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Energy poverty in Portugal, Italy, and Norway: awareness, short-term driving forces, and barriers in the built environment

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Energy poverty in Portugal, Italy, and Norway: awareness, short-term driving forces, and barriers in the built environment

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Abstract. Portugal, Italy, and Norway differ by energy performance of buildings and gross domestic product (GDP). Portugal has significantly highest thermal discomfort with harsher winters. In 2021, 80% of Portuguese buildings had a low energy rating, with 75% of buildings without thermal insulation, highly contributing to the energy poverty (EP) of the country. In Italy, despite a generally mild climate, the building stock has low thermal performance. The most affected areas are the suburban and peri-urban ones, with an EP rate in southern regions between 13% and 20% compared to 8.8% at national level. Moreover, 65% of buildings were constructed before the first law on energy saving criteria and a 25% of it has never undergone any work of maintenance or improvement. Norway, despite the limited studies performs well respect to other European Economic Area and European Union countries, in investing and using indicators to enhance and monitor the green energies' use. Because of energy price growth, seasonal price fluctuations, and different energy tariffs, energy inequality is increasing. EP risk is underestimated, masked by Norway's high GDP and regional price disparity. Energy inequality is increasing due to energy price growth, seasonal price fluctuations, and energy prices' geographical inequality. The barriers in reducing EP are the underestimation of risk masked by the high GDP, and the need of homogenized prices in Norway. This study provides an overview to discuss EP awareness and it assesses the drivers and barriers that influence building's energy efficiency renovation.

1. Energy poverty awareness

The environmental and economic challenges in the existing European built environment are increasing day by day since the financial and economic crisis in 2008 (Fig. 1). Under these circumstances, approximately 8% of European consumers do not have access to essential energy products and services

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also due to global inflation, thus living in energy poverty (EP). The EU Directorate-General for Energy (DG Ener or ENER) defines EP as “a situation in which households are unable to access essential energy services and products and arises when energy costs take up a large portion of a consumer's income or when they are forced to cut back on energy use to the point where it severely affects their health and well-being” [1]. After the COVID-19 pandemic, indoor air quality and comfort level at the dwellings received more attention, mainly driven by health and well-being needs [2]. On the other hand, the pandemic and Eurozone crisis (Fig. 1) caused the stock market to crash, the global economy to slow, the energy market to decrease [3] through supply-demand imbalance and slow supply recovery. Finally, the war in Ukraine (2022) led to a surge in energy prices (e.g., gas prices to reach about ten times the average of the last decade) driven by curtails in Russia’s exportation fossil fuels [4]. To tackle the growing risk of EP, key strategies have to ensure access to clean and affordable energy for all and reconsider the role of buildings in the energy consumption in the light of sustainability. In EU, building stocks are responsible for about 40% of the EU’s total energy consumption [5]. Depending on each country, the risk of EP in the urban built environment needs to be assessed considering multifactorial driving forces. Countries should combine short-term measures (e.g., social tariffs, reform tax systems, energy prices, ban on disconnections) with long-term measures (e.g., energy retrofitting of dwellings and renewable energy sources installation programs) to tackle the structural causes of EP.

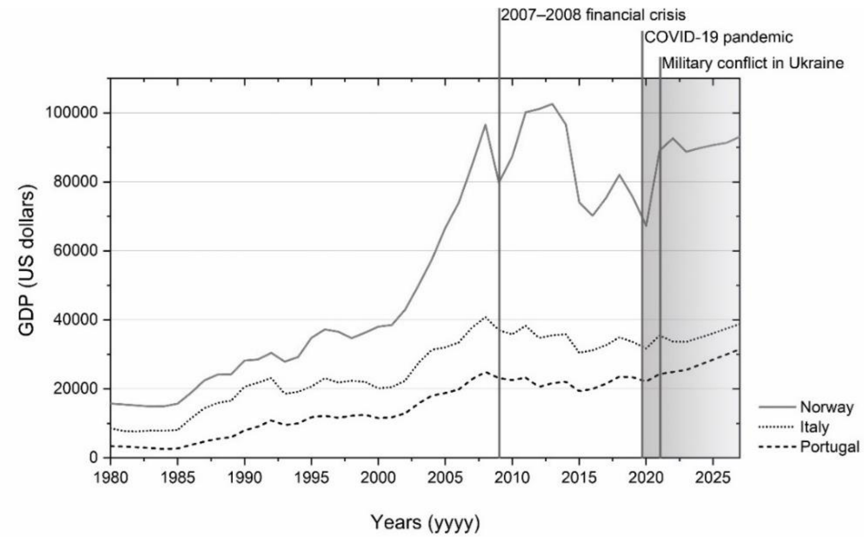

Figure 1. GDP per capita, current prices (U.S. dollars per capita) in Portugal, Italy, and Norway [6]. The three incidents highlighted with an emphasis to the pandemic since the impact is for long-term.

ODYSSEE-MURE (‘a decision support tool for energy efficiency policy evaluation’ project) scoreboard [7] measures the scores of the countries on different energy efficiency (EE) criteria (e.g., EE level, EE progress, and EE policies). Although Norway does not have data, the EE awareness seems higher in countries with high GDP, well-established social policies or a small population as Finland, Netherlands, and Estonia. Table 1 shows that thanks to the EU recovery fund policies after the pandemic, Italy and Portugal substantially improved their EE policies, becoming virtuous countries in the fight against EP through legislative and financial support. These measures have acted as a driving force for the EE trend, especially in Italy in the last two years of 2020-2021 [7].

