient heating systems. These issues are exacerbated during the colder months, when energy demand increases and vulnerable populations find it particularly difficult to afford heating. The Italian government has implemented various measures to improve energy efficiency, including incentives for residential energy upgrades, investments in renewable energy projects, and efforts to modernise the energy grid. These efforts are aimed at reducing the country's carbon footprint, enhancing energy security, and improving the quality of life for its citizens. Italy's journey toward a more sustainable energy future involves addressing both energy poverty and environmental concerns. As the country continues to invest in renewable energy and energy efficiency, it aims to not only reduce its dependence on imported fossil fuels but also ensure that all citizens, including the most vulnerable, have access to affordable, reliable, and clean energy.

3.5.1. National Energy Policy and Climate Action Plan: Strategies for a Sustainable Future

Italy, like many European countries, is firmly committed to addressing the twin challenges of energy transition and energy poverty. Guided by strategic policies such as the National Integrated Energy and Climate Plan (PNIEC), the Renewable Energy Communities (RECs) decree, the Superbonus program, and Regional Environmental Energy Plan (PEAR), Italy has established a comprehensive framework to promote sustainability, reduce greenhouse gas emissions, and ensure equitable access to energy for all. These policies are not only about environmental responsibility but also about creating a more inclusive and resilient energy system, particularly for vulnerable populations.

At the heart of Italy's energy strategy is the PNIEC, which lays out the country's energy and climate objectives through 2030. The PNIEC outlines several ambitious targets, including a 40% reduction in greenhouse gas emissions compared to 1990 levels, a significant increase in the share of renewable energy in the national energy mix, and substantial improvements in energy efficiency. Importantly, the PNIEC also focuses on addressing energy poverty, aiming to improve energy accessibility for all Italians, especially those struggling to afford essential energy services. With an estimated investment of €174 billion between 2024 and 2030, the plan prioritises improving building efficiency, reducing energy costs, and providing support for the most vulnerable households [95]. This is critical, as around 9.3% of Italian households currently experience energy poverty, facing difficulties in maintaining adequate heating and electricity due to high costs or poorly insulated homes. A key initiative within the PNIEC is the Superbonus program, which offers significant tax incentives to households that invest in energy efficiency upgrades. The Superbonus, which initially provided a 110% tax deduction, has been a crucial tool in enhancing building insulation, upgrading heating systems, and installing renewable energy solutions like photovoltaic panels. These improvements not only lower household energy bills but also contribute to reducing carbon emissions [96]. According to data updated to 31 August 2023 by the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), the 110% Superbonus involved over 425,000 buildings in Italy. That is about 3.5% of the total number of residential buildings in the country [97]. As of 2024, the Superbonus has spurred investments of over €119 billion, playing a pivotal role in improving living conditions,

especially for low-income families [98]. However, in 2023, the tax deduction was adjusted to 90%, and further reductions are planned in the coming years, highlighting the evolving nature of this policy. In addition to the Superbonus, the expansion of social energy support mechanisms is another critical measure introduced by the PNIEC. The social electricity and gas bonus, which supported over 4 million households in 2023, provides direct financial assistance to low-income families, helping them manage energy costs. This bonus varies based on household size, with those in larger households receiving higher benefits. Such initiatives help ensure that even the most disadvantaged populations can access affordable energy, thus alleviating some of the burdens of energy poverty.

Another approach is the promotion of RECs, a vital part of Italy's energy future. RECs enable citizens, local authorities, and businesses to come together to produce, consume, and share locally generated renewable energy. This decentralised model not only reduces reliance on traditional energy suppliers but also fosters community engagement and social cohesion [99]. With 154 RECs currently operating across the country, Italy is leveraging local collaboration to enhance energy independence, reduce energy costs, and contribute to the broader goal of achieving energy sustainability [100]. The RECs decree supports low-income households by providing tax incentives for the construction of renewable energy plants, offering a tangible solution to reduce energy expenses. The premium tariffs for shared electricity, determined by plant size and location, incentivise the development of renewable energy infrastructure, further supporting communities and reducing reliance on fossil fuels [101]. Italy's regional approach to energy planning is also essential to ensuring a fair and just energy transition.

The Regional Environmental Energy Plan (PEAR) program translates national and European energy goals into targeted strategies tailored to regional needs. For example, the PEAR Marche focuses on improving energy efficiency, boosting renewable energy production, and promoting energy eco-efficiency through initiatives such as decentralised energy systems and innovative technologies. These regional plans ensure that local communities, including those most vulnerable to energy poverty, have access to affordable and sustainable energy solutions. The PEAR Marche alone has invested €177,424 in projects aimed at tackling energy poverty and improving energy access, underscoring the importance of localised, context-specific strategies [102].

Together, the PNIEC, the RECs decree, the Superbonus, and the PEARs form a robust and integrated framework for tackling Italy's energy challenges. These policies not only aim to reduce Italy's carbon footprint and transition to renewable energy but also ensure that the benefits of this transition are shared equitably, particularly with the country's most vulnerable populations. By focusing on energy efficiency, renewable energy production, and financial support for disadvantaged households, Italy is working towards a more sustainable, affordable, and inclusive energy system, one that will provide long-term benefits for both the environment and society.

3.5.2. National Political Context

In response to growing concerns about energy security, particularly following geopolitical tensions and supply chain disruptions, Italy has adopted a comprehensive set of policy measures to reduce dependence on foreign energy sources and strengthen national resilience. These policies are deeply integrated into the broader EU framework and aligned with global sustainability goals, reflecting a strategic shift in the country's energy approach. Italy has historically been reliant on imported energy, particularly natural gas, which has accounted for a significant share of its energy mix. Before the escalation of geopolitical tensions in Eastern Europe, Italy imported approximately 40% of its natural gas from Russia (Fig. 24). This heavy dependence exposed the country to supply disruptions and price volatility, prompting policymakers to take decisive action to secure alternative energy sources.

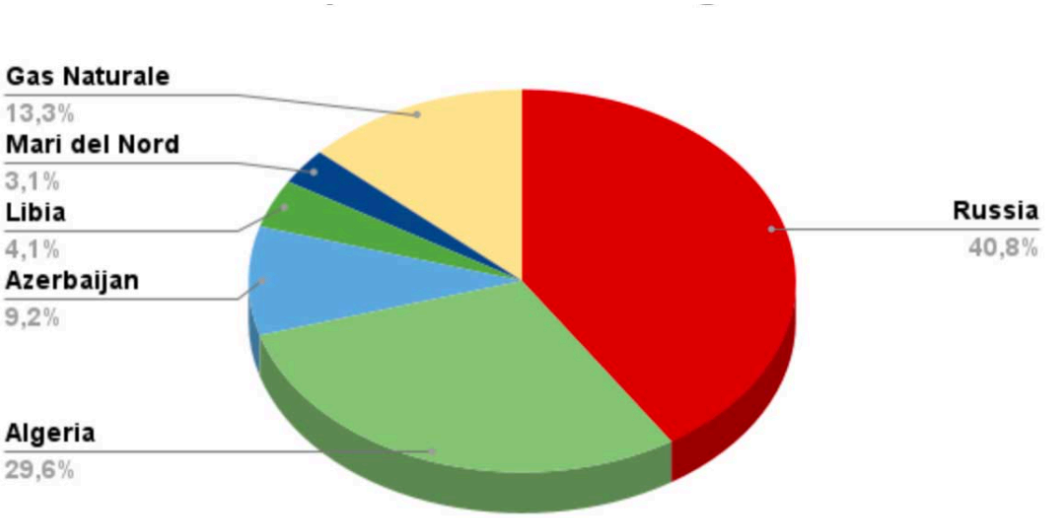


Figure 24: Italian gas imports before 2022 [103]

The geopolitical instability not only highlighted Italy's energy vulnerability but also accelerated the country's commitment to diversifying its energy mix. The EU's REPowerEU plan, aimed at reducing Europe's dependence on Russian fossil fuels, provided a guiding framework for Italy's energy security strategy. Italy's response was swift and multifaceted, addressing short-term energy shortages while laying the foundation for long-term sustainability and independence. A key pillar of Italy's energy security strategy has been the diversification of energy suppliers. Immediately following the Ukraine crisis, Italy sought to secure alternative gas supplies from countries such as Algeria, Azerbaijan, Qatar, and the United States. The government negotiated new agreements with these countries to ensure stable and diversified gas imports, reducing dependence on Russian gas to 19.3% by the end of 2022 and further down to 4.6% in 2023 [104]. Italy has also invested in expanding its Liquefied Natural Gas (LNG) infrastructure to facilitate imports from global suppliers. The expansion of regasification terminals, including the installation of new Floating Storage and Regasification Units (FSRUs) in strategic coastal areas, has increased Italy's capacity to process LNG and integrate it into the national grid. This initiative aligns with broader European efforts to enhance LNG capacity and reduce reliance on pipeline gas.

Recognising the need for greater self-sufficiency, Italy has placed renewed emphasis on increasing domestic energy production. This includes both traditional fossil fuels and renewable sources. In the short term, the government has authorised new offshore and onshore gas extraction projects to maximise domestic production. While these measures serve as a transitional strategy, they are accompanied by substantial investments in renewable energy. Italy has set ambitious targets for the expansion of renewable energy, with a particular focus on solar, wind, and hydropower. The government has streamlined permitting processes for renewable energy projects, reducing bureaucratic barriers that have historically hindered development. As part of the National Recovery and Resilience Plan (PNRR), Italy has allocated billions of euros for renewable energy infrastructure, including the development of large-scale solar plants and offshore wind projects in the Mediterranean. Looking ahead, Italy's energy strategy will continue to evolve in response to technological advancements, market dynamics, and geopolitical developments. The transition to a greener energy mix remains a top priority, with ongoing investments in hydrogen technology, energy storage solutions, and smart grids to enhance system reliability and efficiency. In conclusion, Italy's approach to energy security is characterised by a combination of diversification, expanded domestic production, and greater reliance on renewables.

3.5.3. National Economic and Legislative Context

Starting from the second half of 2021, Italy faced a significant surge in electricity, gas, and fuel prices. Initially, this increase was attributed to the post-pandemic economic recovery, supply chain disruptions, and heightened global demand for energy. However, from February 2022, there were more price spikes and rising concerns over energy security (Fig. 25) [104].

