Measurement and mapping of **energy poverty** in Europe

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E3Modelling Energy Economy Environment

A little bit about me

2004 – 2010 → I studied Mechanical Engineering in Greece

2010 – 2013 → MSc in Sustainable Energy Technologies in TU Delft, the Netherlands

2013 – 2018 → PhD in Architecture, TU Delft, the Netherlands

"Energy performance progress of the Dutch non-profit housing stock: a longitudinal assessment."

2018 – 2021 → Scientific Project Officer at the Joint Research Centre of the European Commission

- Energy efficiency in Buildings
- Power and heat sector coupling
- Energy poverty

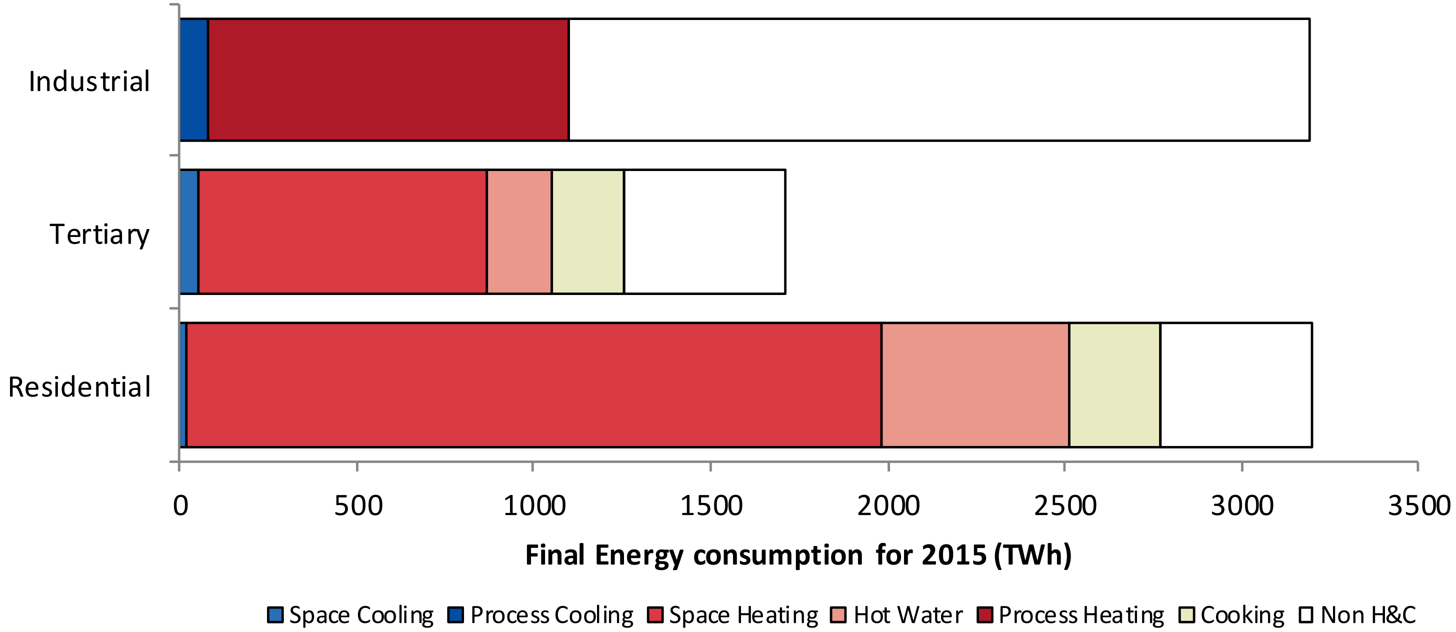
2021 – today → Energy efficiency researcher at E3 Modelling

EU buildings decarbonisation

Heating & Cooling sector – EU27

- It represents **half of the energy consumption** in the EU. And it is supplied 75% by fossil fuels

- **Buildings**, including residential and services sectors, currently **account for 40%** of the total final EU energy **consumption**



Kavvadias, K., Jiménez-Navarro, J. P., & Thomassen, G. (2019). *Decarbonising the EU Heating Sector: Integration of the Power and Heating Sector*. Publications Office of the European Union.

Energy poverty

In a global North context, energy poverty has roots in the British term “**fuel poverty**,” established by Brenda Boardman (1991).

Energy poverty is a situation in which households are unable to access essential energy services and products. (European Commission)

In 2010, World Economic Forum defined energy poverty as the lack of access to sustainable modern energy services and products.

Energy poverty, commonly understood to describe a situation where individuals are **not able to adequately heat their homes at affordable cost**, is an increasingly recognized problem across EU Member States.

Energy poverty

It is a complex phenomenon that combines three major pillars:

- society and social policies
- energy and energy policies
- economy and economic policies

Not studying it in this context impedes us from understanding it.

Energy poverty

Energy poverty occurs when energy bills represent a high percentage of consumers' income,