This study focuses on three European countries, Portugal, Italy, and Norway, with different climates and GDPs. The aim of this contribution is to depict an overview of the awareness and short-term drivers of EP in Portugal, Italy, and Norway, as they are driven by differences in energy prices, and in implemented policies. In addition, we investigate on what is the north-south binary in EP which may bring even rich country as Norway to experience EP.

Table 1. 2020 and 2021 EP awareness in Portugal, Italy, and countries in Europe with highest score.

Ranking	2020	2021	2020	2021	2020	2021	2020	2021
	EE Level		EE trend		EE Policies		Combined Score	
Italy	0.60	0.63	0.04	0.63	0.07	0.89	0.24	0.70
Portugal	0.53	0.78	0.76	0.67	0.07	0.96	0.45	0.89
Norway	N.A.	N.A.	N.A.	N.A.	0.08	N.A.	N.A.	N.A.
Highest Score	Finland	Finland	Ireland	Netherlands	France	Estonia	Ireland	Finland

2. Materials and Methods

In literature, three main methodological approaches are used to measure EP: (i) quantitative approach evaluating the EP consequences in terms of diseases and mortality over the past few years; (ii) conceptual approach [8] and [9] based on the subjective perception of interviewed persons living in EP conditions; (iii) energy cost-based approach analysing data on household/countries income, and energy sources.

In this study, the energy cost-based approach is followed considering countries' GDP, countries' legislation, energy policies implementation, and the existing energy infrastructures and costs, with a specific focus on three countries i.e., Portugal, Italy, and Norway. These countries are selected for this study due to the collaboration that is ongoing within the framework of the EFFICACY (Energy eFFiciency buIlding and CirculAR eConomY for thermal insulating solutions) networking project aimed to creating a database on most used thermal insulation solutions. Here, the analysis focuses on short-term measures implemented in the three countries, providing a discussion on: (i) energy sources and consumption; (ii) legislative guidelines and requirements; (iii) ongoing trends in renewable energy use, and energy costs. To obtain needed information, the existing open databases are used e.g., available statistical data, laws, and regulations both at national and European level. Although it is known that the energy costs depend on the building stock conditions and EE of the sources, as well as the efficiency of appliances and Heating, Ventilating and Air Conditioning (HVAC) systems used in it, it is out of the scope of this contribution to investigate such details and the obsolescence of the building stock (i.e., number and type of buildings, the construction period) in three countries as it can be easily found in the literature [10–13].

3. Results

3.1 Main energy sources and energy consumption in Portugal, Italy, and Norway

Portugal is a temperate climate country with a vast coast bathed north and south by the Atlantic Ocean. Thermal discomfort is significantly higher compared to other countries with harsher winter seasons and lower temperatures, such as the Nordic countries. Portugal is highly dependent on imported energy. A web survey [14] conducted in 2017 (n=795) revealed that 74% and 25% of respondents considered their houses to be too cold during the winter or too hot during the summer, respectively. Only 1% reported that their houses provided thermal comfort. 44% of respondents considering their houses both cold in the winter and too hot in the summer reported the lack of thermal insulation as the main cause, while 27% did not identify any cause.

Notwithstanding, Portugal is making progress in facing the challenge of discomfort and of shifting towards renewable energy sources as in 2010, 34% of the energy in Portugal for heating and cooling was renewable, increasing to 41.5% in 2020 [15]. In 2021, in Portugal there was a total energy consumption of 266 TWh, 18.7% of this amount was split among households (i.e., 4.829 kWh per capita in 2021) [16] with 63% of the electricity used for buildings coming from wind and hydropower sources. In 2021, the electricity produced by renewable sources was mainly from hydro (13.455 GWh) and wind (13.216 GWh) [15]. The electricity consumption per year per capita in Portugal has been decreasing from 5.834 kWh in 2016 to 4.829 kWh in 2021, although the significant increase of the energy prices

[17]. In 2021, Portugal was the 10th country in the EU with the highest electricity prices for domestic consumption, with an average price of 0.2296 euros/kWh mainly due to tariffs and taxes [18]. Therefore, this aspect impedes electricity to compete with other fuels, thus presenting a barrier to achieving Portugal's goals for electrification. It is worth noting that Portugal's energy and climate policies focused on electrification of building energy demand towards carbon neutrality. In fact, a high level of electrification was already achieved by Portugal, with electricity covering 25% of the total final energy demand and 56% of building energy demand [16]. Very recently, thanks to the recovery and resilience plan devoted to Portugal by the EU after the pandemic, the country is receiving 13.9 billion euros in grants and 2.7 billion euros in loans [19]. The plan includes 610 million euros for EE and renewable energy measures to be applied in buildings [19]. Facing frequent droughts, the higher electricity prices are also due to low water levels stored in the reservoirs and the need to import more energy [15].