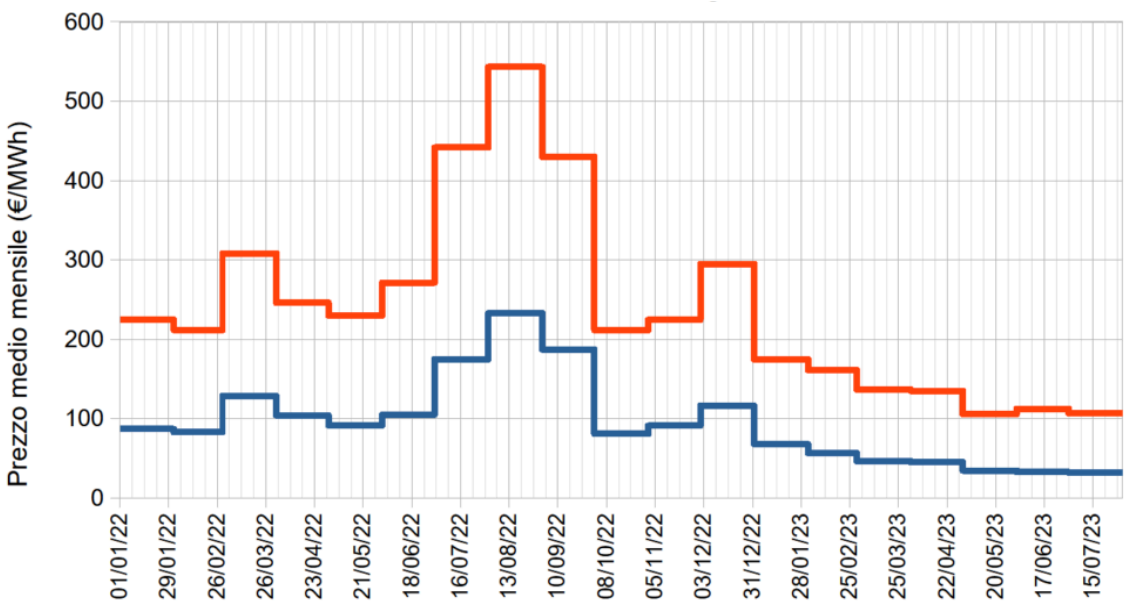


Figure 25: Italy's trend of electricity (orange) and gas (blue) prices [105]

To counteract the economic and social repercussions of rising energy costs, the Italian government introduced a series of legislative measures aimed at protecting households, businesses, and public services. Among the key interventions:

- **Reduction of System Charges**: Temporary financial allocations were implemented to alleviate the burden of energy bills by offsetting system charges, which constitute a substantial portion of electricity and gas costs [106].
- **Strengthening of Social Bonuses**: The government expanded the eligibility criteria and increased the amount of social bonuses for electricity and gas, targeting vulnerable consumers to shield them from extreme price fluctuations [106].
- **Public Guarantees for Business Liquidity**: To support businesses struggling with the rising costs of raw materials and energy, extraordinary public guarantees were provided through the Small and Medium-sized Enterprises (SMEs) Guarantee Fund [106].
- **Tax Measures**: Tax credits were granted to businesses to offset the increased costs of gas and electricity. Additionally, Value Added Tax (VAT) on gas was reduced to 5%,

and excise duties on fuel were temporarily lowered to curb inflationary pressures [107].

- **Support for Households' Purchasing Power**: One-off allowances were provided to workers, pensioners, and social benefit recipients. Moreover, labor contributions were reduced to mitigate the loss of purchasing power due to rising living costs

The fiscal impact of these energy relief measures has been substantial. As of September 30, 2022, the estimated increase in net borrowing for the year amounted to approximately €55.48 billion. Of this amount, about €41.44 billion was allocated directly to energy cost containment policies, while €14.04 billion was directed towards economic support for households (€12.49 billion) and businesses (€1.55 billion), facilitating liquidity and energy transition investments. The energy crisis has prompted Italy to accelerate its transition toward energy independence and sustainability. The government has prioritised diversifying energy sources, strengthening renewable energy production, and investing in energy efficiency projects. Legislative efforts are also being directed toward securing long-term gas supply agreements, expanding storage capacities, and modernising energy infrastructure. These measures reflect Italy's ongoing commitment to stabilising energy prices, securing economic growth, and mitigating the social impact of energy market volatility through a comprehensive mix of fiscal, economic, and regulatory interventions.

3.5.4. National Environmental Context

Italy has set ambitious targets for reducing CO_2 emissions and addressing energy poverty, aligning its policies with European Union directives, though with some distinctions in its approach. The country's PNIEC outlines a 33% reduction in GHG emissions by 2030, compared to 2005 levels, for sectors not covered by the ETS. However, under the ongoing revision of the 'Fit for 55' package, Italy's emissions reduction target is expected to rise to 43.7% below 2005 levels, signaling the need for more intense national efforts to meet these updated standards.

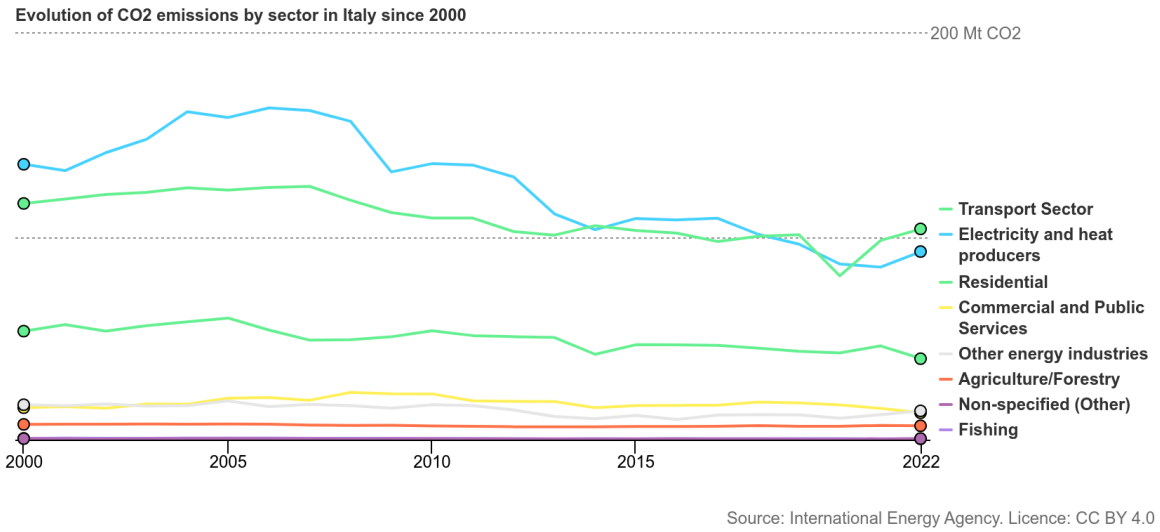


Figure 26: Evolution of CO_2 emissions by sector [108]

Looking at a longer-term trajectory, the PNIEC also aims for a 30% reduction in emissions by 2030 compared to 1990 levels (Fig. 27). While this target is an essential step toward decarbonisation, it is considered insufficient to align with the global climate goal of limiting warming to 1.5°C. According to independent climate alignment, Italy would need to reduce emissions by 61% to 71% compared to 1990 levels to meet this target, corresponding to 149-201 $MtCO_{2eq}$ (Fig. 26). In this context, Italy must significantly accelerate its climate actions, doubling its efforts beyond the current measures laid out in the PNIEC to meet these more ambitious goals. A key component of Italy's decarbonisation strategy involves the expansion of renewable energy sources, particularly solar and wind power. The PNIEC sets a target of 70% renewable electricity generation by 2030, requiring significant investments in infrastructure, grid modernisation, and storage capacity. Additionally, energy efficiency improvements in the residential, commercial, and industrial sectors are critical to achieving emissions reductions. Policies such as the "Superbonus 110%" for building renovations have contributed to reducing emissions from heating and improving energy efficiency, though challenges remain in ensuring long-term funding and equitable access.

Italy's transport sector also plays a crucial role in achieving its climate goals. The government has committed to increasing electric vehicle adoption, improving public transportation, and

investing in sustainable mobility solutions, including the expansion of high-speed rail networks. However, road transport still accounts for a significant share of emissions, necessitating stronger incentives for low-emission vehicles and stricter regulations on internal combustion engines. Furthermore, addressing energy poverty remains a priority within Italy's climate strategy. Rising energy costs have disproportionately affected vulnerable households, prompting government interventions such as social energy tariffs and direct subsidies. However, a more sustainable approach involves integrating energy efficiency programs with social policies to reduce dependency on fossil fuels while ensuring affordable energy access for all. In the industrial sector, Italy faces the challenge of decarbonising high-emission industries such as steel, cement, and chemicals. This will require substantial investments in innovative technologies like hydrogen, CCS, and circular economy initiatives aimed at reducing waste and improving resource efficiency. To meet the more ambitious targets set by the EU, Italy must implement additional policy measures, accelerate renewable energy deployment, enhance grid capacity, and reinforce incentives for energy efficiency and sustainable transport. Without a significant scaling-up of efforts, Italy risks falling short of its climate commitments, underscoring the need for a comprehensive and multi-sectoral approach to decarbonisation.

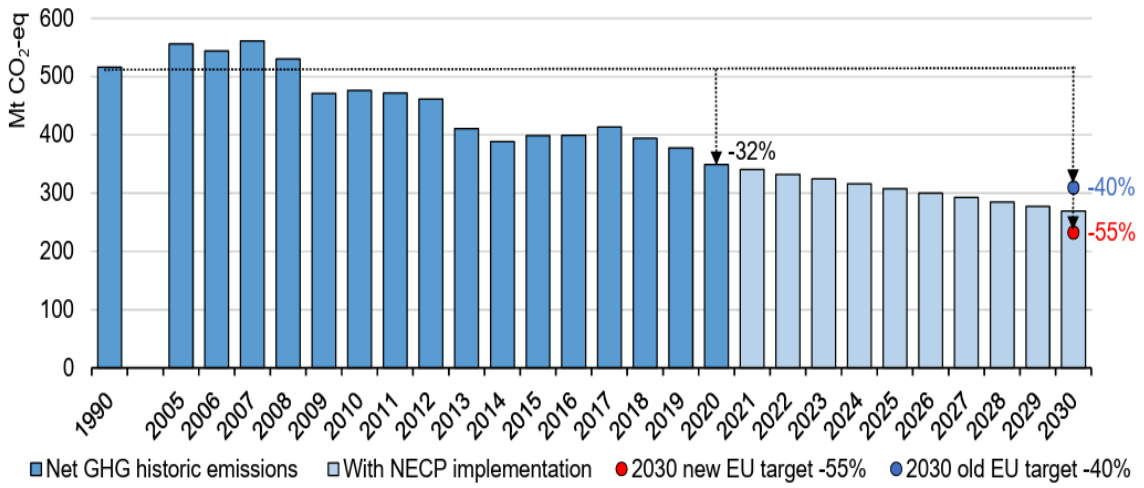


Figure 27: Italy's historic net greenhouse gas emissions, projections and 2030 targets [109]

3.5.5. National Social Context

Investments in the energy and construction sectors in Italy have played a crucial role in promoting economic and social benefits, stimulating employment, and improving the standard of living for many families. In particular, the green energy sector, construction, and energy efficiency have been key drivers of growth, with positive impacts on quality of life and the overall economy. An emblematic example of these policies is the Superbonus 110%, a government initiative aimed at incentivising the energy renovation of buildings (Fig. 28). In addition to stimulating the economy, the Superbonus has led to a significant reduction in greenhouse gas emissions, with an estimated decrease of 1.42 million tons of CO_2 per year, contributing to the fight against climate change [110].