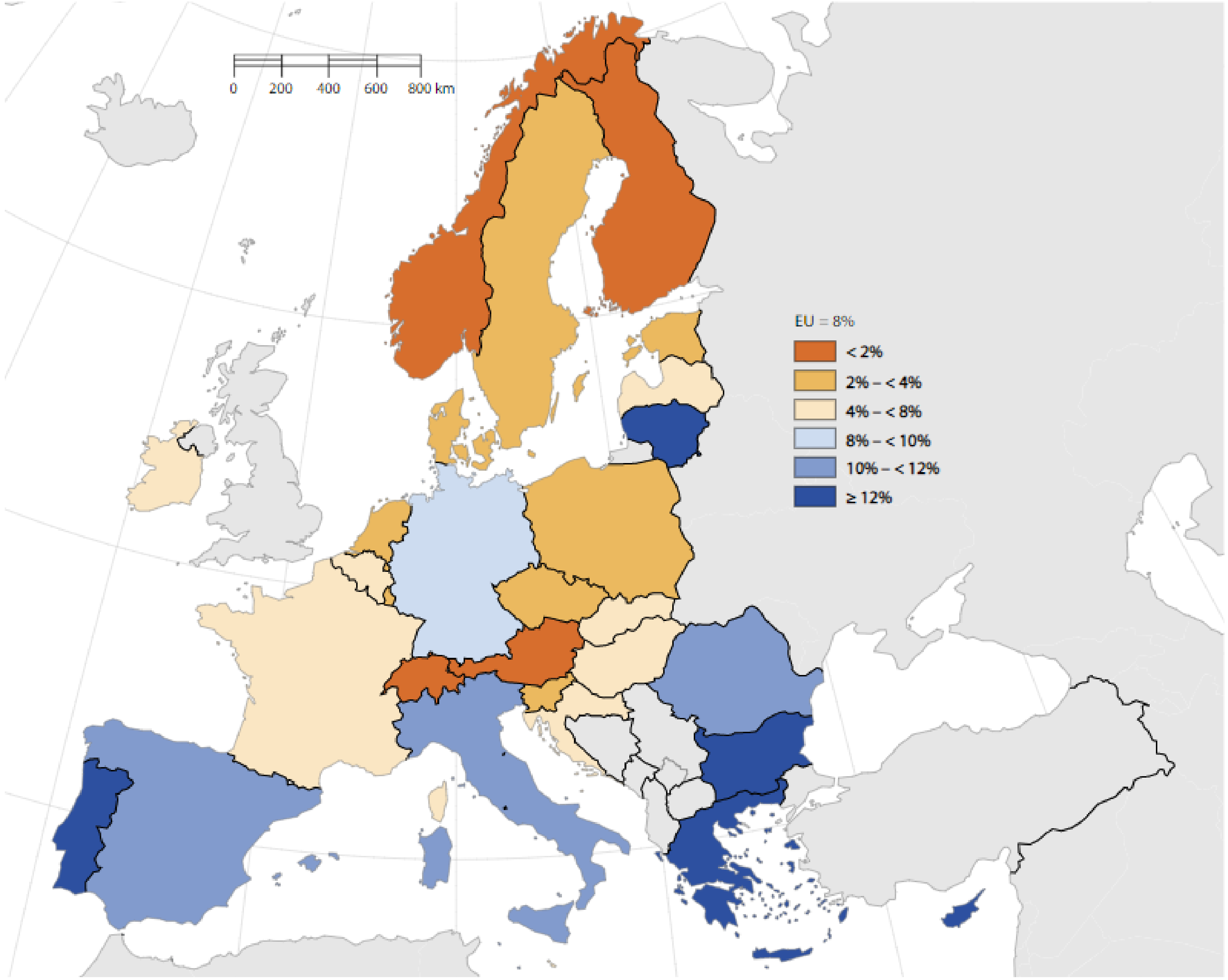
or when they must reduce their household's energy consumption to a degree that negatively impacts their health and well-being.

Due to its private nature, as it mainly affects households, and its complexity, energy poverty remains a major challenge to be further addressed in the EU.

According to Eurostat's figures, about 35 million EU citizens (approximately 8% of the EU population) were unable to keep their homes adequately warm in 2020.

Energy poverty

Inability to keep home adequately warm, 2020
(% of the population)



Czechia, France, Netherlands, Poland, Slovakia: provisional data
Ireland, Italy, Latvia: 2019 data
As a result, the EU value has been estimated.

Administrative boundaries: © EuroGeographics © UN–FAO © Turkstat
Cartography: Eurostat – IMAGE, 10/2021

ec.europa.eu/eurostat

Energy poverty

The situation varied across the EU Member States with the largest share of people saying that they were unable to keep their home adequately warm in Bulgaria (27%), followed by Lithuania (23%), Cyprus (21%), and Portugal and Greece (both with 17%).

On top of that, the surge in energy prices that started in 2021 and worsened with Russia's invasion of Ukraine, along with the impact of the COVID-19 crisis, are likely to have worsened an already difficult situation for many EU citizens.

Where does the EU stand with policies addressing energy poverty?

EU Policy context

2016-18: Clean Energy for All Europeans package for 2030
- GHG -40%
- RES 32%
- EE 32.5%

2018-19: Clean Planet For All Strategy
- Climate neutrality in the EU by 2050
- –> Zero net CO2 emissions
- Various pathways

National Energy and Climate Plans (NECPs) end 2019
- Compatible with the RES target
- Short in Energy Efficiency ambition

Current trends
- Coal phase-out, large RES projects
- E-mobility emerging
- Green gas and Hydrogen projects launched

Last months
- Climate Target Plan ~ **55%** GHG emission reduction in 2030
- 2021 review of Clean Energy for All Package targets **upwards**

REPowerEU Plan

Energy poverty in the EU Policy packages

Energy poverty remains a major challenge to be further addressed in the EU.

In the effort to tackle it, protect vulnerable consumers, and thus create a just energy transition to climate neutrality, policy efforts have increased, and energy poverty is a key topic in the **“Clean energy for all Europeans”** package (European Commission, 2019).

It is obligatory for Member States to include measures to tackle energy poverty in the **NECPs** (National Energy and Climate Plans).

Energy Poverty is present explicitly in the **EED** (Energy Efficiency Directive) of the European Commission along with several policy briefs and strategies.