In 2021, **Italy** recorded gross consumption (or national demand) of 319.9 TWh and net of 280.0 TWh [20]. The primary energy consumption is mainly driven by oil, other liquids, and natural gas, which in 2016 accounted for over three quarters of Italy's total consumption. The other sources are coal, hydropower, and other renewable energies. As a net importer of crude oil and natural gas, Italy relies heavily on imports to meet approximately 93% of its oil and natural gas needs, with most natural gas import originating in Russia via the Gazprom gas transmission system (pipelines through Ukraine and from South-Eastern Europe). As for electricity generation, in 2016 around 67% came from fossil fuels, while renewable energies, including hydroelectricity, were responsible for around 33% of the country's electricity production (2016). The use of renewable energy sources for heating and cooling, have increased from 16% in 2010 to 20% in 2020 [15]. Currently, Italy is committed to eliminating the production of electricity from coal completely by 2025. Between 2015 and 2020, the percentage of electricity produced in Italy from renewable sources (in particular wind and solar) increased from 13% to 16% [21]. Italy manages to exploit the capacity from hydropower, from the wind, and solar energy resources, and from bioenergy [22], in view of reducing its dependence on imported fossil gas and aligning itself with European directives in line with Paris climate agreement.

In **Norway**, the energy consumption of buildings is predominantly electricity based on hydroelectric power, with some district heating or bioenergy-based sources. The use of renewable energy sources for heating and cooling, have increased from 34% in 2010 to 36% in 2020 [15]. The share of fossil fuels is very low and has been declining over the years [23]. In 2020, the total energy consumption in Norway was 211 TWh and 21.80% of this amount was split among households [24]. With 23,000 kWh of consumption per year and capita, Norway ranks second in electric consumption after Iceland with 23.000 kWh of consumption per year and per capita representing circa 80% of domestic energy consumption [25]. This high level of electricity consumption may be advocated to the low electricity prices [26] mostly due to the large share of hydropower [27]. As for the renewable resources, IRENA Statistics [22] provides the power capacity data for hydropower, wind energy, solar energy, and bioenergy. In Norway, hydropower is the most capacitive in terms of generation of energy, and wind energy, solar energy, and bioenergy, despite having low values, remain with a low increasing trend over the time.

3.2 Legislative, guidelines and requirements

Climate change and fossil-dependant energy growth led to the development of a package of EU's policies and measures that consider a low-energy economy and secure, competitive, locally produced, reduces dependence on energy imports, cuts emissions, and drives jobs [28]. The European market directives as well as others and regulation have influenced all the three countries (fig. 2). Especially, the EU Energy Performance in Buildings Directive (EPBD) was published in 2002 following the 1997 Kyoto Protocol in which EU countries compromised to achieve a reduction of 8% in the greenhouse gas (GHG) emissions from 2008 to 2012, when compared to data of 1990 [29].

The first thermal regulation in **Portugal** was published in 1990 [30] and it introduced the use of thermal insulation requirements on the design of new buildings to raise awareness on thermal comfort, insulation, and shading. In 1998, the publication of the Air-Conditioning Energy Systems Codes (RSECE) [31] allowed to improve the indoor thermal comfort and IAQ. After EPBD, the following requirements were imposed: methodology for calculating the energy performance of buildings; minimum requirements for new and retrofitted buildings; energy certification of buildings; inspection of boilers and air conditioning installations. EPBD was transposed, originating the Buildings Energy Certification System and IAQ [31] and the Air-Conditioning Energy Systems Codes [32]. The first revision of RCCTE took place in 2006, giving rise to the RCCTE 2006 [33] which defined a set of minimum characteristics required for the thermal properties of the building envelope, aimed at minimizing buildings sick syndromes anomalies, at increasing their durability and meet comfort requirements also considering the energy cost. New requirements for the heating and cooling energy needs, the heat transfer coefficient and the solar heating gain coefficient were presented in the document. This regulation was the basis for the energy performance certificate (EPC) In 2010, the EU Directive 2002/91/EC [29] was recast to further tighten the requirements according to the Action Plan for Energy published in 2007. The EU directive 2010/31/EU [34], dealt with new EU ”20–20–20” objectives, which were, in brief, the reduction by 20% of GHG emissions compared to 1990 levels, the increase by 20% of the EE in the EU and the achievement of 20% in use of renewables respect to the total energy consumption. The main objective of EPBD recast was also to improve the EE performance of buildings. EPBD recast (2010) was transposed into national law through Decree 118/2013 [35], merging, in the same document, the Certification System Building Energy (SCE), the Regulation on the energy performance of residential buildings (REH), and the Regulation on the energy performance of service buildings (RECS) General principles are also defined for each definition of requirements, materialized in specific requisite for new buildings, buildings subject to major intervention, and existing buildings.