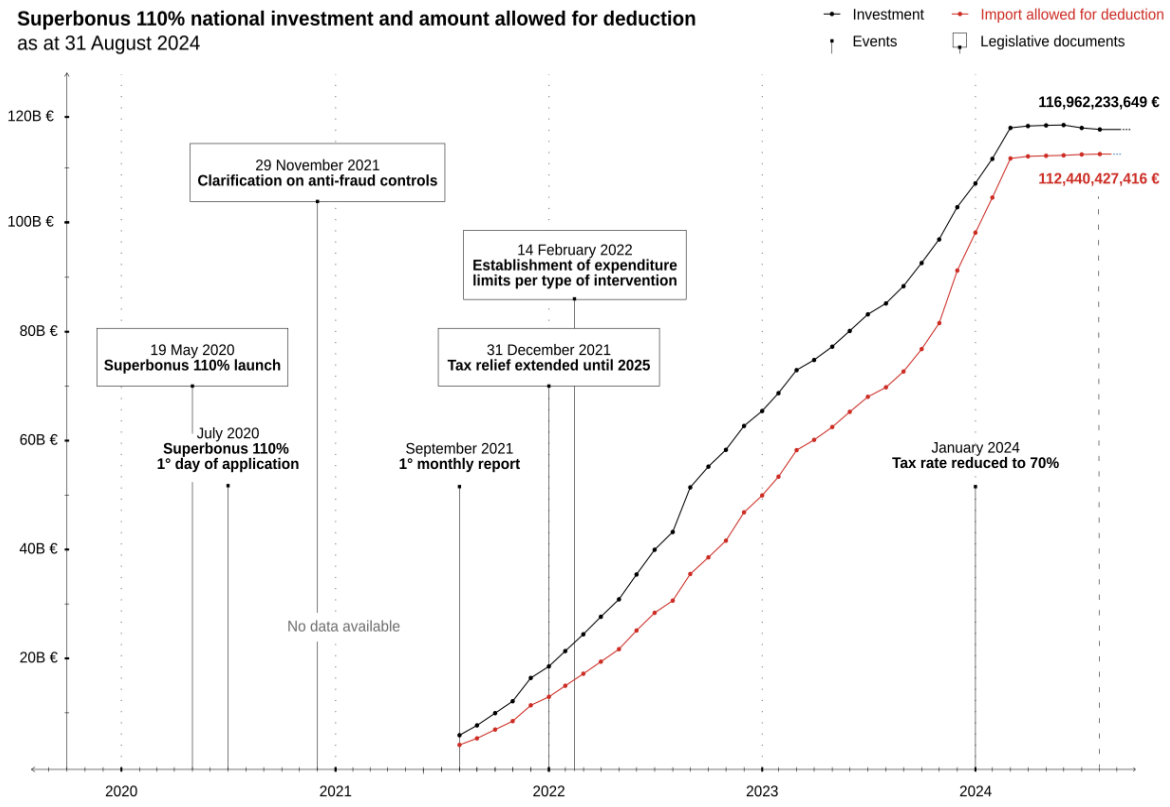


Figure 28: Superbonus 110% national investment from 2024 until 2025 [110]

In addition to individual benefits, these investments have also had a positive impact on municipal and government revenues. Funds generated by energy projects, such as those related to renewable energy and energy efficiency, have been reinvested into public services such as healthcare, education, and infrastructure, creating a virtuous cycle that benefits society as a whole. From 2005 to 2022, Italy made significant progress, with a reduction in energy demand per unit of GDP of 23.4% and a 32% decrease in greenhouse gas emissions (Fig. 27), contributing to making energy more accessible and combating energy poverty, a key goal of national policies [111]. Meanwhile, the adoption of smart and sustainable buildings is gaining ground in Italy. Investments in the Smart Buildings sector have grown significantly, reaching 6.5 billion euros in 2022, signaling an increasing focus on building solutions that improve energy efficiency and reduce consumption. These projects not only promote sustainability but also offer new jobs and technological development opportunities [112].

Another key aspect is represented by RECs, an innovative model that integrates the production and consumption of energy from renewable sources with social benefits [113]. RECs are made up of citizens, small and medium-sized businesses, local authorities, and other organisations that collaborate to produce and share clean energy. These initiatives, in addition to promoting energy transition, foster social cohesion and inclusion, offering economic benefits to participants, such as incentives for produced energy and reduced bills. However, despite their great potential, the development of energy communities in Italy has been slowed by regulatory and bureaucratic delays. To date, only 154 RECs have been established, compared to an estimated potential of 400, highlighting the need for a clearer regulatory framework and simplified procedures to facilitate the spread of these initiatives [114]. In summary, investments in the energy and construction sectors in Italy not only stimulate economic growth and job creation but also represent fundamental tools for reducing energy poverty and promoting a more sustainable and equitable future. Renewable Energy Communities, in particular, offer a unique opportunity to combine the energy transition with social solidarity, reducing inequalities and stimulating local development. Thus overcoming the current issues would allow a transformation that aims not only to improve environmental sustainability but also to strengthen social cohesion and the well-being of its communities.

3.5.6. Energy Poverty Situation in Italy

Energy poverty has emerged as one of the most urgent social issues in recent years, affecting millions of Italian families and limiting access to essential energy services such as heating, lighting, and the use of basic household appliances. According to the National Institute of Statistics (ISTAT) data, in 2021, over 2.2 million Italian households, equivalent to 8.5% of the total, lived in conditions of energy poverty, struggling to afford the necessary energy to maintain a decent standard of living (Fig. 29). This phenomenon not only negatively impacts people's well-being but also exacerbates social and territorial inequalities, with the most vulnerable population groups, such as the elderly, the unemployed, and low-income families, being the most exposed to the risk of energy exclusion.

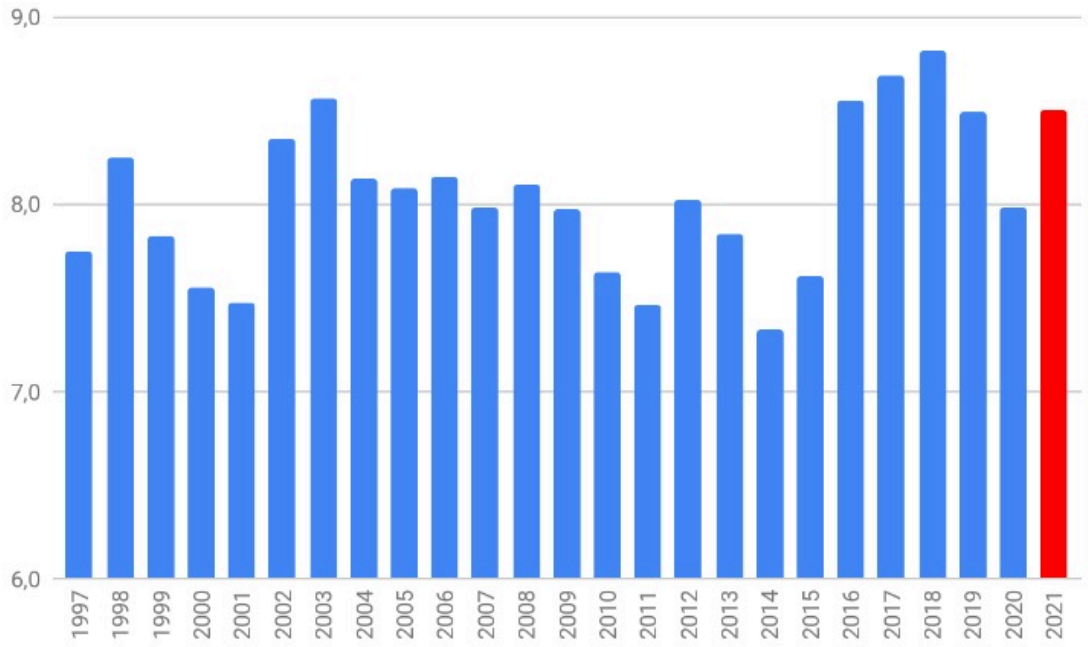


Figure 29: Energy poverty in Italy (in % of the total population) [115]

Recognising the severity of the problem, the Italian government has included the fight against energy poverty among the priority objectives of its energy policies. The 2020 PNIEC and the 2017 National Energy Strategy (SEN) set a goal to reduce the incidence of energy poverty to between 7% and 8% by 2030. To achieve this target, a series of targeted measures have been adopted, structured along three main axes: direct economic support, improvement of building energy efficiency, and promotion of energy awareness among citizens. One of the main tools adopted to combat energy poverty is economic assistance programs for vulnerable families. Among these, social bonuses for electricity and gas directly reduce the cost of bills for low-income households or those experiencing economic hardship. These incentives have been strengthened in recent years, particularly in response to the global energy crisis, to provide greater support to the most disadvantaged segments of the population. At the same time, the government has introduced a series of tax incentives to encourage energy efficiency improvements. Among these, the Superbonus 110% is one of the most significant measures, allowing property owners to obtain tax deductions for renovation work aimed at improving building energy efficiency, such as thermal insulation, replacing heating systems with more efficient solutions, and installing photovoltaic systems. Improving the energy efficiency of buildings is a crucial aspect in the fight against energy poverty. Italy has adopted several programs aimed at promoting the energy retrofitting of both public and private buildings. Among these, incentives for building energy certification and funds for the renovation of public housing and social housing stand out. Targeted interventions, such as replacing windows, adopting condensing boilers, and using innovative insulating materials, not only reduce energy consumption and household expenses but also lower greenhouse gas emissions, contributing to the decarbonisation goals set by European policies.

Another key element in the strategy against energy poverty is the implementation of awareness and education initiatives for citizens. Educational programs, such as the "energy tutors" initiative, aim to help families better understand their consumption habits and make more informed choices to reduce energy waste. These projects include, for example, personalised consultations for the most vulnerable families, practical advice on improving household energy use, and information campaigns on the benefits of energy efficiency. Additionally, the promotion of local energy communities, based on the sharing of renewable resources, is emerging as an innovative solution to reduce energy costs and promote a more

equitable and sustainable consumption model. Despite the progress made, the challenge of energy poverty in Italy remains complex and requires an acceleration of efforts to ensure fair and sustainable access to energy. The ongoing energy transition, with the expansion of renewable sources and the gradual phase-out of fossil fuels, must be accompanied by social policies capable of protecting the most vulnerable populations from the economic impacts of change. To ensure a just and inclusive transition, it will be essential to enhance investments in energy infrastructure, promote further incentives for energy efficiency, and expand support measures for struggling families. Only through an integrated approach that combines economic support, technological innovation, and awareness can Italy achieve its energy poverty reduction goals and build a more sustainable future for all.

3.5.7. Local Targets for CO_2 Reduction and Combating Energy Poverty: Pathways to a Sustainable Future

In 2016, the Marche Region in Italy recorded per capita GHG emissions of 4.87 tCO_{2eq}, notably lower than both the national average of 7.1 tCO_{2eq} and the European average of 8.41 tCO_{2eq} for the same year. This statistic highlights the region's relative efficiency in terms of carbon emissions compared to broader national and European trends. A comprehensive analysis of emissions across 11 economic sectors in the region revealed that the primary contributors to greenhouse gas emissions were road transport, non-industrial combustion (primarily for domestic and commercial heating), and industrial combustion. In 2016, total annual emissions in the Marche Region amounted to approximately 5.9 million tCO_{2eq}, serving as a key indicator for tracking the region's progress towards meeting its environmental sustainability goals. Looking toward the future, the Marche Region is committed to achieving the EU's ambitious emission reduction targets for 2030, which call for a significant reduction in greenhouse gas emissions and enhanced resilience to climate change. This commitment is aligned with the EU's broader strategy for a climate-neutral Europe, aimed at drastically reducing emissions and improving infrastructure to handle the challenges posed by extreme climate events. As part of this effort, the region is working to meet its emission reduction obligations through various local measures that contribute to the overarching European goals. The most recent available data on emissions spans from 2016 to

2019 (Fig. 30), with updated figures for 2020 to 2023. This updated data will provide further insight into the region's progress in meeting its targets and adapting to climate change.