Energy poverty in the EU Policy packages

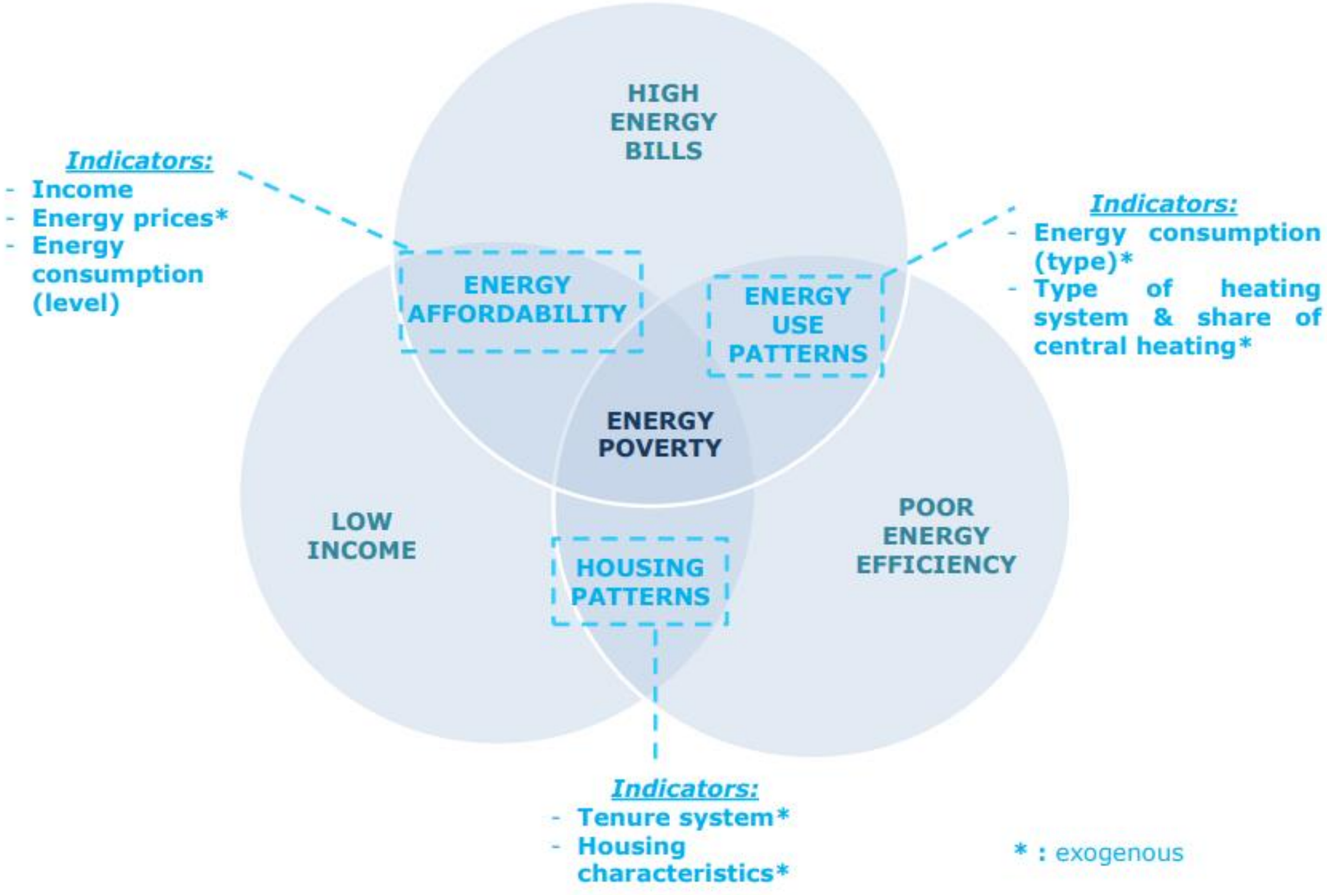
The Fit for 55 package, adopted in July 2021,

proposed specific measures to identify key drivers of energy-poverty risks for consumers,

such as **too high energy prices**, **low household income** and **poor energy-efficient buildings** and appliances, taking into account structural solutions to vulnerabilities and underlying inequalities.

But how can we and how do we measure energy poverty?

Energy poverty indicators



Measuring energy poverty

There are three prevailing measurement methods to identify energy poverty, including

(i) **expenditure-based indicators** that estimate the magnitude of energy poverty on a household by considering the household's energy costs and income and comparing them to a selected threshold;

(ii) **consensual-based indicators**, based on which inhabitants assess their household's living conditions, regarding thermal comfort and other conditions (humidity, insulation, etc.), and their ability to afford expenditures required to secure healthy living conditions; and

(iii) **direct measurement**, which sets a standard for an offered energy service (heating/cooling) and assesses energy poverty against this standard

(Siksnelyte-Butkiene et al., 2021).

Measuring energy poverty

(i) **expenditure-based indicators** that estimate the magnitude of energy poverty on a household by considering the household's energy costs and income and comparing them to a selected threshold;

The first method used to measure energy poverty was the **ten-percent rule** proposed by Boardman in 1991. The ten-percent rule identifies as energy poor those households that spend on energy expenses more than 10% of their net income.

The rule has been contested about its success to identify the phenomenon when other factors (e.g., energy efficiency, social factors, etc.) are considered.

Measuring energy poverty

Another approach on measuring energy poverty is that of **Equivalisation of Modelled Energy Costs**, proposed by Antepara et al. (2020) to face the problem of unreliable energy consumption data or behavioural practices due to socioeconomic factors that may modify domestic energy use patterns.

To integrate more aspects, several **multidimensional energy poverty indices** have been established in the literature (e.g., Nussbaumer et al., 2012; Bersisa, 2019; Ntaintasis et al., 2019; Crentsil et al., 2019).