The first **Italian** legislation about EE in buildings was published in 1976 [36] and introduced thermal insulation criteria of buildings and the design of thermal systems. Over time, it has been supplemented by three documents, as reported in [37]: (i) Presidential Decree (DPR) 1052/77 that defined the criteria for applying the Law and the terms for submitting the Technical Report; (ii) Ministerial Decree (DM) 10/3/1977 that established the climatic zones and the values of the heat dispersion coefficient in buildings and; (iii) Ministerial Decree (DM) 30/7/1986 that updated the heat dispersion coefficient, based on the Surface/volume (S/V) aspect ratio of the building and the climatic zone of the location. The law that integrated and partially replaced the law n.373/76, is the Law 9 January 1991 n. 10 [38], implementing the National Energy Plan on the rational use of energy, energy saving and development of renewable energy sources. The implementation of this law was regulated through two successive decrees: (i) DPR 412/93 [39] that classifies country into six climatic zones, distinguishing them according to the Degree Days criterion, regardless of the geographical location; (ii) DPR 551/99 [40] which consists of a series of changes and integrations on the regulation laying down rules for the design, installation, operation, and maintenance of thermal systems in buildings for the purpose of containing energy consumption. In 2005, as the implementing the EU Directive 2002/91/EC, Legislative Decree (DL) 192/2005 was issued which sets limits on the value of the primary energy requirement. Subsequently, it was modified with the DL 311/2006. In 2009, the complete implementation of DL no. 192/2005 provides for the publication of further implementing decrees: (i) Presidential Decree 2 April 2009, n. 59 "Methods for calculating the energy performance of buildings and systems" (to be repealed in implementation of DL No. 63/2013); (ii) DM Economic Development June 26, 2009 "National guidelines for the energy certification of buildings" and; (ii) EU Directive on Energy Services 2006/32/EC [41] is implemented by Italy through DL 115/2008. In Italy, the concept of nearly zero energy buildings (nZEB) was introduced within the DL 63/2013. Among the most recent publications, the DM June 26, 2015, is implementing decree of law 90/2013.

In **Norway**, the national legal framework of relevant building laws and regulations is the Technical Regulations (TEK) [42] i.e., the deregulation of TEK10 [43]. Before it, there were building codes 1928, 1949, 1969, 1980, 1987, 1997, 2007. The last in terms of time being the TEK17 on adjustments of prescriptive requirements to reduce costs in residential buildings and clarify and simplify functional and performance requirements. The building codes 1928 and 1949 were valid only the cities, however, after the 1969 code, it is implemented to all country. In addition, from 1980 the climate zones became homogeneous for the whole country. In TEK10, the chapter 14 was expressly dedicated to the topic of 'energy' as well as in TEK17. To be specific, in chapter 14.2, the requirements for energy demand were specified, e.g., the total net energy demand per each building category, and energy measures as the U-values of outside walls (0.18 W/m²K), roofs (0.13 W/m²K), floors (0.1 W/m²K). Based on TEK17 (still in effect), the total net energy demand cannot exceed 95 kWh/m2 heated available area (BRA) per year for residential blocks. The calculations of buildings' energy needs, and heat loss must follow in addition the Norwegian Standard NS3031:2014 [44] that is derived from EN15603:2008. TEK17 can be considered one of the strictest building requirements in Europe to achieve carbon-neutral initiatives by 2027. An agreement made in the Norwegian Parliament in 2012 stated that all new buildings must reach the 'Passive House' level by 2015, and the NZEB (Nearly zero-emission building) level by 2020; thus, the requirements for 2020 and the national definition of NZEB in Norway are complying with the European Directive 2010/31/EU [45]. Since 2017 TEK17 standard reduces the existing gap between "normal" houses and passive houses – NS 3700:2013 [46]. Although Norway is not a member of EU, it signed in 1992 the European Economic Area (EEA) agreement established since 1994 [47]. Through this agreement, Norway became a part of the EU's internal energy market. Since many of the directives and regulations in the energy field in EU are incorporated into the EEA Agreement, Norway is following the EU legislation reported at the beginning of section 3.2 [48].

All the national regulations, including the implementations of EU legislations, are summarised in the figure 2 for each country.

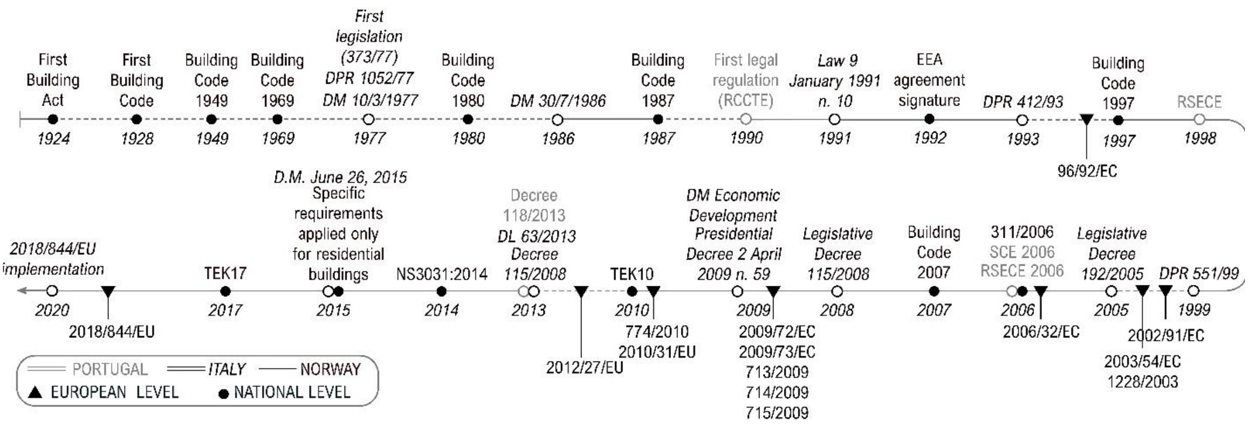

Figure 2. Legislative timeline of tree countries and Europe.