Figure 30: Emission in tCO_2 per region (2016-2019) [116]

In addition to its focus on reducing emissions, the Marche Region has made significant strides in combating energy poverty, which remains a critical issue for many low-income households in the region. In 2022, approximately 4,000 families received economic aid to help alleviate energy-related financial burdens, with a dedicated fund of €100,000 aimed at supporting individuals facing economic hardship and health issues, particularly in covering electricity and gas bills. The region continued its support for vulnerable households in 2023, allocating an additional €2.5 million to address energy poverty. These funds are specifically earmarked for renewable energy production projects and enhancing the efficiency of domestic heating and electricity systems, with priority given to homeowners and families with a gross annual income below €40,000. This targeted financial assistance ensures that households struggling with energy costs are supported, while also promoting the adoption of more sustainable energy solutions. These actions reflect the Marche Region's broader commitment to achieving environmental sustainability and social inclusion. By integrating efforts to reduce emissions

with policies designed to improve access to affordable energy, the region is striving to create a more equitable and resilient energy system. The region's focus on supporting renewable energy initiatives, improving energy efficiency in homes, and providing targeted financial assistance to low-income households demonstrates a balanced approach to tackling both the environmental and social dimensions of the energy transition. As the region continues to advance its policies, it will be essential to monitor the progress of these efforts and ensure that they contribute to a more sustainable and inclusive future for all citizens.

3.5.8. Obstacles and Key Challenges

Energy poverty in Italy continues to pose significant challenges, hindering the country's progress toward a fair and sustainable energy transition. The barriers that contribute to this issue are multifaceted and require a coordinated approach to address. Below are the key difficulties Italy faces in tackling energy poverty:

- **Territorial Inequality:** Italy's territorial disparities between the North and South play a critical role in exacerbating energy poverty. While the northern regions benefit from more developed energy infrastructure and higher economic capacity, the southern regions struggle with outdated systems and chronic underinvestment. The energy infrastructure in many southern areas is inefficient, leading to higher costs and lower energy reliability for consumers. The investment gap between the northern and southern regions is estimated to be around 40%, which further exacerbates the divide, making it more difficult for southern regions to implement effective energy policies and initiatives aimed at reducing energy poverty.
- **Bureaucratic Barriers:** Government incentives, such as the Superbonus, have been pivotal in promoting energy efficiency improvements across the country. However, the bureaucratic complexities associated with these incentives present significant hurdles, especially for low-income households. The process often involves excessive documentation, long waiting times for approvals, and frequent changes in regulations. A study by Censis revealed that 35% of families who could benefit from these programs refrain from applying due to bureaucratic difficulties. These obstacles make it especially challenging for vulnerable populations to access the energy efficiency benefits that could significantly improve their living conditions.

- **Lack of Awareness:** A widespread lack of awareness about government programs designed to reduce energy poverty further hinders progress. Many Italians, particularly elderly individuals and those living in rural areas, are unaware of the subsidies and incentives available to help them address energy inefficiencies in their homes. According to a 2022 survey, nearly 47% of Italians are unaware of the energy subsidies available to them. This lack of awareness results in low participation rates in energy-saving initiatives, meaning many households are missing opportunities to improve their living standards through energy efficiency measures.
- **Limited Access to Finance:** Although financial incentives exist, economically disadvantaged households often struggle to afford the initial costs of energy upgrades. Many incentive programs require upfront payments, which are prohibitive for low-income families. Furthermore, financial institutions often demand guarantees that these households cannot provide, effectively limiting their access to credit. Research shows that over 30% of Italian households at risk of energy poverty cannot obtain financing for energy-efficient home improvements, which remains a significant obstacle to achieving a nationwide energy transition.
- **Aging Building Stock:** The obsolescence of Italy's housing stock is another major challenge in addressing energy poverty. Around 60% of Italian residential buildings were constructed before the 1980s, and many lack adequate insulation and modern energy-efficient systems. The cost of retrofitting these older buildings to meet contemporary energy efficiency standards is often prohibitively high, making it unattainable for many low-income families. ENEA has estimated that retrofitting older buildings could lead to heating cost savings of up to 50%, but the initial investment required remains a significant barrier.
- **Slow Transition to Renewables:** Despite progress in increasing the share of renewable energy in Italy's energy mix, the country still relies heavily on fossil fuels, particularly natural gas, which accounts for approximately 42% of electricity production. The pace of transition to renewable energy sources has been slow, in part due to regulatory barriers and infrastructure limitations. The development of smart grids and decentralised energy systems has faced delays, making it difficult to integrate renewable sources effectively. Until the grid is modernised and made more

flexible, the transition to a more sustainable energy system will remain a challenge, preventing Italy from fully embracing clean energy solutions.

- **Vulnerability of Marginalised Communities:** Marginalised communities, particularly those in rural or mountainous areas, face additional challenges in accessing both energy infrastructure and support programs. These areas often suffer from an infrastructure gap, where energy supply disruptions are more frequent, and the ability to access financial aid or government programs is limited due to logistical constraints. Isolated communities risk being left behind in the energy transition unless targeted interventions are put in place to ensure they benefit from energy efficiency programs and renewable energy initiatives.

To overcome these challenges, Italy must adopt a comprehensive approach that addresses the various dimensions of energy poverty. Key measures should include:

- **Simplifying bureaucratic processes:** Streamlining the application and approval procedures for government incentives will help reduce the barriers faced by low-income households.
- **Raising awareness:** Expanding outreach efforts to ensure that vulnerable populations are informed about available programs will increase participation in energy efficiency initiatives.
- **Improving access to finance:** Developing financial products tailored to low-income households, such as low-interest loans or grants, would help overcome the upfront cost barrier for energy upgrades.
- **Investing in building retrofitting:** Prioritising energy retrofitting programs for older buildings would make significant improvements in energy efficiency, reduce heating costs, and lower overall energy consumption for households.
- **Expediting the renewable energy transition:** Speeding up the development of smart grids and decentralised energy systems is crucial to enabling the integration of renewable energy sources, reducing reliance on fossil fuels, and enhancing energy security.

- **Targeted policies for marginalised communities:** Ensuring that isolated and rural communities are not excluded from energy programs is essential to achieving an equitable energy transition for all citizens.

Italy's energy transition will only be successful if it is inclusive and addresses the needs of its most vulnerable populations. By investing in infrastructure, increasing access to financial support, simplifying administrative procedures, and raising awareness, Italy can make significant progress toward overcoming energy poverty and achieving a sustainable, fair, and inclusive energy system for all its citizens.

3.5.9. Case Study

Description of the area:

Castelsant'Angelo Sul Nera is a charming mountain village located in the Marche region, in the province of Macerata, nestled in the heart of the central Apennines, within the renowned Monti Sibillini National Park (Fig. 31). This small settlement is one of the highest municipalities in the region, standing at approximately 760 meters above sea level, on the western slope of the Marche region, close to the border with Umbria [117].

Figure 31: Location of Castelsant'Angelo Sul Nera

The area is characterised by rugged and fascinating terrain, made up of a succession of mountain ridges, dense forests, deeply cut valleys, and crystal-clear streams. Castelsant'Angelo sul Nera lies near significant peaks such as Monte Cornaccione, Monte Bove, and Monte Cardosa, serving as a privileged access point to the higher elevations of the Monti Sibillini range, which rises above 2,000 meters.

One of the most important natural features of the area is the Nera River, which originates near the village itself. Its sources are found in a landscape of rare beauty, nourishing a rich and diverse ecosystem, characterised by wetlands, wild fauna, and a flora typical of the Apennine environment. The village is composed of numerous hamlets scattered across hillsides, forests, and valleys, a settlement pattern that historically reflects the need to utilise every available piece of land in this mountainous and challenging territory. However, this layout has also made Castelsant'Angelo sul Nera a rather isolated place, especially during the winter months, when snow and harsh weather can make access to surrounding areas difficult.

A dramatic event that deeply marked the village's recent history was the 2016 earthquake. Castelsant'Angelo sul Nera was one of the towns most severely affected by the seismic events that struck central Italy. The tremors of October 26th and 30th caused extensive damage to homes, historic buildings, and infrastructure, forcing many residents to evacuate (Fig. 32). Like other nearby towns, the village experienced a rapid population decline, with significant demographic, economic, and social consequences. Much of the historic center is still undergoing reconstruction, although the area has preserved its identity and strong bond with the natural environment.

Figure 32: An area of the center after the earthquake in 2016 [118]

Despite these challenges, Castelsant'Angelo sul Nera remains a hidden gem of the Apennines, a destination for hikers, nature lovers, and visitors seeking authenticity, tranquility, and unspoiled landscapes.

3.6. The Netherlands

The Netherlands, a country in Western Europe, is a fascinating blend of history, culture, and progressive values. With a population of around 17 million people, it is a small but incredibly influential nation on the global stage. Known for its remarkable landscape, much of the Netherlands lies below sea level, which has led to its unique engineering feats, such as the creation of extensive dikes and the reclamation of land from the sea through polders. This relationship with water is a defining characteristic of the nation, shaping not only its geography but also its identity. The Dutch have developed an intricate balance between modernity and tradition, which is reflected in their art, architecture, and daily life. Amsterdam, the capital, is a hub of history, culture, and commerce, with world-renowned

museums like the Rijksmuseum, Van Gogh Museum, and Anne Frank House, all standing testament to the country's rich artistic and historical heritage.

The Netherlands' political structure is another facet that draws attention. As a constitutional monarchy with a parliamentary system, it maintains a deep sense of tradition while also embracing democratic principles. The monarchy, led by King Willem-Alexander, plays a symbolic role, but real political power rests with the elected government. This system underpins the country's strong sense of civic responsibility, with an active, politically engaged populace that values liberty, tolerance, and social justice. Economically, the Netherlands punches well above its weight. It is one of the world's largest exporters, particularly of agricultural products, and has a thriving tech and financial sector. Its strategic location in Europe, combined with an open economy and trade policies, positions it as a key player in the global marketplace. Rotterdam, with its massive port, is the largest in Europe, cementing the Netherlands' role as a key trading hub. The country is also recognised globally for its progressive social policies. It was one of the first to legalise same-sex marriage, and its liberal stances on issues like drug use, euthanasia, and LGBTQ+ rights make it a beacon of liberal thought in an often conservative world. In fact, the Netherlands often finds itself at the center of debates on human rights, freedom, and equality, with its history of tolerance and openness guiding its approach to modern issues. In terms of cultural identity, the Dutch have always been at the crossroads of European history. From their golden age of exploration and trade in the 17th century to their pivotal role in modern international relations through The Hague, the Netherlands has always positioned itself as a forward-thinking and progressive nation. Whether through their contributions to global art and philosophy or their role in shaping the EU, the Netherlands continues to play a significant role in shaping both European and world affairs. Tourism in the Netherlands, too, is a reflection of this balance between tradition and modernity. From the iconic windmills of Kinderdijk to the tulip fields of Keukenhof, visitors are drawn to the country's picturesque charm. But beyond its scenic landscapes, the Netherlands is a modern, vibrant country that attracts people for its open-mindedness, quality of life, and innovative spirit. Thus, the Netherlands is not simply a place defined by its canals and tulips—it is a nation that has navigated the complexities of modern life while holding steadfast to its core values of liberty, tolerance, and progress. It is a small country with a big

impact, both regionally and globally, continuing to shape and influence the world around it [119].

