# The multifaced challenge to tackle energy poverty: outlook scenarios for EU countries

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**Abstact.** COVID-19 pandemic has exacerbated household energy poverty in many countries. During the latter half of 2021, as the situation gradually improved, a new threat emerged in the form of an inflationary surge in energy prices, exacerbated by the ongoing Russian-Ukrainian conflict. In this paper, we attempt to provide pragmatic projections of energy poverty in European countries over the next five years. Furthermore, the study will investigate whether nations that actively support the transition to green energy are better positioned to mitigate the adverse effects of these events on the energy poverty situation. The findings indicate that several factors contribute to energy poverty in European countries, and the short-term outlook does not look good. There is, however, a glimmer of hope for countries that prioritize and expedite their transition to green energy. A shift to renewable energy sources may contribute to a more resilient and stable energy landscape by protecting countries from the volatile nature of traditional energy markets and geopolitical conflicts. The policymakers are urged to consider sustainable energy transition not only as a means of combating climate change, but also as an essential component of economic recovery and social well-being, particularly in the context of unpredictable global events.

**Keywords:** energy poverty; energy transition; dynamic factors analysis.

## 1. Introduction

The increasing incidence of energy poverty (EP) in European households is due to the effects of the COVID-19 crisis (e.g., [1]). In addition to the pandemic health crisis, the war between Russia and Ukraine has led to higher prices for energy products, exacerbating EP. The purchasing power of households, especially those most vulnerable, has been eroded by the inflation spiral triggered by the end of the acute pandemic phase and the beginning of the war between Russia and Ukraine. Recently, Carfora et al. [2] showed that the pandemic increased the share of households with heating difficulties and that the first positive effects of returning to pre-pandemic levels will not be seen until 2024. However, the proposed forecasting framework did not consider the rise in energy prices, which has impacted European households significantly. This impact is partly due to the heavy energy dependence of EU countries on foreign sources. The rise in energy prices has increased energy bills and strained households' budgets. When developing forecasting frameworks, it is essential to include the impact of energy prices to reflect the households' economic and financial conditions accurately. With the aim to better address the above-mentioned issues the European Commission (EC) decided to accelerate the transition from a predominantly fossil-based energy generation system to one more reliant on renewable sources to reduce dependence. For this reason, this paper aims to provide a valuable tool to support challenging policy decisions and identify how to reach the medium-term goals to alleviate EP. With this in mind, the paper addresses two research questions. Firstly, it aims to investigate whether countries supporting a path towards a fully green energy transition better manage price fluctuations and the adverse effects of ongoing social, political, and economic crises on energy poverty. Secondly, by providing energy poverty predictions for European countries over the next five years, it aims to investigate whether, and when European countries will be able to emerge from the deepening energy poverty that occurred as a consequence of the pandemic effects and rapid rise in energy prices.

## 2. Empirical strategy

The analysis of a complex issue requires the use of quantitative methods, taking into account the complex relationships among the variables. Dynamic factor analysis (DFA) is a statistical dimension-reduction technique for time-series data that meets this need. With this method, starting from a large number of $k$ variables, it can get an outcome of a relatively small number of $m$ common dynamic factors. The number of estimated dynamic factors is equal to the original number of variables, but they are uncorrelated and a few factors explain most of the overall variability. In this work 15 time series have been selected to create a balanced panel dataset of 26 countries during the 2007-2020 time span. The variables were then grouped into three (k=3) homogeneous thematic areas: i) economic and social conditions, ii) environmental degradation, and iii) housing conditions. From each thematic area a dynamic factor has been drawn. The three dynamic factors were then put into relation with an Eurostat energy poverty indicator: the % of the population reporting that they cannot keep their homes adequately warm (*enp*) and three exogenous variables, in a panel model with this structure:

$$enp_{it} = \alpha_i + \sum_{k=1}^{3} \beta_k x_{it-1}^{k} + \boldsymbol{\gamma r}_{it} + u_{it}. \qquad [1]$$

where $t = 1, \ldots, T$ is the time span (2007-2020), $\alpha_i$ is the individual (country), time-invariant, fixed effect, $\boldsymbol{r}$ is the matrix containing the exogenous regressors while $u_{it}$ is the disturbance with mean equal to 0**.** Among the exogenous regressors, to take the impact of the business cycle, the gross domestic product index, provided by Eurostat, for the sample countries is used in the model. The electricity price for households (the average national price in Euro per kWh including taxes and levies for medium size household consumers) is inserted to assess the impact of the price on EP. Finally, to proxy the transition to green generation, a specific ET indicator was developed as the difference between the share of energy fed into the national energy grid generated from non-renewable sources and the share generated from renewable sources.