3.3. Scenarios and trends in renewable energy use, and energy costs

Natural gas is a major fuel for electricity production and heating in the EU. The European countries have different energy dependencies on Russia. In 2020, the net imports of natural gas from Russia to the three countries were: Italy (43.5%), Portugal (9.7%) and Norway (0%) [49]. For household consumers (defined as medium-sized consumers with an annual consumption between 2500 kWh and 5000 kWh), electricity prices in the first half of 2022 were higher in Italy (€0.3115 per kWh), followed by Portugal (€0.2067 per kWh) and Norway (€0.1994 per kWh) [26] as it is represented in table 2.

Table 2. Electricity prices (€ per kWh) for 2022 and main RES amount (ktoe) in Portugal, Italy and Norway for 2022.

	Electricity price (€ per kWh), 2022	Main RES, 2020	RES amount (ktoe), 2020
Portugal	0.2067	Hydro	723
		Wind	1057
Italy	0.3115	Hydro	4126
		Solar	2145
		Wind	1706
Norway	0.1994	Hydro	12218

In Portugal, in 2020, the main renewable energy sources were hydro and wind with amounts of 723 ktoe and 1057 ktoe, respectively [15]. In the case of Italy, for the same year, hydro, solar and wind were the main sources with values of 4126 ktoe, 2145 ktoe and 1706 ktoe. Norway uses mainly hydropower for electricity generation, representing 90% of total renewable sources with a value of 12218 ktoe in 2020 (table 2).

In line with data from the EU, in **Portugal**, in 2020, the buildings sector was the one that most contributed to final energy consumption, with a weight of around 32.9% of final energy consumption (19.4 % referring to the domestic sector and 13.4% to the services sector) [50]. Given the current instability of the energy sector, the governments of Portugal and Spain worked together to define a mechanism to set a reference price for natural gas consumed in electricity generation in the Iberian Electricity Market [51]. The final price did not increase too much in 2022 due to this mechanism.

In **Italy**, since the last quarter of 2021 there has been a considerable increase in the price of gas and electricity. For example, the price of gas reached around 100 €/MWh (considering the starting price of 20 €/MWh in the first quarter of 2021) [52]. To contain the increases in energy prices, the Italian government has implemented extraordinary and temporary measures, such as the introduction of measures starting from the second half of 2021 (with DLs 73/2021 and 130/2021), and the strengthened in 2022 (with the Budget Law 2022 and the DLs 4, 17, 21, 80, 115 and 144 of 2022). In addition, as a further help, there was the expansion of the number of beneficiaries of the energy bonuses and the increase in the value of these bonuses and of the granting of tax credits to all the ones in precarious economic conditions [26].

In the case of **Norway**, Norwegian Water Resources and Energy Directorate (NVE) [53,54] and Long-term Market Analysis [55], estimate that the energy prices will increase in the next years. At present, energy prices vary across Norway with the south having higher electricity price compared to centre and north. According to the NVE the average power prices will be 38, 35, and 31 øre/kWh whereas Statnett reported the same prices as 40, 35, and 31 €/MW, that means NVE and Statnett have a difference in the average power price of up to 9 EUR/MWh between North and South of Norway in 2030 [56]. This massive price difference is due to: (1) low water reservoirs in the south of the country due to the small amount of rainfall over the summer; (2) high energy amount exported to the continent, meaning supply has problems covering internal needs in the south of the country; (3) little transmission capacity from north to south so that in southern Norway, the import is done through more expensive energy [57]. According to Stattnet [55] prices in southern Norway will also increase on average by 10 €/MWh in 2025 and 5 €/MWh in 2030, that is much more than scenarios expected in northern and central Norway. The above-mentioned deregulations on the energy sector, including electric markets deregulations, are structural changes at national context which may increase inequality and EP [58,59]. This appeared after the analysis of data from digitalization and smart metering of energy consumption, and from the carbon-pricing of fossil-based electricity. These changes in prices however were also connected to the cost of infrastructure modernization as the electrification of fossil-based technology, and the construction of new offshore cables built for better integrating and homogenize the Norwegian energy market. To cope with the expected increase of total energy use in the next years, the NVE has proposed a structure of the electricity tariff that increases prices [60]. This policy aims to incentivize consumers to even out their energy consumption throughout the day to decrease the total energy consumption during peak hours. Even though energy retrofitting interventions remain necessary [61].

3.4. Awareness, barriers, and facilitators for alleviating EP

Figure 3 illustrates the relationship between the EP awareness, the energy use behaviour, and the external barriers as well as the possible external facilitators which may influence (positively or negatively) a user behaviour modification. These influences can create changes individually, or they can trigger cascade effect causing bigger behaviour revolution. The figure has been redrawn after [62–64].

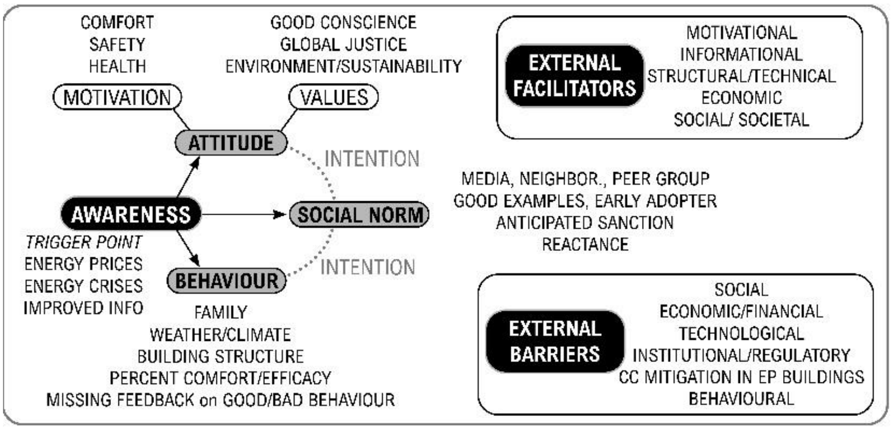

Figure 3. EP awareness relation (produced after [62–64]).