3.6.1. National Energy Policy and Climate Action Plan: Strategies for a Sustainable Future

The Netherlands has established a comprehensive framework to transition toward a low-carbon, sustainable future while ensuring economic resilience and social equity. At the core of its strategy is the Climate Act (Klimaatwet), enacted in 2019, which sets legally binding targets for reducing greenhouse gas emissions by 49% by 2030 and achieving a 95% reduction by 2050, compared to 1990 levels [120]. These objectives are operationalised through the National Climate Agreement, a collaborative framework between the government, businesses, and civil society that outlines sectoral measures across electricity, industry, transport, agriculture, and the built environment. To align with EU-wide objectives, the Netherlands has also adopted the NECP 2021-2030 [121], which provides a roadmap for achieving these reductions through a combination of renewable energy expansion, carbon pricing mechanisms, and technological innovation [121].

One of the Netherlands' primary strategies to accelerate decarbonisation is its SDE++ subsidy scheme (Stimulering Duurzame Energieproductie en Klimaattransitie), a competitive auction system that incentivises projects based on cost-effective CO_2 reductions. This program has significantly boosted investments in offshore wind, green hydrogen production, and CCS technologies [122]. Additionally, the energy tax reform has been introduced to encourage energy efficiency and the transition to renewable sources by progressively increasing levies on fossil fuel consumption while offering financial incentives for sustainable energy investments. However, despite these efforts, the Netherlands faces critical challenges in meeting its climate targets. Grid congestion, particularly in densely populated urban areas and industrial zones, has emerged as a bottleneck for renewable energy expansion. The closure of Groningen’s natural gas fields due to seismic risks has further accelerated the need for an electricity-based heating transition, intensifying demand on the already strained energy infrastructure. Moreover, the transition to cleaner energy sources, while necessary for long-term sustainability, could increase energy costs for vulnerable households, exacerbating the risk of energy poverty. The cost of heating transitions, coupled with rising electricity prices, particularly in urban areas with high living costs, threatens to leave many households

unable to afford adequate energy services. This, alongside grid congestion, highlights the urgent need to integrate energy poverty concerns into the broader climate policy agenda. Without additional interventions, recent reports indicate that the country risks falling short of its 2030 emissions reduction target, necessitating further policy refinement and investment [123]. Moving forward, the Dutch government is exploring new regulatory measures, including mandatory energy efficiency upgrades for rental properties, stricter emissions standards for industrial clusters, and further decarbonisation of the transport sector through the expansion of electric vehicle infrastructure. Furthermore, increasing the deployment of local energy cooperatives and community-driven initiatives, such as decentralised solar and wind projects, could enhance energy security while addressing social inequalities, including energy poverty. The Netherlands remains a leader in climate action, but sustained political commitment, private sector collaboration, and technological advancements will be essential to achieving its long-term sustainability goals.

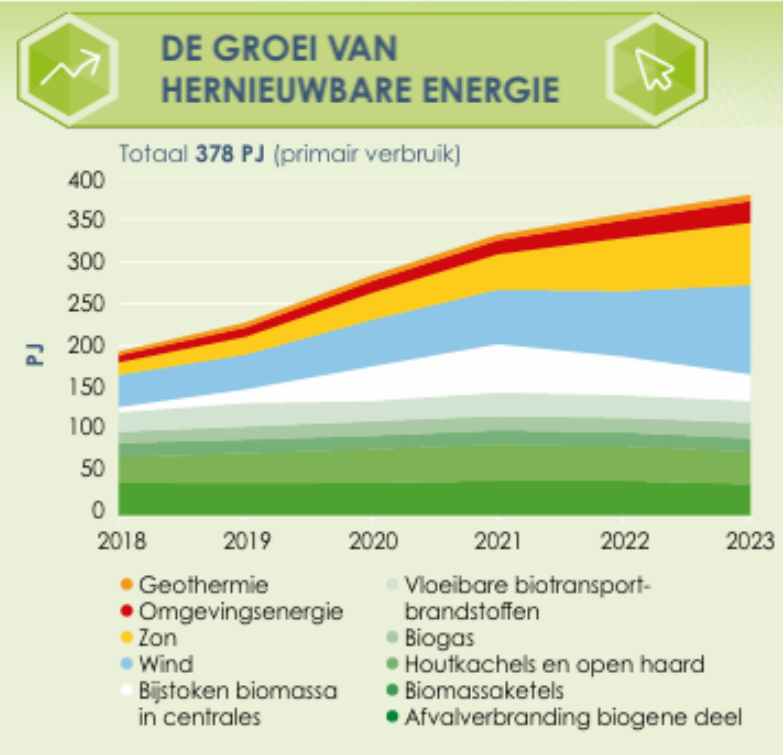


Figure 33: The energy share in the Netherlands [124]

3.6.2. National Political Context

In the Netherlands, the energy transition stands as one of the most significant political and economic challenges of the 21st century. With ambitious climate goals and a strong commitment to reducing greenhouse gas emissions, the Dutch government has set itself a target of a carbon-neutral economy by 2050. This involves a shift from fossil fuels to renewable energy sources like wind, solar, and biomass. However, this transition is not without its challenges, particularly regarding the affordability and accessibility of energy for all citizens. The Dutch government's approach to energy transition is grounded in its broader climate policy. The Netherlands has made significant strides in the deployment of renewable energy. It has become a leader in wind energy, particularly offshore wind farms, and solar energy has seen substantial growth in recent years. These technologies are seen as central to achieving the country's climate goals. By 2030, the Netherlands aims to generate 70% of its electricity from renewable sources, a goal that will require substantial investments in infrastructure, technology, and innovation [120]. The government has also committed to phasing out coal by 2030, a key part of its efforts to reduce emissions. This decision is in line with the broader European Green Deal [125], which aims for a net-zero emissions economy by 2050.

While the phasing out of coal is an important step toward a sustainable future, it also raises concerns regarding the immediate impact on energy prices and security of supply. The move towards renewable energy is not without its social implications, particularly in terms of energy affordability. The transition to greener sources of energy, while essential for combating climate change, often comes with higher upfront costs. These include the installation of renewable energy infrastructure, the decommissioning of fossil fuel plants, and the development of storage solutions for intermittent energy sources like wind and solar. Energy prices in the Netherlands have risen significantly in recent years, in part due to these increased costs. For many consumers, especially lower-income households, the impact is acute. As fossil fuels become less central to the energy mix, prices for natural gas and electricity are expected to fluctuate, further straining household budgets. The Netherlands, like much of Europe, faces significant challenges when it comes to energy security. The war in Ukraine and subsequent disruption of natural gas supplies to Europe have heightened concerns over energy dependence. In response, the Dutch government has been actively seeking ways to reduce its

reliance on external energy sources and boost the domestic renewable energy capacity. However, the transition to renewables, while a long-term solution, does not yet provide the same level of stability and security as fossil fuels.

As the Netherlands works to increase its energy independence, it also faces the challenge of managing the volatility of global energy markets. The shift to renewables, although essential for climate goals, does not eliminate the need for a stable, reliable energy supply, especially as renewable energy production can be inconsistent depending on weather conditions [122]. The pace of the energy transition has raised concerns about the social equity of the process. Energy transition policies that prioritise sustainability and climate goals can sometimes neglect the needs of vulnerable groups who may struggle with rising energy costs. While green energy is touted as the solution for a sustainable future, the immediate financial burden of transitioning to these systems is felt disproportionately by lower-income groups, renters, and rural communities. In particular, the high costs of transitioning residential heating systems from natural gas to renewable alternatives such as heat pumps or district heating systems can create significant financial barriers. Furthermore, while energy efficiency programs exist, such as subsidies for home insulation, they are often insufficient or difficult to access for those in most need. For low-income households, the upfront cost of making energy-efficient upgrades can be prohibitive, limiting their ability to benefit from a greener energy system. In response to these challenges, the Dutch government has introduced a range of policies aimed at facilitating the energy transition while ensuring that it is affordable for all citizens [126]. One such policy is the investment in renewable energy infrastructure, such as offshore wind farms and solar parks. These initiatives are designed to drive down the cost of renewable energy production over time, making it more affordable for consumers. Additionally, the government has committed to large-scale subsidies for low-income households to help with energy costs and the installation of energy-efficient technologies. These measures are designed to ease the financial burden on households that would otherwise struggle with the costs of transitioning to green energy solutions. However, critics argue that these subsidies, while helpful, are often insufficient to address the scale of the problem, and there is a growing call for more comprehensive support measures.

The Netherlands is also focusing on innovation to drive down the costs of renewable energy technologies. Research and development in areas such as energy storage, smart grids, and

energy efficiency solutions are seen as key to making the energy transition more affordable and effective [127]. Furthermore, the government is working to stimulate the growth of green jobs in the renewable energy sector, recognising that a transition to a low-carbon economy can also provide significant economic opportunities [128]. The role of market forces in the energy transition is another area of debate. While the government is making significant investments in renewable energy infrastructure, much of the transition is being driven by private market actors. The growing demand for renewable energy, coupled with technological advancements, has led to a boom in the private sector's involvement in green energy production. However, market forces alone may not be enough to guarantee an equitable and successful transition. Public policy will remain critical in guiding the energy sector toward a low-carbon future, particularly in terms of ensuring that the transition benefits all segments of society. The government must carefully manage the balance between market-driven innovations and the need for equitable access to affordable energy.

3.6.3. National Economic and Legislative Context

At the heart of the Dutch energy transition is the economic imperative of reducing GHG emissions while fostering new industries and technologies. The Netherlands has committed to reducing its emissions by 49% by 2030, compared to 1990 levels, as part of the Klimaatakkoord (2019) [129]. This policy framework is designed not only to fulfill international climate obligations but also to capitalise on the economic opportunities that come with green innovation. From offshore wind farms in the North Sea to solar power initiatives, the Dutch economy is increasingly aligning itself with the principles of sustainability and green growth. Renewable energy, once viewed as a niche sector, has become central to the future of the economy, promising the creation of new jobs, the revitalisation of industrial sectors, and the stimulation of technological advancements in green technologies [130]. However, the transition is not without its challenges. The Netherlands' historic reliance on natural gas, particularly from the Groningen field, has raised questions about the affordability of energy during the shift to renewables. The closing of coal plants by 2030 and the need for large-scale investments in renewable infrastructure have led to fluctuating energy prices, creating an economic dilemma. For households, especially those in vulnerable situations, energy poverty remains a pressing issue. Energy prices, often subject to

global commodity markets, have risen sharply, and the cost burden falls disproportionately on low-income households, forcing the government to introduce compensation and social support measures. Here, the discourse broadens from economic growth to an ethical concern over who bears the cost of a green transition. The legislative architecture governing energy in the Netherlands is a key aspect of the ongoing energy debate. The energy Law (Energiewet) serves as the backbone of the country's energy regulation, setting the framework for energy markets, pricing, and infrastructure. The law, while facilitating market liberalisation, also ensures that the transition to renewable energy is supported by stable regulations that incentivise investments in clean technologies [131]. The government's active role in creating market mechanisms that promote the development of renewable energy sources, such as wind and solar, is essential in achieving the targets set out in the Klimaatakkoord.