To measure energy poverty at the European level, the **EU Energy Poverty Advisory Hub** (EPAH) has proposed several different indicators, four primary and nineteen secondary.

Measuring energy poverty - Energy Poverty Advisory Hub

The primary indicators comprise the shares of the (sub-) **population that delay paying utility bills and that cannot keep their home sufficiently warm,** calculated on the basis of answers to closed-ended questions (EUSilc);

as well as **household income and energy expenditure** (with data from Household Budget Surveys- HBS)—e.g., energy expenses being more than twice the national average household income.

Measuring energy poverty - Energy Poverty Advisory Hub

The secondary indicators include **average prices** paid by a household per kWh from district heating or generated from specific components such as fuel oil, biomass, and coal;

electricity and gas prices for different types of consumers;

energy consumption expenditure on electricity, gas, and other fuels **as a share of income** for 5 income quintiles;

accommodation-related indicators such as average number of rooms per person in owned, rented, and all dwellings;

location (densely populated or intermediate residential area);

dwelling condition (leakage, dampness, or rot);

and people at **risk of poverty or social exclusion or death** in winter.

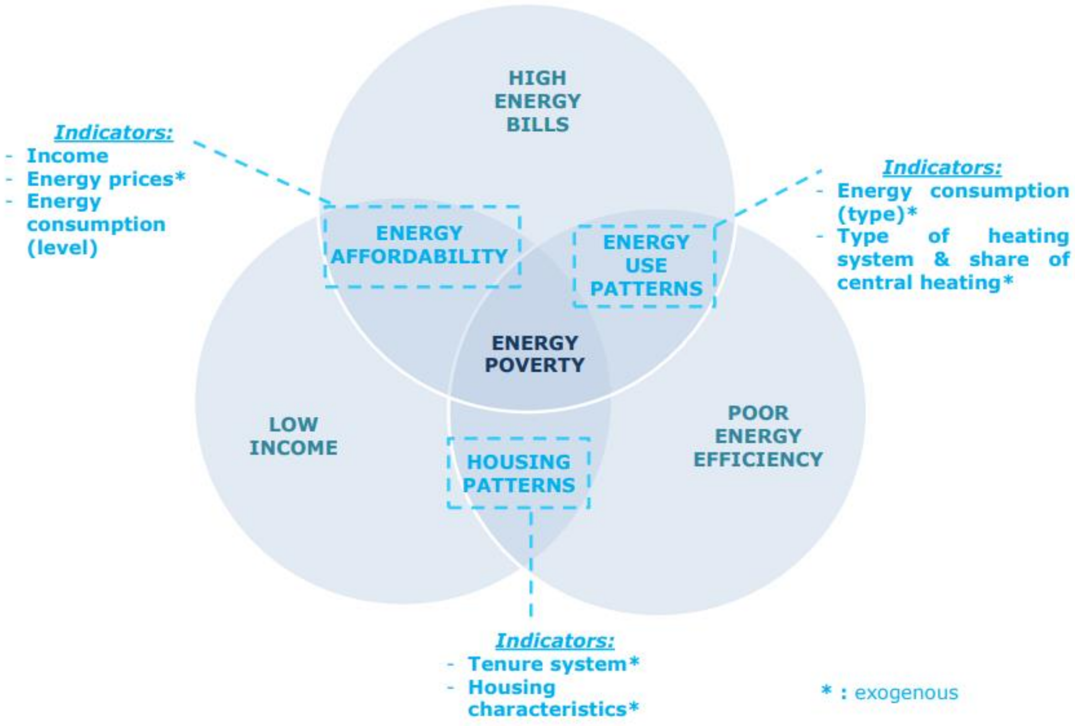
Measuring energy poverty – Covenant of Mayors

The 2030 framework of the Covenant of Mayors also commits to contributing to energy poverty alleviation , based on **six classes of indicators**:

- climate,
- facilities/housing,
- mobility,
- socio-economic aspects,
- policy and regulatory framework and
- participation / awareness raising.

Measuring energy poverty

To conclude, energy poverty is a complex phenomenon touching upon several societal issues. Measuring it is a challenge.



Questions so far?