EP awareness may rise after a trigger point in people life which may be due to the increase of energy prices, the spread of an energy crisis triggered by geopolitical instability or the availability and response to improved information. Such awareness can grow fast or slow depending on personal attitudes constituted by some motivations [65], such as achieving minimum standards of health, safety, and comfort inside the sick and/or inefficient buildings. While at facilitators levels such attitude is more driven by values towards the achievement of carbon free energy transition, energy use reduction, and Climate Change mitigation actions. This contribution highlights as these values are shared by all the three investigated countries that are implementing policies and measures to expand modern energy access while minimizing greenhouse gas emissions and provide affordable and just energy sources. The awareness however is not only built on attitude but rather on energy user behaviour which should be modified to minimize energy cost. A change in behaviour requires time and efforts and can be strongly influenced by social norm through flow of information coming from mass media, neighbourhoods, peers' group, family members. Behavioural and usage change may be also triggered by social shocks (i.e., reactance to a strong energy crisis) or by the fear of sanctions.

This social norm aspect can easily become a barrier in EP [65]. Under the legislative point of view, barriers are the mistrust in governmental policies [66–69] including: the complexity and time-requirement for the understanding of legislative support in energy retrofitting interventions; the political invisibility of the low-income part of the population; the lack or the uncertainty because of contradictory information or the deficiency of feedback. Then another relevant barrier is the economic one that highlights there is a lack of money to afford long-term measure to tackle EP as well as the payback period is too long, or the payback rate of the investment is too low. For this reason, low-income landlords or people in socially vulnerable situations (e.g., unemployed, single parents, ethnic minorities, and elders) might prefer short-term measures.

Then, this contribution has reported how the shift towards renewable energy sources is gaining ground in all the three countries, although future scenarios are showing a likely increase in utility bills, that eventually will drive up EP for low-income families. They may become unable to face future energy cost or cost of European climate goals policies implementation although these are the measures that should warrantee energy justice, modern energy services, and reduced environmental impacts.

Finally, the structural/technical barriers are caused by the climate, the geography (i.e., the light or darkness and the peripherical position), the building structure (age size, type, ownership status, implementation of energy retrofit, etc.).

At global scale comparing the north-south axis, Bouzarovski [70] reports that the global north is facing EP because of "fuel poverty" (i.e., poor EE of residential buildings and low affordability of energy) while the global south is facing EP because of difficulties to access to modern energy infrastructure. At European level, infrastructural energy access is a common challenge in Norway, whereas issues of energy affordability and efficiency are widespread in Mediterranean countries that are becoming more and more aware about them. This means that a north-south axis comparison does not work so easily as it is context-sensitive.

4. Conclusions

This study contributes to portray an overview and discussion of EP awareness in three countries, namely Portugal, Italy, and Norway, as well as to assess what is the status of energy consumption and of renewable energy sources now in place. The study continues summarizing how in recent years the most effective short-term measures to tackle EP have been the implementation of national legislative decrees in line with the EU energy packages, and the policies, bonuses and granting of tax credits deriving by the recovery plans after the Covid-19 pandemic**.**

In **all** the three investigated countries the intention to grow EP awareness are based on a mix of attitude driven by motivation and sustainable values, social norm in the country and energy use behaviour.

The detected external **barriers** in reducing EP are multidimensional, as for example social and financial with the risk of EP underestimation, masked by the high GDP and the need of homogenized in the country the energy price regulations.

EP can decrease in case of some strategies are taken on time, e.g., both short-term economic and institutional/regulatory solutions as provision of bonus and granting tax credits, and long-term legislative support guiding energy retrofitting interventions. Both the energy consumption users and stakeholders must be aware of the actual level of EP because through this consciousness they can act to strengthen their motivation and values for changing to reduce both consumption and improve their comfort, health, and safety conditions in households. All together these motivation and action contribute to build an energy just social norm. Especially facility managers should assist users providing knowledge about energy codes classification, possible thermal insulation solutions or costly effective renewable energy sources to implement.

EP observatories working continuously at national level, as well as local EP advisory hubs at local level need to be implemented for both raising awareness and driving policy changes. Such institutions or supports actions have in addition to be guided by the EU Energy Poverty Observatory (EPOV) especially in countries like Norway where there is the risk that EP is masked by the high GDP. Beside the implementation of effective short-term measures (e.g., energy cost reduction for low-income people) that are urgently needed to cope with existing cases of EP; the long-term measures (e.g., energy retrofitting thermal insulation solutions in existing buildings, and installation of RES) are those that have the real potential of carrying on an effective energy transition towards a more equitable society.

Principles and policy decisions can trigger these long-term measures thanks to both tangible investments and intangible investments in the field of education, which have a long-term potential in modifying people knowledge, understanding, and behaviour when dealing with energy use.