However, the relationship between energy policy and economic outcomes is not always straightforward. On the one hand, the Dutch government has introduced ambitious policies to expand renewable energy sources. On the other hand, the EU's overarching policies, particularly the European Green Deal, influence national actions, compelling the Netherlands to navigate the complexities of compliance with both national and EU-level commitments. The shift to a green economy also prompts a legislative examination of how to balance market forces with public interest. The Dutch government's energy policies are not only shaped by domestic economic concerns but also by broader environmental justice considerations. As part of the European Union, the Netherlands is committed to achieving net-zero emissions by 2050 and is a key player in the EU Emission Trading System (ETS). The debate surrounding the energy transition in the Netherlands is thus inextricably linked to larger global narratives on climate change and environmental responsibility. In the context of international climate agreements, the Netherlands' energy policies reflect the complex intersection of national sovereignty and global responsibility. While the country has made significant strides in reducing emissions through investments in renewable energy, the urgency of addressing climate change demands that the Netherlands not only adhere to its targets but also play a leading role in global climate diplomacy. The rhetoric surrounding energy transition thus extends beyond national borders and enters the domain of global justice, asking how a wealthy nation like the Netherlands can both mitigate its emissions and support less-developed nations in achieving their energy goals.

3.6.4. National Environmental Context

The Netherlands stands at a crucial juncture in its pursuit of a sustainable and reliable energy future. The NECP lays the foundation for how the country envisions its energy landscape in 2050, one that is resilient, environmentally responsible, and economically sound. At the heart of this vision is the commitment to reducing GHG emissions by 49% by 2030 (compared to 1990 levels) and achieving a remarkable 95% reduction by 2050. These ambitious targets, set out in the Climate Act of May 28, 2019, underscore the urgency of addressing climate change while ensuring that the transition remains feasible and inclusive for all sectors of society. The Netherlands follows a collaborative approach to policymaking, often referred to as the "Polder Model," which brings together over 100 stakeholders from various industries, municipalities, and civil society organisations. This consensus-driven strategy is central to the national climate agreement, ensuring broad societal support and shared responsibility across five key sectors: electricity, industry, transportation, agriculture, and the built environment. By fostering dialogue and cooperation, the government aims to implement climate measures in a step-by-step manner, optimising the time available until 2050 while minimising financial strain on households and businesses.

A Balanced and Cost-Efficient Approach

A key challenge in the energy transition is striking a balance between ambitious climate goals and economic stability. To achieve this, the Dutch government continuously evaluates and refines its policies, with annual progress updates and climate plan revisions every five years. Measures are carefully designed to be cost-efficient, ensuring that the transition remains financially viable for both individuals and businesses. One of the cornerstone strategies is the alignment of carbon pricing mechanisms across different sectors. The introduction of a carbon levy for industries, combined with feebate schemes and the European ETS, creates strong financial incentives to reduce emissions without disrupting economic growth. The Netherlands integrates these national efforts with broader EU-wide initiatives such as the European Green Deal, reinforcing its commitment to sustainability while fostering innovation and energy security.

Transforming Key Sectors

Achieving the country's climate ambitions requires significant transformations across all major sectors. Each plays a critical role in driving emissions reductions and shaping a cleaner, more sustainable future.

Built Environment: A Transition to Fossil-Free Heating

The built environment is undergoing a major shift, with a strong focus on improving energy efficiency and moving away from fossil fuels. The government aims to enhance the energy performance of 1.5 million homes and reduce emissions from utility buildings by at least 1 megaton of CO_2. A crucial aspect of this transition is eliminating natural gas for heating in new buildings, while upgrading existing structures to enable fossil-free heating solutions. Municipalities take the lead in this neighborhood-by-neighborhood transformation, adopting a participatory approach that involves residents and local businesses. Furthermore, the energy tax system has been adjusted to provide stronger incentives for energy efficiency and CO_2 reduction, ensuring that households and businesses are encouraged to adopt cleaner technologies.

Traffic and Transport: Moving Towards Emission-Free Mobility

The transportation sector is a critical area of focus, given its significant contribution to national emissions. By 2030, all newly registered passenger vehicles in the Netherlands must be emission-free. To facilitate this shift, the government has introduced a series of incentives, including tax benefits for electric vehicles and financial support for the second-hand EV market. In parallel, the country is investing in a comprehensive charging infrastructure, with a target of 1.8 million charging points by 2030. Beyond electrification, the government is actively promoting a modal shift from cars to bicycles and public transport, aligning with the Netherlands' long-standing reputation as a leader in sustainable urban mobility. Additionally, innovative logistical solutions are being implemented to optimise freight transport, reducing emissions through smarter and more efficient delivery systems.

Industry: A New Era of Sustainable Production

The industrial sector, traditionally one of the largest contributors to GHG emissions, is undergoing profound changes. A targeted carbon levy was introduced in 2021, starting at €30

per ton of CO_2, and is set to rise to €125–150 per ton by 2030, including the ETS price. This measure ensures that companies exceeding their emissions reduction targets bear the financial cost of their environmental impact. To support the transition, the government provides funding through the Renewable Energy Grant Scheme (SDE) and other CO_2-reducing programs. Investments in hydrogen and other sustainable fuels play a crucial role in decarbonising industrial processes, ensuring that Dutch businesses remain competitive in a low-carbon economy.

Electricity: A Rapid Shift to Renewable Energy

The Dutch electricity sector is undergoing one of the most significant transformations. The government has set a clear trajectory to phase out coal-fired electricity generation by 2025–2030, with the first closures already taking place in 2020. The emphasis is on accelerating the deployment of renewable energy sources, particularly offshore wind power, while also expanding onshore wind and solar capacity. To maintain momentum, the government continues to provide subsidies for additional renewable energy capacity until at least 2025, aiming for renewables to account for approximately 70% of electricity production by 2030 (Fig. 34, 35). Additionally, a minimum CO_2 price for electricity generation has been introduced to further drive emissions reductions and encourage investment in cleaner technologies.

Agriculture and Land Use: Sustainable Practices for a Greener Future

Agriculture is a key sector in the Dutch economy, but it also presents challenges in the fight against climate change. The government is promoting more sustainable heating methods in greenhouse horticulture while actively working to reduce methane emissions from livestock through improved manure processing techniques. To enhance carbon sequestration, pilot programs are being launched to explore climate-friendly land use practices. Furthermore, the government is encouraging sustainable food consumption and waste reduction initiatives, fostering a more circular and resource-efficient agricultural sector.

Ensuring an Affordable and Equitable Transition

The underlying principle of the Dutch Climate Agreement is that the energy transition must be both achievable and affordable for everyone. Policymakers recognised that while reducing

emissions is essential, the financial burden should be distributed fairly between businesses and citizens. The government's approach aims to limit the financial impact on households by introducing step-by-step measures, ensuring that costs remain manageable over time. In economic terms, the additional annual costs associated with the Climate Agreement are estimated to be less than 0.5% of GDP by 2030. This measured approach ensures that the transition remains within reach for Dutch society while still delivering on ambitious climate commitments. The Netherlands is at the forefront of the energy transition, striving for ambitious CO_2 reduction targets and climate neutrality. While national policies set the framework for sustainability, it is at the regional and municipal levels where the real transformation takes shape. Each of the twelve Dutch provinces and major cities brings its unique challenges, opportunities, and initiatives to the table, creating a diverse and multi-layered approach to tackling climate change. Despite a shared national ambition, regional variations in geography, economic structures, and historical energy dependencies have led to a broad spectrum of strategies. In the northern provinces, for instance, the closure of the Groningen gas fields, once a major source of energy, has forced a shift toward renewable alternatives, while in the Randstad, issues like energy poverty in landlord-owned housing complicate progress. These nuances highlight the necessity of locally tailored solutions within the broader national framework.

Regional Energy Strategies: A Decentralised Approach to Climate Goals

Each province in the Netherlands has developed its own regional energy strategy, aligning with national objectives while addressing local conditions. These strategies shape how energy is generated, distributed, and consumed in each area, ensuring that climate goals are both ambitious and practical.

Northern Netherlands: From Fossil Fuels to Hydrogen and Renewables

The provinces of Groningen, Friesland, and Drenthe have historically played a central role in the Netherlands' energy landscape, particularly due to natural gas extraction. However, as the Groningen gas fields are phased out due to induced earthquakes and structural damage to homes, the region is transforming into a renewable energy hub. Groningen has set an ambitious target of CO_2 neutrality by 2035, well ahead of national goals, by investing in green

hydrogen development, offshore wind energy in Eemshaven, and the Hydrogen Energy Application (HEAVENN) project, positioning itself as a leader in Europe's hydrogen economy. Friesland, with its "Fossylfrij Fryslân" (Fossil-Free Friesland) initiative, is focusing on offshore wind farms along the IJsselmeer and sustainable agriculture practices to reach climate neutrality by 2050. Drenthe is investing heavily in solar fields, energy-neutral villages, and peat restoration projects that act as natural carbon sinks.

Eastern and Central Netherlands: Industrial and Cross-Border Collaborations

The provinces of Overijssel, Gelderland, and Flevoland have taken a pragmatic approach by combining industrial decarbonisation with renewable energy generation. Overijssel has set one of the highest reduction targets (55% CO_2 reduction by 2030) and is working closely with Germany on cross-border energy solutions. Flevoland, known for its vast open landscapes, boasts the highest per capita renewable energy production in the Netherlands, thanks to large-scale wind farms and sustainable urban planning in cities like Almere and Lelystad. Gelderland is home to the "Gelders Energieakkoord," a coalition of over 200 partners working on industrial sustainability and circular economy initiatives, particularly in the Arnhem-Nijmegen region.

The Randstad: High-Density Urban Solutions and Energy Poverty Challenges

The Randstad, comprising North Holland, South Holland, and Utrecht, faces a unique set of challenges due to its high population density and housing market complexities. North Holland is tackling industrial emissions by focusing on the decarbonisation of Tata Steel in IJmuiden and the sustainable transformation of the Port of Amsterdam. South Holland, home to Rotterdam's massive industrial port, has launched the Porthos carbon capture and storage project, a critical initiative in reducing emissions from one of Europe's largest fossil-fuel-based industrial clusters. Utrecht prioritises sustainable mobility and carbon-neutral buildings, with extensive investments in cycling infrastructure and green urban planning. One of the most pressing issues in the Randstad is energy poverty, particularly in cities where rental housing is dominant. Many landlords are reluctant to invest in energy

efficiency measures, leaving tenants with high energy costs and poorly insulated homes. This trend is especially pronounced in Amsterdam, Utrecht, Rotterdam, and The Hague, where the impact of inefficient buildings on lower-income households is becoming a growing concern. Addressing this requires targeted policies that incentivise landlords to retrofit properties with sustainable heating and insulation solutions.

Southern Netherlands: Innovation and Cross-Border Sustainability

In the south, Zeeland, North Brabant, and Limburg have distinct approaches to the energy transition. Zeeland, with its coastal geography, focuses on offshore wind, tidal energy projects like Oosterschelde, and emerging blue energy (salinity gradient technology) research. North Brabant, a hub for technological innovation, is leveraging the Brainport Eindhoven cluster to develop smart mobility and high-tech industry sustainability solutions. Limburg, with its industrial legacy, is transitioning the Chemelot chemical cluster towards a greener future and utilising mine water thermal energy to repurpose its former mining infrastructure.