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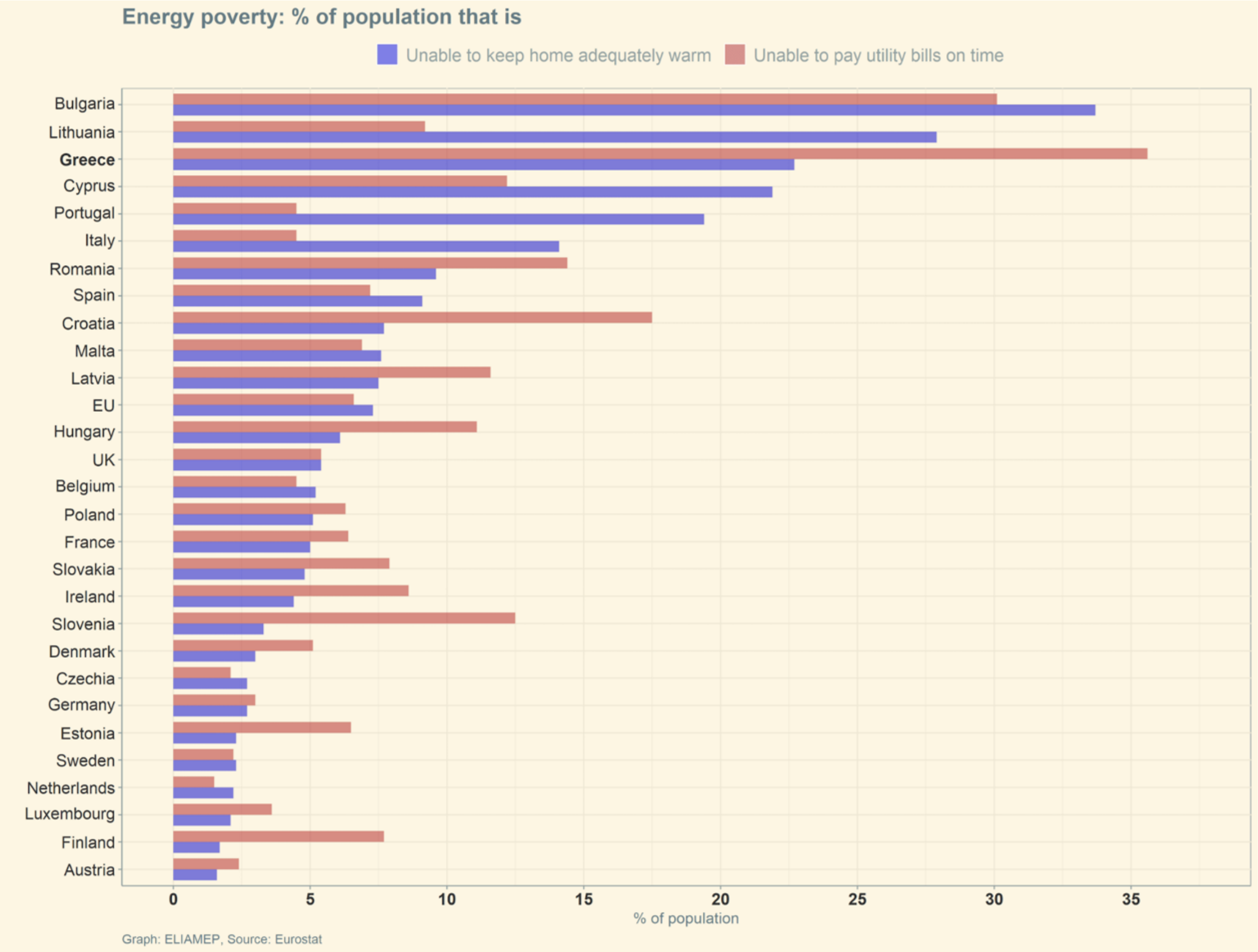
The case study of Greece

The Greek energy policy framework comprises laws and regulations that are largely harmonised with most of the relevant EC directives and policy measures aiming at protecting **vulnerable consumers and especially low-income households.**



The case study of Greece

Among the several methodological approaches for identifying energy-poor households, the Hellenic Ministry of Environment and Energy has selected the 4 EPAH indicators to make an initial assessment of the situation in the country (NEPAP, 2021).

The Centre of Renewable Energy Sources and Saving (CRES), in charge of the National Observatory of Energy Poverty, has proposed an additional indicator, namely the coverage of basic energy needs per household, calculated as the **ratio of actual recorded energy consumption to theoretically required energy consumption for specific uses.**

The case study of Greece

Actions are promoted towards three axes:

- consumer protection (financial support to households affected by extreme conditions of energy poverty, and protection through regulatory measures),
- energy efficiency and RES diffusion (financing measures with long-term impact, such as improvement of deep building renovations, energy efficiency improvements, and increased use of Renewable Energy Sources), and
- informative and training actions for affected consumers and professionals of energy saving actions.

Implications of the European Green Deal on energy poverty and equity

In our recent paper “Energy poverty & just transformation in Greece”* we wanted to

analyse the accruing impacts if the EU implements the Fit-for-55 target of reducing its greenhouse gas (GHG) emissions by at least 55% in 2030, compared to 1990 levels, and then achieves the goal of climate neutrality by 2050.

This study focusses on Greece and combines a qualitative analysis of the EU and Greek policy context and strategic framework for energy poverty as well as related poverty alleviation measures with a state-of-the-art model-based assessment of the equity and distributional impacts of the net-zero transition in the country.

*Dr. Panagiotis Fragkos, Eleni Kanellou, George Konstantopoulos, Dr. Alexandros Nikas, Dr. Kostas Fragkiadakis, Dr. Faidra Filipidou, Dr. Theofano Fotiou, Prof. Haris Doukas

Implications of the European Green Deal on energy poverty and equity

In simpler words:

How can we model how energy poverty will evolve in Greece?

What are the impacts of the energy transition on energy poor households?

Which are those policy measures that can be implemented in order to ensure a just energy transition for all?

Implications of the European Green Deal on energy poverty and equity

The decarbonisation of the energy system is not expected to impact uniformly all sectors of the economy, with large reductions expected in carbon-intensive activities, such as mining/extraction, refineries, and fossil-based power generation.

These changes in the structure of energy-economic systems will be accompanied by changes in fuel and electricity prices as well as changes in financing requirements:

the purchase and operation of energy and electrical equipment/appliances will change with increasing capital expenditures (CAPEX) and lower operating and fuel purchase expenditures (OPEX).

Implications of the European Green Deal on energy poverty and equity

The analysis in this section is based on the state-of-the-art GEM-E3-FIT model, a computable general equilibrium (CGE) model for assessing the implications of energy and climate policies.

Typically, general equilibrium models feature a single representative household in each national economy that averages incomes and consumption patterns.

However useful when large-scale modelling is required, **this aggregation may mask critical insights regarding social and distributional implications** of climate policies among diverse households;

Implications of the European Green Deal on energy poverty and equity

Distributional impacts refer to how costs and benefits of a policy or sets of policies are distributed among different regions, sectors, and households. Ignoring such distributional effects in climate policy-making may result in regressive distributional impacts and increased societal inequalities due to the lack of measures to mitigate negative impacts on vulnerable population groups.