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References

[1] EU Directorate-General for Energy. Energy poverty. https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energy-poverty-eu_en
[2] World Green Building Council. Why Europe’s buildings can play a critical role in addressing the ongoing energy crisis. https://worldgbc.org/article/why-europes-buildings-can-play-a-critical-role-in-addressing-the-ongoing-energy-crisis/
[3] Zhang D, Hu M and Ji Q 2020 Financial markets under the global pandemic of COVID-19 *Financ Res Lett* **36** 101528

[4] Grajewski M and EPRS (European Parliamentary Research Service) 2022 *Russia's war on Ukraine and the energy Crisis.* https://www.europarl.europa.eu/RegData
[5] Bertoldi P, Economidou M, Palermo V, Boza-Kiss B and Todeschi V 2021 How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU *Wiley Interdiscip Rev Energy Environ* **10**
[6] World Economic Outlook. World Economic Outlook (October 2022) - GDP per capita, current prices. https://www.imf.org/external/datamapper/
[7] Odyssee-Mure project. EU countries scoring tool for energy efficiency indicators and policies | ODYSSEE-MURE. https://www.odyssee-mure.eu/data-tools
[8] Thompson N 2016 Anti-Discriminatory Practice : Equality, Diversity and Social Justice.
[9] Hemel C van den and Rademakers M F 2016 Building Customer-centric Organizations: Shaping Factors and Barriers *Journal of Creating Value* **2** 211–30
[10] Magalhães S M C and Leal V M S 2014 Characterization of thermal performance and nominal heating gap of the residential building stock using the EPBD-derived databases: The case of Portugal mainland *Energy Build* **70** 167–79
[11] Caputo P and Pasetti G 2017 Boosting the energy renovation rate of the private building stock in Italy: Policies and innovative GIS-based tools *Sustain Cities Soc* **34** 394–404
[12] Ballarini I, Corrado V, Madonna F, Paduos S and Ravasio F 2017 Energy refurbishment of the Italian residential building stock: energy and cost analysis through the application of the building typology *Energy Policy* **105** 148–60
[13] Sartori I, Wachenfeldt B J and Hestnes A G 2009 Energy demand in the Norwegian building stock: Scenarios on potential reduction *Energy Policy* **37** 1614–27
[14] PCS/Quercus 2017 1ª Análise dos resultados do inquérito. https://www.csustentavel.com/wp-content/uploads/2017/12/an%C3%A1liseresultadosinqu%C3%A9rito_esta%C3%A7%C3%A3ofria.pdf
[15] Eurostat SHARES (Renewables) - Energy. https://ec.europa.eu/eurostat/web/energy/data/shares
[16] Ritchie H and Roser M 2022 Portugal: Energy Country Profile - Our World in Data. https://ourworldindata.org/energy/country/portugal
[17] International Energy Agency Iea Energy Policy Review Portugal 2021. https://www.iea.org/
[18] Eurostat. 2022 Electricity prices for household consumers - bi-annual data (from 2007 onwards).
[19] Recuperar Portugal. Recovery and Resilience Plan (RRP). Plano de Recuperação e Resiliência português. https://recuperarportugal.gov.pt/?lang=en
[20] TERNA 2021 2021 Digital report. https://www.terna-reports.it/2021/en/#driving-energy
[21] EMBER 2022 Italy | Electricity Transition. https://ember-climate.org
[22] IRENA 2022 Renewable Capacitiy Statistics 2022. https://www.irena.org
[23] Multiconsult 2022 Residential building portfolio- carbon and energy footprint
[24] Ministry of Petroleum and Energy 2020 Energy use by sector. https://energifaktanorge.no
[25] SSB 2014 Energy consumption in households. https://www.ssb.no
[26] Eurostat 2021 Electricity price statistics - Statistics Explained. https://ec.europa.eu/eurostat/
[27] Førsund F R 2015 International Series in Operations Research & Management Science Hydropower Economics Second Edition
[28] Ciucci M 2021 Energy policy: general principles | Fact Sheets on the European Union | European Parliament. https://www.europarl.europa.eu/factsheets/en/sheet/68/energy-policy-general-principles

IOP Conf. Series: Earth and Environmental Science 1176 (2023) 012023 doi:10.1088/1755-1315/1176/1/012023