The Role of Cities: Pioneering Local Climate Action

Beyond the provincial level, Dutch cities are taking bold steps toward climate neutrality. Many have developed their own climate action plans that translate national goals into locally tailored initiatives. Amsterdam is implementing a climate neutral 2050 roadmap, prioritising the phase-out of natural gas, clean electricity, sustainable transport, and circular economy measures. The city aims for a 55% CO_2 reduction by 2030. Rotterdam, home to Europe's largest port, has integrated climate goals into its economic strategy, focusing on port and industrial decarbonisation, clean energy, and sustainable consumption. Utrecht, which aspires to be the Netherlands' first circular economy region, is heavily investing in car-free zones and expanded cycling infrastructure. The Hague has committed to achieving climate neutrality by 2030, emphasising sustainable government buildings and municipal operations. Smaller cities and municipalities are also making significant contributions. Many have joined the Covenant of Mayors, committing to CO_2 reduction goals that often exceed national targets. Recognising that they control roughly 50% of local greenhouse gas emissions, municipalities are leveraging policies such as building regulations (e.g., mandatory Electric Vehicles (EVs)

charging stations in new developments) and zoning laws (e.g., zero-emission heating requirements) to drive sustainability efforts.

The Path Forward: A Collaborative National-Regional Effort

The Dutch energy transition is a complex, multi-layered process that requires cooperation between the national government, provinces, municipalities, and private stakeholders. While national targets provide a guiding framework, it is at the local level where real implementation happens. Each province and city faces its own unique hurdles, whether transitioning from fossil fuel dependency, managing energy poverty, or integrating industrial sustainability. However, by aligning local efforts with national and European policies, the Netherlands is building a decentralised but cohesive climate strategy that balances ambition with practicality. As the country moves towards 2050, the success of the energy transition will depend on continuous adaptation, financial investment, and stakeholder engagement. From wind turbines in Flevoland to hydrogen hubs in Groningen and sustainable urban planning in Amsterdam, the Netherlands demonstrates that while climate action must be coordinated at the highest levels, it ultimately thrives through local and regional innovation.

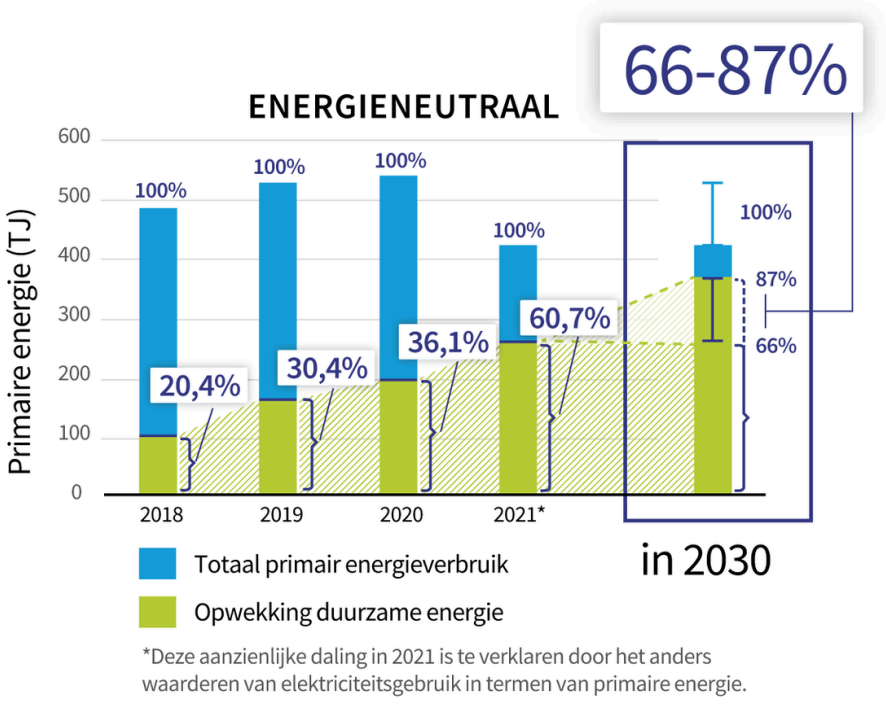


Figure 34: Primary energy (blue) and renewable energy (green) share in the Netherlands [120]

Elektriciteitsproductie

Jaar	Fossiel (mld kWh)	Wind (mld kWh)	Zon (mld kWh)	Biomassa (mld kWh)	Water (mld kWh)	Kernenergie + Overig (mld kWh)
2015	87,48	7,55	1,11	4,34	0,09	5,19
2016	91,88	8,17	1,60	4,30	0,10	5,01
2017	91,91	10,57	2,20	3,99	0,06	4,72
2018	88,75	10,55	3,71	3,91	0,07	3,85
2019	91,62	11,51	5,40	5,07	0,07	4,19
2020	83,73	15,28	8,57	7,89	0,05	4,33
2021	74,94	17,68	11,30	9,82	0,09	4,09
2022	66,29	21,07	16,66	8,73	0,05	4,48
2023	57,93	28,93	19,58	6,75	0,07	4,29
2024	55,40	32,70	21,65	6,37	0,09	3,95

Figure 35: Electric energy share in The Netherlands [120]

3.6.5. National Social Context

As the Netherlands grapples with the social dimensions of its energy transition, there has been increasing attention on the concept of "energy democracy." Energy democracy emphasises the involvement of citizens in energy decision-making processes and the decentralisation of energy systems. Rather than a top-down, government-led approach to energy transition, energy democracy advocates for local communities, cooperatives, and individuals to play a more active role in shaping the energy future. This approach seeks to challenge traditional, centralised energy systems dominated by large utilities and corporations, which often prioritise profit over social and environmental concerns. Instead, energy democracy encourages a more participatory and transparent energy system where people can collectively own and manage renewable energy projects, such as community wind farms or solar cooperatives. This model not only ensures that energy transition benefits are more widely

distributed but also empowers communities to take control over their energy future. In the Netherlands, energy cooperatives have been emerging as an important aspect of the transition. These cooperatives allow citizens to invest in renewable energy projects in their communities, such as solar and wind farms, and collectively share in the benefits. The rise of such initiatives reflects a broader desire for more democratic energy systems, where power (both literally and figuratively) is more evenly distributed. However, while energy democracy holds great potential, it also raises questions about how to ensure that these decentralised models are inclusive and accessible to all members of society. The challenge lies in ensuring that the most vulnerable communities, those who are often the least able to invest in renewable technologies, are not excluded from these opportunities. Energy democracy must therefore be accompanied by policies that support social equity and ensure that everyone has a stake in the green energy transition.

The Dutch energy transition is also informed by broader global narratives of climate justice. As part of the European Union's Green Deal and the UN Sustainable Development Goals (SDGs), the Netherlands has committed to reducing its carbon emissions, promoting renewable energy, and ensuring that its energy policies do not exacerbate global inequalities. For many activists and policymakers, the energy transition is not just a domestic issue but a global one. The Netherlands, as a wealthy nation, has a responsibility to lead by example, mitigating its own emissions while also supporting climate action in developing countries. The intersection of domestic energy policies and global climate justice is a key aspect of the social discourse on energy in the Netherlands. The country's energy transition is thus framed within a larger conversation about international solidarity and responsibility. For instance, the Dutch government has pledged to support developing nations in their efforts to transition to renewable energy and adapt to climate change. This internationalist perspective recognises that the effects of climate change and energy inequality are felt most acutely by those who have contributed the least to global emissions, highlighting the need for policies that prioritise global justice alongside national goals.

3.6.6. Energy Poverty Situation in The Netherlands

Energy poverty is becoming a pressing issue in the Netherlands, affecting a growing number of households. While the country has ambitious climate goals and a strong renewable energy

agenda, the transition has not been equally beneficial for everyone. Structural challenges in the housing market, economic barriers, policy inconsistencies, and grid congestion are all contributing to a system where lower-income households bear a disproportionate burden. The housing market plays a critical role in this problem. Over the years, government fiscal policies—such as tax incentives for homeowners—have contributed to skyrocketing real estate prices. As a result, younger generations and lower-income households are increasingly unable to afford homeownership, forcing them to rent instead. However, many rental properties, especially those owned by private landlords, are poorly insulated and inefficient. Since tenants pay the energy bills, landlords have little financial incentive to invest in energy-saving improvements. This split incentive problem has led to high energy costs for renters and exacerbated energy poverty in urban centers, particularly in Amsterdam, Rotterdam, The Hague, and Utrecht. While social housing in the Netherlands is relatively well-developed compared to other countries, the renovation rate is too slow to keep up with climate targets or significantly reduce energy costs for tenants. Older, pre-1980s buildings—where many low-income households live—are often poorly insulated and consume excessive amounts of energy for heating. Despite efforts to phase out natural gas heating in new constructions, older homes still rely heavily on it, making the transition to all-electric housing even more complex.

Economic Barriers: The Cost of Going Green

For many households, transitioning to a more energy-efficient home is simply unaffordable. High upfront costs for renovations, such as installing better insulation, heat pumps, or double-glazed windows, put these improvements out of reach for those who would benefit the most. While subsidies exist, they are often complex to apply for, requiring paperwork and technical knowledge that many vulnerable households lack access to. The rising cost of energy further worsens the situation. The shift toward renewable energy has led to fluctuations in electricity prices, and lower-income households, who already struggle with high rent and living costs, are particularly affected. Compounding this issue is the energy tax structure, which places a disproportionately higher burden on small consumers than on large industrial users. While businesses benefit from lower energy taxes, private households end up paying more, making energy poverty a systemic issue that needs urgent policy intervention.

The Solar Panel Paradox: Unintended Consequences of Energy Transition

At first glance, solar energy seems like an obvious solution to reducing household energy costs. However, the reality in the Netherlands has become more complicated due to grid congestion and changing policies from energy providers. The Dutch energy grid was not designed to handle the vast influx of decentralised solar power. During sunny months, the grid experiences an oversupply of electricity, while in winter, energy demand surpasses renewable generation capacity. As a result, energy companies are struggling with financial losses, as they are required to accept surplus solar energy in summer while still needing to supply more electricity in winter. Their response? Imposing extra taxes on households selling electricity back to the grid reducing the financial benefits of solar panels for homeowners. This unpredictability has led some households to invest in home battery storage systems. By storing excess solar energy and selling it back to the grid at peak demand times, homeowners can bypass extra feed-in charges. However, battery systems remain expensive, limiting access primarily to wealthier households, leaving lower-income families behind once again.

Policy and Implementation Challenges

Although the Dutch government has introduced various programs to support energy efficiency, the policy landscape remains fragmented and difficult to navigate. Multiple ministries and local governments share responsibility for tackling energy poverty, leading to inefficiencies and inconsistencies in implementation. Vulnerable households often struggle to access the right subsidies due to complex application processes, lack of awareness, and language barriers for non-Dutch speakers. Another key issue is the difficulty in identifying energy-poor households. Unlike income poverty, which is relatively easy to measure, energy poverty is more nuanced, it depends on factors such as housing quality, energy prices, and individual consumption patterns. Without a clear and consistent definition, many households that need support are not being properly targeted. Moreover, many policies have taken a one-size-fits-all approach, failing to account for different household circumstances. While financial incentives might work well for middle-class homeowners, they do little to help renters who have no control over their housing conditions. A more tailored approach, one that specifically addresses different groups, such as social housing tenants, private renters, and low-income homeowners, is necessary.