For this reason, **GEM-E3-FIT is further expanded to represent ten household income classes in EU Member States**, to consistently capture the potential distributional impacts of ambitious energy and climate policies for Greece until 2050 (a detailed description of the model expansion can be found in Fragkos et al 2021).

Measuring income inequality and its relation to energy poverty

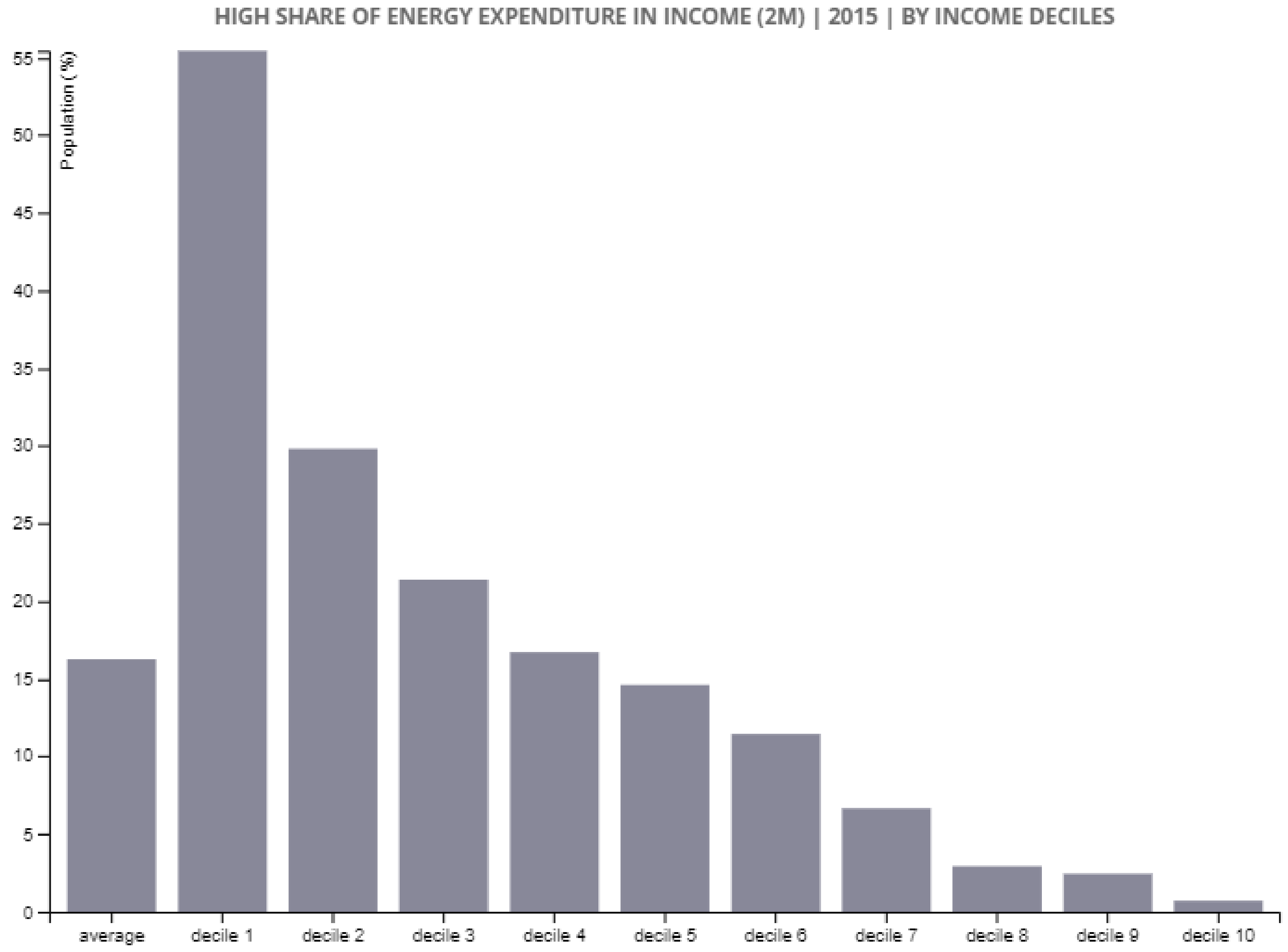
Indicator	Description/ relevance for inequality
Mean and median income by household	The mean income is the amount obtained by dividing the total aggregate income of a group by the number of units. The median is the income level that divides the population into two groups of equal size. The use of the median corrects potential distortion that may be caused by the existence of extreme values.
Decile dispersion ratio	This measure presents the ratio of the average income of e.g., the richest 10% of the population divided by the average income of the poorest 10% (Haughton, and Khandker, 2009). The indicator is vulnerable to extreme values and outliers.
S80/S20 income quintile share ratio or 20:20 ratio	Comparing the income received by the top 20% of the population with the bottom 20% of the population.
Gini coefficient	The Gini coefficient is based on the Lorenz curve, a cumulative frequency curve that compares the distribution of income with the uniform distribution that represents equality. It represents the extent to which the distribution of income differs between an equal distribution (Gini coefficient of 0) and perfect inequality (Gini coefficient of 1).
Atkinson index	This index is based on the Gini index and includes a sensitivity parameter, which can range from 0 (meaning indifference about the nature of the income distribution), to infinity (where the focus is on the lowest income group) (De Maio, 2007).
At risk poverty rate	The share of people with an equivalised disposable income below the at-risk-of-poverty threshold, which is set at 60% of the national median equivalised disposable income (Eurostat, 2019).
Severely and materially deprived	It reflects the inability of a household to afford some goods and services considered to be necessary for an adequate life (Eurostat, 2019). The indicator measures the share of population that cannot afford three (material deprivation) or four (severe material deprivation) of the nine items listed in a reference year.