This fixed-effects panel specification is able to seize the relationship between energy transition and EP within EU Member States by providing useful indications on how the energy transition counteracts energy poverty and by providing forecasts of EP trends up to the 2027 upon three different scenarios:

i) Conservative Scenario: In this scenario, it is assumed that renewable energy sources will not significantly replace fossil fuels in terms of generation capacity within the next five years.

ii) Intermediate Scenario: Under this scenario, there is projected to be a gradual, linear replacement of generation capacity from fossil power plants with renewable sources over the next five years.

iii) Exponential Scenario: This scenario is akin to the intermediate one but posits a more rapid, exponential substitution of generation capacity from fossil power plants with renewable energy sources within the same five-year timeframe.

Under the scenarios developed, the expected value of EP for a generic year *t+h.* with *h=1…., n* is conditioned on the set of information, *E(X),* and exogenous regressors (r) that is available at time *t*:

$$E(Y_{t+h}) = \boldsymbol{\beta}' E(\boldsymbol{X}) + \boldsymbol{\gamma}' E(\boldsymbol{r}) + E(u_t)$$

The forecasted 2021-2027 levels of the three dynamic factors $E(X)$ are obtained based on the autoregressive path, which by construction leads to the dynamic factors:

$$E(X_{2021}) = c + \varphi X_{2020}$$
$$\vdots$$
$$E(X_{2027}) = c + \varphi E(X_{2026}).$$

Concerning the other regressors, the levels of GDP, expected by the International Monetary Fund World Economic Outlook (release October 2023) and the expected electricity prices on the basis of the World Bank Commodity Price Forecasts (release October 2023), have been inserted. In each of the three scenarios described above, the energy transition indicator estimated on the basis of their assumptions was included.

## 3. Results and policy implications

The estimated coefficients (Table 1) are all significant and in line with the expected signs, confirming that the proposed multidimensional latent factors and all the other exogenous regressors affect EP.

**Table 1** model coefficients

| Description | Coefficient | std Error | p-value |
|---|---|---|---|
| Economic and social conditions dynamic factor | 0.211 | 0.106 | 0.047 |
| Environmental degradation dynamic factor | -0.638 | 0.127 | 0.000 |
| Housing conditions dynamic factor | 0.278 | 0.104 | 0.008 |
| Gross Domestic Product index | -0.136 | 0.023 | 0.000 |
| Households' electricity prices | 29.239 | 10.041 | 0.004 |
| Energy transition | 0.247 | 0.049 | 0.000 |

The three scenarios showed that the energy transition makes it possible to reduce the share of households reporting themselves in a condition of EP, even if it occurs with different effects depending on the assumed pathway.

Focusing on the conservative scenario (see Fig.1), the incidence of energy poverty will decrease not due to the effect of the transition but because of the dynamics of economic growth and energy prices, as projected by the World Bank and the IMF, respectively. Countries traditionally with strong economies (such as France and Germany) or those with already low levels of energy poverty (Sweden and Finland) will experience a significant decrease in the percentage of households reporting difficulties in heating their homes. On the other hand, the most economically depressed countries or those characterized by high levels of energy poverty will not experience significant benefits.

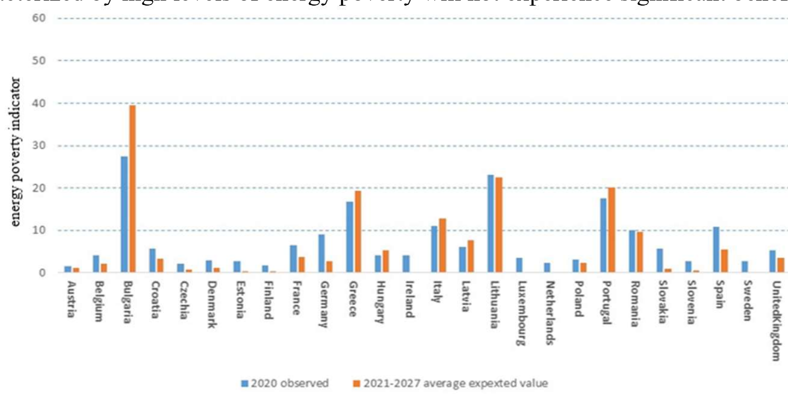


**Fig. 1.** Scenario 1. 2020 observed EP indicators vs average forecasted values.

The effects of the transition will be more pronounced in the other two scenarios (see. Fig. 2 and 3), where, while maintaining the characteristics of the first scenario, a substantial reduction in the incidence of energy poverty will be observed. In general, it is observed that the coming years should see an average reduction in the incidence of energy poverty in European countries, although there are clear signs that it will still lead to an increase in some nations. The energy transition, including the reduction in electricity costs (e.g., [3, 4]), will bring the expected benefits to families in need, which an anticipated phase of economic expansion will amplify. As a consequence of the mentioned conditions, international, European, and national authorities should recognize that country-specific interventions are needed to prevent further increases in inequality as EP increases. It is acknowledged that actions to tackle EP may vary depending on the context and peculiarities of each country. As demonstrated, decisive action toward energy transition is certainly helpful in reducing the impact of EP. Clearly, a linear increase is not enough, but substantial investment is needed that will lead to exponential growth in the amount of electricity produced from renewables that gradually replaces that portion generated from traditional sources. Moreover, investments in the energy transition will, over the years, lead to lower electricity rates (e.g., [5]).