[29] European Parliament and Council of the European Union 1999 DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings.
[30] Diário da República Eletrónico (DRE) 1990 Decree-Law No. 40/90, of February 6. https://dre.pt/dre/detalhe/decreto-lei/40-1990-334611?_ts=1664755200034
[31] Diário da República Eletrónico (DRE) 2006 Decree Law 78/2006, Buildings Energy Certification System. https://dre.pt/dre/detalhe/decreto-lei/78-2006-672458
[32] Diário da República Eletrónico (DRE) 2006 Decree Law 79/2006, Air-Conditioning Energy Systems Code. https://dre.pt/dre/detalhe/decreto-lei/79-2006-672459
[33] Diário da República Eletrónico (DRE) 2006 Decree Law 80/2006, Regulation of Thermal Behavior Characteristics of Buildings. https://dre.pt/dre/detalhe/decreto-lei/80-2006-672456
[34] European Parliament and of the Council 2010 Directive 2010/31/EU on the energy performance of buildings
[35] Diário da República Eletrónico (DRE) 2013 Decree Law 118/2013, Portuguese Energy Certification system and indoor air quality (SCE) and Regulation on the energy performance of residential buildings (REH) and Regulation on the energy performance of service buildings (RECS). https://dre.pt/dre/detalhe/decreto-lei/118-2013-499237
[36] Gazzetta Ufficiale 1976 LAW 30 March 1976, n. 373Standards for the containment of energy consumption for thermal use in buildings. https://www.gazzettaufficiale.it/eli/id/1976/06/07/076U0373/sg
[37] Meloni E 2021 Storia normativa energetica del settore edilizio: genesi e prospettive
[38] Gazzetta Ufficiale 1991 LAW 9 January 1991, n. 10Rules for the implementation of the National Energy Plan on rational use of energy, energy saving and development renewable energy sources. https://www.gazzettaufficiale.it/eli/id/1991/01/16/091G0015/sg
[39] Presidency of the Council of Ministers 1993 DECREE OF THE PRESIDENT OF THE REPUBLIC 26 August 1993, n. 412. https://www.normattiva.it
[40] Gazzetta Ufficiale 1999 DECREE OF THE PRESIDENT OF THE REPUBLIC 21 December 1999, n. 551. https://www.gazzettaufficiale.it/eli/id/2000/04/06/000G0118/sg
[41] EUR-Lex 2006 Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC (Text with EEA relevance)
[42] Direktoratet for byggkvalitet (DIBK) 2017 Regulations on technical requirements for construction works (TEK17). https://dibk.no/regelverk/byggteknisk-forskrift-tek17/
[43] Direktoratet for byggkvalitet (DIBK) 2010 Regulations on technical requirements for building works (TEK10). https://dibk.no/regelverk/tek/
[44] Standard Norge 2014 NS 3031:2014. https://www.standard.no/no/Nettbutikk/produktkatalogen/Produktpresentasjon/?ProductID=702386
[45] Brekke T, Isachsen O K I and Strand M 2016 Implementation of the EPBD in Norway
[46] Standard Norge 2013 NS 3700:2013. https://www.standard.no
[47] European External Action Service (EEAS) 2021 The European Union and Norway
[48] Ministry of Petroleum and Energy 2015 Key EU energy legislation - Energifakta Norge
[49] EU energy mix and import dependency EU energy mix and import dependency - Statistics Explained
[50] The Directorate-General for Energy and Geology Diretiva do Desempenho Energético dos Edifícios
[51] Diário da República Eletrónico (DRE) 2022 Decree-Law No. 33/2022, of May 14

[52] ENEA 2022 Energia: analisi ENEA, in crescita consumi (+2,5%) ed emissioni (+8%), rinnovabili -9,5% — it
[53] The Norwegian Water Resources and Energy Directorate (NVE) 2021 Energieffektivisering 'Energy efficiency'
[54] Amundsen J S and Holm I B 2018 *Kraftmarkedsanalyse 2018 - 2030*
[55] Stattnet 2021 Long-term Market Analysis 2020-2050 - Update Spring 2021
[56] Schäffer L E and Graabak I 2019 *Power Price Scenarios: Results from the Reference scenario and the Low Emission scenario* (Trondheim)
[57] Norwell F 2021 EXPLAINED: Why are energy costs soaring in southern Norway?
[58] Burholt V and Windle G 2006 Keeping warm? Self-reported housing and home energy efficiency factors impacting on older people heating homes in North Wales *Energy Policy* **34** 1198–208
[59] Bouzarovski S 2014 Energy poverty in the European Union: landscapes of vulnerability *Wiley Interdiscip Rev Energy Environ* **3** 276–89
[60] Fridtjof Nansen Institute 2020 A Study of Energy Poverty in Norwegian Households Miljørettet innovasjon i norsk lakseoppdrett
[61] Sareen S, Waage M, Smirnova P, Boakye-Botah J and Loe M R 2022 Double energy vulnerability in the Norwegian low-carbon urban transport transition *People, Place and Policy* 1–20
[62] Klöckner C A, Sopha B M, Matthies E and Bjørnstad E 2013 Energy efficiency in Norwegian households-identifying motivators and barriers with a focus group approach *International Journal of Environment and Sustainable Development* **12** 396–415
[63] Egmond C 2008 Nothing is as practical as a good theory, Analysis of theories and a tool for developing interventions to influence energy-related behaviour
[64] Ajzen I 1991 The theory of planned behavior *Organ Behav Hum Decis Process* **50** 179–211
[65] Bouzarovski S 2014 Energy poverty in the European Union: landscapes of vulnerability *Wiley Interdiscip Rev Energy Environ* **3** 276–89
[66] Burbidge M, Bouzarovski S, Papantonis D, Stavrakas V, Flamos A, Martini E, Figueira M, Hamzova A, Heeman J, Vondung F and Gericke N Actions to Mitigate Energy Poverty in the Private Rented Sector Structural Factors Impacting Energy Efficiency Policy Implementation in the European Private Rented Sector
[67] Katharina Habersbrunner and Eva-Carina Martschew 2020 Report on gender aspects of existing financial schemes for energy poverty measures
[68] Simcock N, Jenkins K, Mattioli G, Lacey-Barnacle M, Bouzarovski S and Martiskainen M 2020 Vulnerability to fuel and transport poverty
[69] Eurostat 2014 Working paper with the description of the "Income and living conditions dataset"
[70] Sovacool B and Cai W 2019 One Earth Voices Tackling Energy Poverty Energy Poverty as a Sociotechnical Challenge Reduce without Environmental Harm