Inequality and energy poverty indicators

Our study focuses on **expenditure-based indicators** to assess energy poverty dynamics that can be quantified using GEM-E3-FIT model outcomes on **energy expenditure and income per decile**, in particular the share of energy expenditure in income (2M).

This indicator measures the percentage of households, whose share of energy expenditure relative to their disposable income is more than twice the national median share.

Share of energy expenditure in income by income decile in Greece



Modelling income inequality and energy poverty with GEM-E3-FIT

GEM-E3-FIT is multiregional, multi-sectoral, recursive-dynamic, providing details on the macro-economy and its complex interactions with the environment and the energy system.

The model has been recently enhanced with a representation of ten income classes aiming to assess the distributional implications of climate policies. It simultaneously represents 46 regions (including the EU countries individually) and 53 activities linked through bilateral trade flows and runs until 2050 (E3Modelling, 2017).

It covers the interlinkages between productive sectors, consumption, labour and capital, bilateral trade, investment dynamics, and price formation of commodities.

GEM-E3-FIT formulates the supply and demand behaviour of economic agents that are assumed to exhibit optimising behaviour while market derived prices are adjusted to clear markets.

It allows for a consistent comparative analysis of policy scenarios as it ensures that the economic system remains in general equilibrium.

Scenario design

	Scenario Description	EU Climate target	Non-EU climate targets
REF	Reference scenario	Meets the EU NDC in 2030, no additional efforts after 2030	Meet their NDCs in 2030, policy ambition does not increase beyond 2030
DECARB	EU meets EGD Targets by 2030 & 2050, Global decarbonisation to 2^{o}C	EU achieves 55/97% emissions reduction in 2030/ 2050 relative to 1990	Countries adopt ambitious universal carbon pricing to meet the 2^{o}C target

Assumptions and carbon pricing

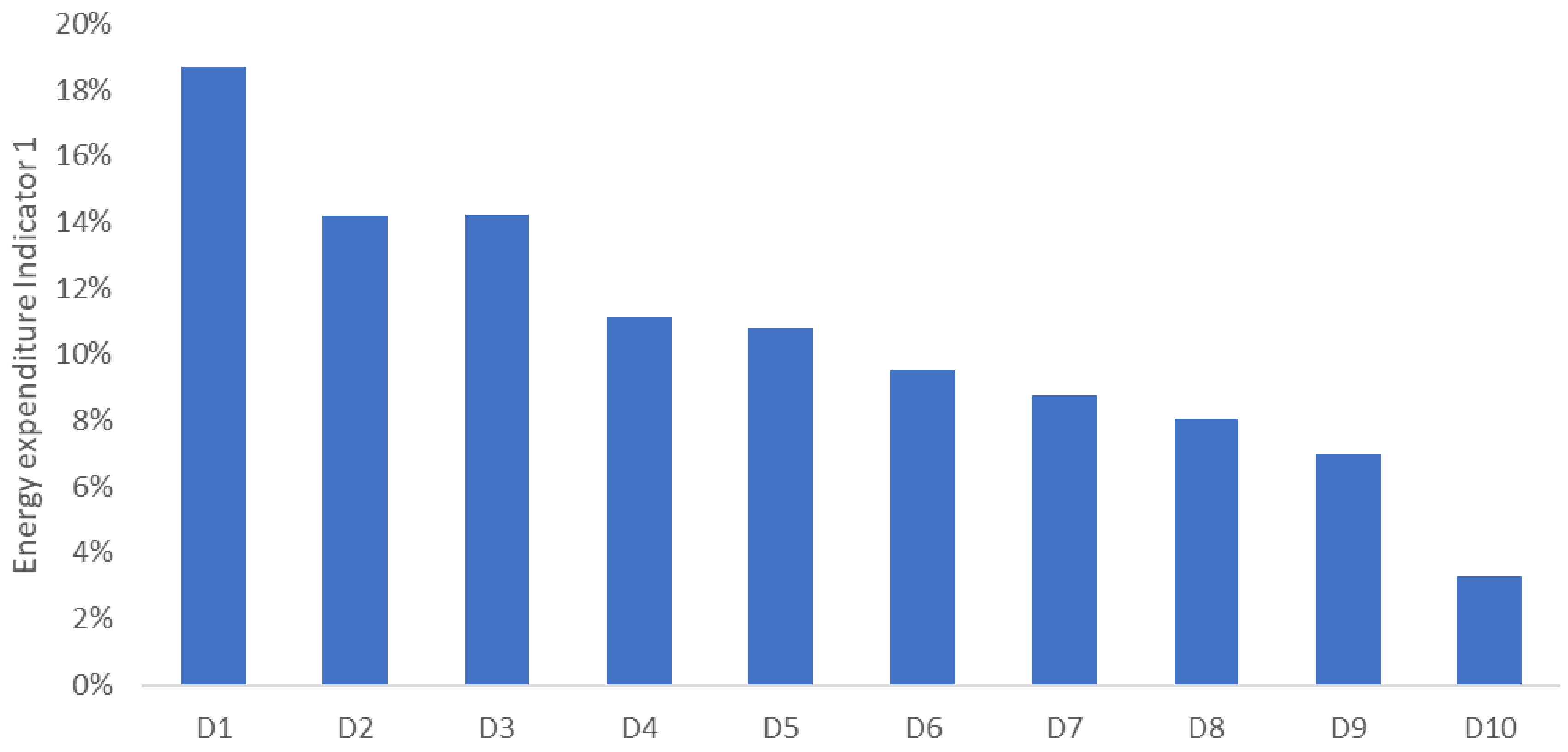
The EU ETS is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively. It is the world's first major carbon market and remains the biggest one.