In the meantime, it would be helpful to consolidate all the diverse electricity and gas benefits into a singular tool linked to each household's individualized risk of EP. This is a highly ambitious target, considering the variations in measurement criteria and the definition of EP across the European Union. Further efforts should be devoted to improving vulnerable households' living and housing conditions [6]. In a historical stage marked by high energy prices, policy authorities should envision (or strengthen if already in place) energy subsidy programs to help vulnerable households improve the condition of their homes by reducing energy consumption and improving efficiency. Investing in energy efficiency and building upgrading projects can reduce households' energy consumption and, consequently, their expenditures. Proposals for reducing energy consumption should consider that a large percentage of households in the EU live in houses with inadequate insulation. This situation may be exacerbated by climate change. Previous studies, such as the one conducted by Damigos et al. [7], have shown that low-income households tend to focus on short-term rather than long-term outcomes, making them prone to make limited decisions (the so-called "discounting gap"). The "Recovery Plan" might play a crucial role in this perspective. Following the 2020 EC recommendations, these funds are expected to be allocated to support households in lowering energy expenses, improving quality of life. Our findings emphasize that the faster the energy transition, the greater the action to counter energy poverty can be.

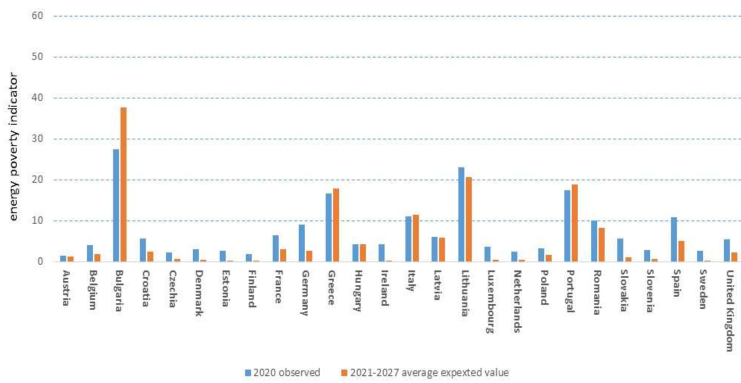


**Fig. 2**. Scenario 2. 2020 observed EP indicators vs average forecasted values.

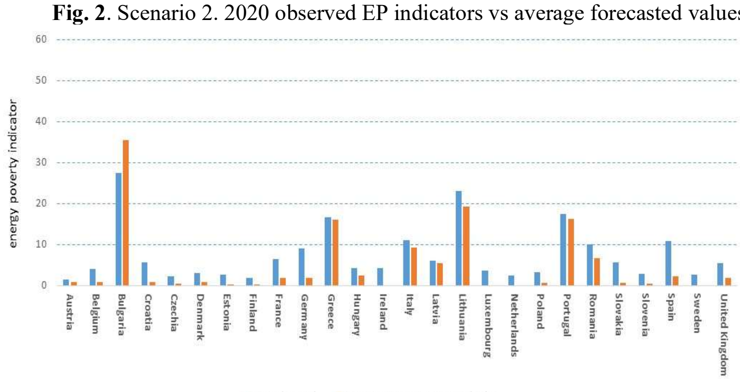


**Fig.3** Scenario 3. 2020 observed EP indicators vs average forecasted values.

Moreover, as further policy implication, encouraging the adoption of renewable energy can help reduce long-term energy costs and improve household energy resilience. Indeed, countries less affected by energy poverty are also the ones in which the share of energy generated from renewable sources fed into the grid predominates over that generated from fossil fuels. The acceleration of the energy crisis due to the recent war, which started after the pandemic period and the resulting severe economic consequences, shows a not encouraging outlook for countries. However, the current challenges can be turned into opportunities for renewable energy over the next few years. An example is offered by taking advantage of benefits from the digitization of work and other daily activities, as it could reduce traveling and the consumption of fossil energy sources [8]. A recommendation urges to promote the collaboration among stakeholders (policymakers, nongovernmental organizations, research institutions, energy suppliers, and others) can help develop integrated policies and customizing solutions to address energy poverty. The synergy can lead to greater effectiveness in identifying needs and implementing targeted interventions that take into account unique country's characteristics, such as different climatic and socioeconomic conditions.

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