Social and Behavioral Challenges

Beyond economic and policy-related barriers, several social and behavioral factors make tackling energy poverty even more complex.

- **Digital divide:** Many government support programs are primarily accessed online, making it difficult for elderly or digitally excluded households to apply.
- **Language barriers:** Non-Dutch-speaking communities often miss out on vital energy efficiency information.
- **Lack of trust:** Some households, particularly those in vulnerable situations, are hesitant to engage with government programs or allow energy efficiency upgrades in their homes.
- **Limited awareness:** Many people are simply unaware of how to reduce their energy consumption effectively or what support is available to them.

The Bigger Picture: Grid Congestion and the Energy Transition

The phase-out of natural gas in the Netherlands has accelerated the shift toward an all-electric energy system. While this transition is crucial for meeting climate targets, it also presents significant challenges. Newly built homes are now constructed without gas connections, making them entirely reliant on electricity for heating and cooking. At the same time, the adoption of EVs is growing rapidly, increasing pressure on an already strained grid. As more households depend on electricity for daily needs, grid congestion is becoming a serious bottleneck, delaying renewable energy adoption and making energy costs more volatile.

Addressing Energy Poverty in a Just Transition

Energy poverty in the Netherlands is not just about high energy bills, it is a structural issue tied to housing, economic policy, and energy market dynamics. Addressing it requires a coordinated approach that ensures climate policies do not disproportionately burden vulnerable households. Some key actions include:

- Reforming rental policies to require landlords to improve energy efficiency in their properties.
- Adjusting energy taxation so that small consumers do not pay a higher burden than large industries.

- Expanding financial support for energy-saving home upgrades, with easier access for low-income households.
- Upgrading the grid infrastructure to handle decentralised renewable energy production more effectively.
- Improving outreach and information programs to ensure that all communities have equal access to energy efficiency resources.

Without targeted policies, there is a risk that the energy transition will widen social inequalities, leaving lower-income households to bear the highest costs while wealthier households benefit from renewable energy incentives. Just transition must ensure that the shift to sustainable energy is not only environmentally responsible but also socially equitable.

3.6.7. Local Targets for CO_2 Reduction and Combating Energy Poverty: Pathways to a Sustainable Future

The Netherlands has set ambitious climate targets, aiming for a 49% CO_2 reduction by 2030 and full climate neutrality by 2050 [132]. These national goals are translated into regional energy strategies, where provinces and municipalities develop localised plans tailored to their specific challenges. While some regions, such as Groningen and Flevoland, focus on large-scale wind and hydrogen energy projects, urban areas like Amsterdam, Rotterdam, Utrecht, and The Hague emphasise sustainable mobility, energy-efficient housing, and decarbonising industrial sectors [133]. Many cities have gone a step further, committing to even more ambitious timelines; for instance, Amsterdam aims for a 55% CO_2 reduction by 2030 and full carbon neutrality by 2050, while Utrecht targets climate neutrality between 2030 and 2040 [134]. Addressing energy poverty while accelerating CO_2 reduction requires a just transition, ensuring that vulnerable populations are not left behind as the Netherlands moves toward a sustainable and equitable energy future.

3.6.8. Obstacles and Key Challenges

The Netherlands' energy transition faces significant challenges despite ambitious goals. Grid congestion, driven by rapid solar and wind expansion, delays renewable energy projects and limits their impact. High upfront costs for sustainable solutions, like insulation, heat pumps,

and solar panels, make them inaccessible to low-income households. Renters face the "split incentive" problem, where landlords avoid energy-efficient upgrades. Energy poverty is worsening as rising prices and taxes disproportionately burden vulnerable groups. New taxes on excess solar power feed-in have also discouraged investment. The phase-out of natural gas, especially after closing Groningen fields, increases reliance on electric heating, further straining the grid. Meanwhile, fragmented policies and complex subsidies hinder access to support, especially for those most in need. [135].

3.6.9. Case Study

As the Netherlands accelerates its transition toward a carbon-neutral economy, community-driven energy initiatives are emerging as powerful tools in addressing energy poverty while promoting local sustainability and energy independence. These initiatives not only provide renewable energy solutions but also empower residents, strengthen local economies, and foster social cohesion. By shifting away from a centralised model of energy production, communities are reclaiming control over their energy sources, ensuring affordability, accessibility, and long-term resilience. One of the most successful solar energy initiatives in the Netherlands is ZonOpSchool [136], a national program that integrates renewable energy with educational outreach. By installing solar panels on school rooftops, this initiative democratises access to solar power through a cooperative financing model, allowing residents to invest and share the financial benefits. The impact extends beyond energy generation, students engage with hands-on sustainability education, while schools redirect savings from reduced electricity costs into educational resources. In Haarlem, for example, six schools now supply renewable energy to surrounding low-income households, reducing local energy costs by an average of 25%. This community-based model showcases how collective action can drive both environmental and social benefits.

Similarly, community-owned wind energy projects are reshaping the Dutch energy landscape. Windpark Krammer, located near Zeeland, exemplifies how grassroots efforts can lead to large-scale renewable energy production. Developed by the cooperatives Zeeuwind and Deltawind, the project’s 34 wind turbines generate 102 MW annually, supplying energy to 100,000 households. Unlike traditional wind energy projects, this initiative is owned by local residents, ensuring that profits are reinvested into the community rather than benefiting

private corporations. Revenue is directed toward local infrastructure projects, public transportation improvements, and environmental programs, reinforcing the economic and social fabric of the region. The success of Windpark Krammer has inspired similar projects across the Netherlands, proving that scalable, community-led renewable energy solutions are viable.

Beyond solar and wind, biogas production presents an innovative way to address both energy poverty and waste management. In Utrecht, the De Stichtse Rijnlanden cooperative transforms organic waste, such as manure and food scraps, into biogas, providing a renewable, affordable energy source for local homes and businesses. This circular economy approach not only reduces methane emissions from untreated waste but also strengthens the rural economy by allowing local farmers to use the nutrient-rich digestate as fertiliser. Such initiatives highlight the interconnected nature of sustainability efforts, where waste reduction, renewable energy production, and economic resilience reinforce one another. Another promising yet underutilised energy source in the Netherlands is geothermal energy, exemplified by the Haagse Aardwarmte project in The Hague. By tapping into deep underground heat reservoirs, the project aims to provide district heating solutions, particularly benefiting low-income neighborhoods. Given the Dutch government's commitment to phasing out natural gas, geothermal energy offers a stable, cost-effective alternative for urban heating. While still in its early stages, the project has the potential to heat over 20,000 homes annually, drastically reducing reliance on fossil fuels and enhancing local energy security.

The Broader Impact of Community Energy Initiatives

The success of these community-driven projects underscores the transformative potential of localised renewable energy solutions. By empowering residents as active stakeholders, such initiatives cultivate a sense of ownership and shared responsibility for the energy transition. Moreover, economic resilience is strengthened as communities reduce dependence on external energy suppliers, lower long-term costs, and create local job opportunities. However, challenges remain. While community energy projects offer a promising alternative to traditional energy models, policy fragmentation, financial barriers, and grid congestion pose significant obstacles. The Dutch government must ensure that regulatory frameworks support rather than hinder these initiatives by simplifying subsidy processes, expanding grid

infrastructure, and encouraging cooperative ownership models. Additionally, targeted efforts are needed to engage low-income communities, ensuring that the transition to clean energy is inclusive and equitable rather than exacerbating existing disparities. By scaling up these successful models and integrating new technologies, the Netherlands can lead the way in developing sustainable, community-driven energy solutions.

4. Conclusions

In the EU, energy poverty affects a minority of households, but with stark country variations. Overall, EU energy poverty averages under 10% of households (rising in recent years due to the geopolitical instability in Ukraine). By contrast, Western Balkan rates are dramatically higher, and Western Balkan families also spend a far larger share of income on energy. Thus, energy poverty is a much more widespread and acute problem in the Balkans than in the EU.

In the EU, energy poverty is mainly driven by a combination of low incomes, high energy prices, and energy-inefficient housing, especially in the post-socialist East and Mediterranean South. Policies often focus on structural solutions like retrofitting housing, energy subsidies, and efficiency upgrades. In the Western Balkans, energy poverty is more multidimensional and deeply rooted in systemic factors, such as poor building insulation, reliance on inefficient heating systems, high electricity intensity and low efficiency standards, dependence on electricity for heating, leading to very high bills, and lower average incomes and limited social welfare systems. Furthermore, Western Balkan households often rely on informal or harmful coping strategies to manage energy poverty. These include underheating rooms, burning waste materials indoors, leading to air pollution and health risks, using inefficient or unsafe heating devices, and accumulating debt. Unlike in most EU countries, where stronger safety nets, higher incomes, and better housing conditions offer protection, such practices remain widespread in the region.

EU member states are legally required to address energy poverty in their NECPs and benefit from substantial funding through mechanisms like the social climate fund, the just transition fund, and national renovation schemes. These programs increasingly support structural solutions, such as energy efficiency retrofits, decentralized renewables, and social tariffs, targeted at low-income and energy-poor households. The revised energy efficiency directive (2025), for example, mandates that a significant share of building renovations be directed toward vulnerable groups. In contrast, Western Balkan countries have less developed frameworks. While governments in the region operate social tariff or subsidy schemes, these measures are often poorly targeted, provide only short-term relief, and fail to address systemic issues like poor housing stock or inefficient heating systems. Energy efficiency programs are minimal and rarely reach the most vulnerable. Although the Energy Community Treaty

requires alignment with EU energy policy, implementation remains slow and uneven. A major obstacle is the lack of disaggregated data on energy poverty, which limits the development of effective, evidence-based policies. As a result, energy-poor households in the Western Balkans remain significantly less supported than their EU counterparts.

EU member states have been steadily building legal and institutional frameworks to promote energy democracy and citizen participation in energy. The EU's *Clean Energy Package* (2019) formally introduced citizen energy communities and renewable energy communities through the internal energy market and renewable energy directives. This legal recognition has spurred national policies that empower local cooperatives through favorable financing, land use and grid-access rules. Consequently, in many EU countries, small consumers are major investors (e.g., Germany or Italy). Member states are also enhancing governance capacity: several are training municipalities and regulators in participatory energy planning and monitoring. In the Western Balkans, by contrast, institutional support for citizen energy is still developing. Local authorities are only beginning to learn how to engage citizens in energy matters, and administrative hurdles remain high.

Energy communities, locally owned cooperatives or co-produced projects, can play a vital role in improving affordability, decentralisation and democratic control of energy. By involving citizens directly, energy communities lower bills, spread clean energy awareness, and make transitions more acceptable. These projects also embody decentralised governance: EU directives even require energy communities to yield social community benefits, rather than profit, reinforcing local accountability.

In the Western Balkans, few energy communities currently exist, but some initiatives are emerging. Their experience shows the importance of a supportive environment, local governments need to recognise that citizens are their best asset in the energy transition. If Balkan countries can put in place enabling policies, such as legal recognition of cooperatives, access to finance, and streamlined grid connection rules, these communities could expand rapidly. By formally recognising and supporting community energy models, Western Balkan countries could utilise local initiatives to reduce energy costs, diversify generation and deepen democratic participation in energy.

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