ETS carbon revenues are recycled through the public budget.

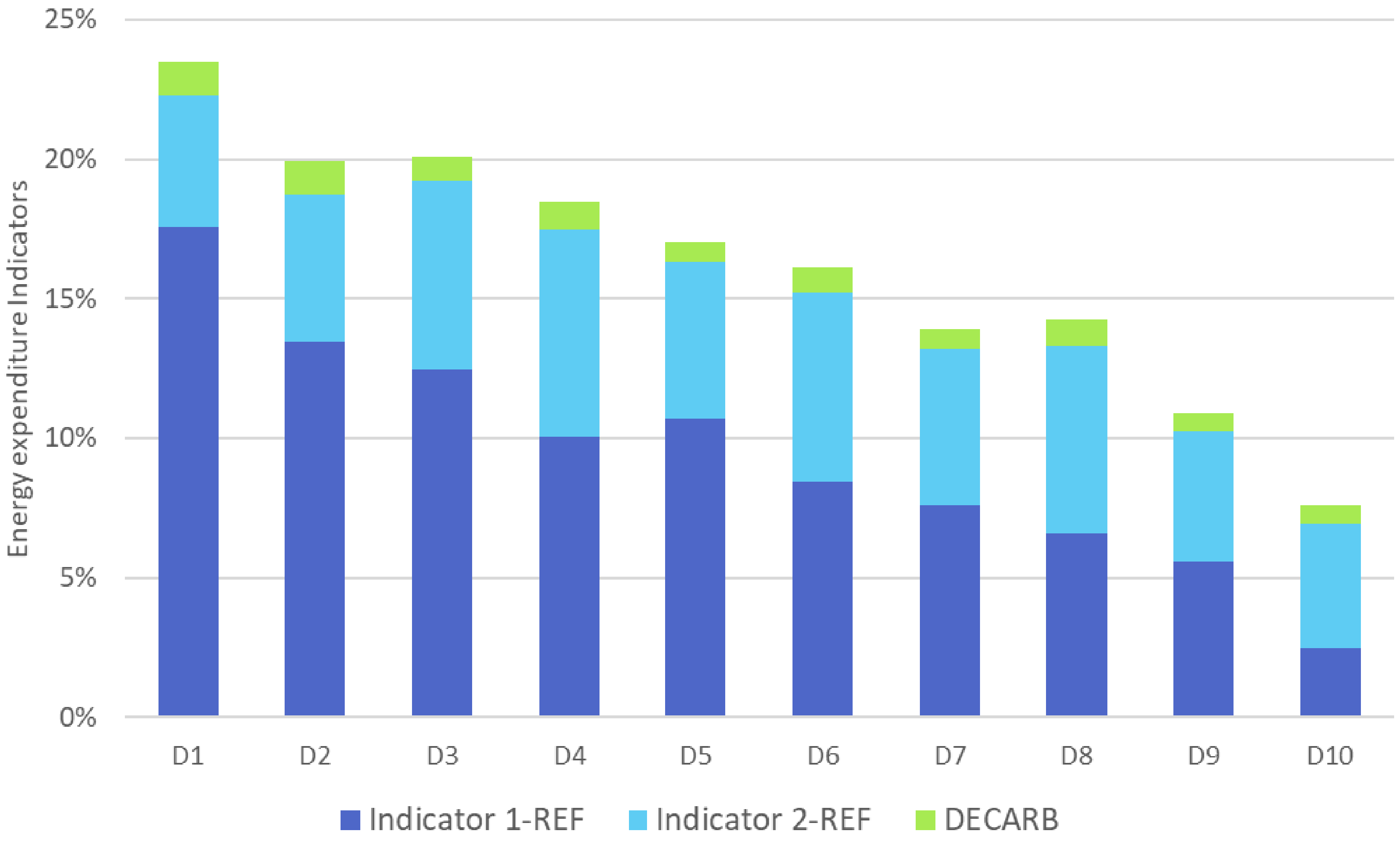
DECARB Scenario:

the policy mix adopted to drive the EU energy system decarbonisation includes various instruments—e.g., strengthened EU ETS, subsidies insulation in buildings, accelerated expansion of renewable energy, ambitious technology standards, increased electrification of energy services, and uptake of innovative mitigation options (e.g., carbon capture storage, hydrogen, etc.).

Energy expenditure Indicator 1 by income decile in Greece in 2020.



Energy expenditure Indicators in Greece for each income decile in 2050 in DECARB scenario.



Concluding remarks

Decarbonisation efforts can result in large-scale economic restructuring with potential regressive distributional impacts, **disproportionately affecting disadvantaged population groups.**

The imposition of additional carbon taxes on energy products and the need to purchase energy efficient albeit more expensive equipment **may negatively affect low-income households that face funding scarcity while increasing the threat of energy poverty**.

Environmental policies are commonly associated, in literature, with regressive distributional impacts that negatively affect low-income households. Ignoring such distributional effects can result in less effective policies and increased social inequalities.

Well-designed strategies and policies are required to achieve progressive outcomes by considering appropriate compensation schemes, either by increasing household income through lump-sum payments, reducing other taxes, or through the social security system.

Concluding remarks

Overall, the model-based analysis shows that decarbonisation increases modestly existing inequality across income classes, with **low-income households facing more negative effects than higher-income ones**.

However, using **carbon revenues as lump-sum transfers to households** and requiring reduced social security contributions has clear benefits. These include increasing total employment while significantly reducing the inequality across income classes.

Thank you for listening!

Questions?

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