EUROPEAN ENERGY POVERTY INDEX (EEPI)

JANUARY 2019

OPENEXP

ASSESSING MEMBER STATES' PROGRESS IN ALLEVIATING THE DOMESTIC AND TRANSPORT ENERGY POVERTY NEXUS

''Everyone has the right to access essential services of ...energy, transport...''

Principle 20 of the European Pillar of Social Rights

The European Energy Poverty Index (EEPI)

The European Energy Poverty Index (EEPI) is a composite indicator which scores and ranks Member States' progress in alleviating domestic and transport energy poverty as well as their nexus. The EEPI is composed of two sub-indexes, the European Domestic Energy Poverty sub-Index (EDEPI) and the European Transport Energy Poverty sub-index (ETEPI). The EEPI score is computed, for the first income quintile population (lowest income level) as a geometric mean of the EDEPI and the ETEPI. The higher the score, the better the performance of the country. Equal weights of one are used in the computation of this first edition of the EEPI. However, readers can opt for different weights for each metric and each sub-index and recompute the EEPI at: www.openexp.eu/eepi.

The EDEPI score is computed as a geometric mean of the metrics assessing causes and symptoms of domestic energy poverty including the share of energy expenditures out of total expenditures, the share of the first income quintile citizens unable to keep their homes warm in winter and/or cool in summer as well as the share of the first income quintile citizens living in dwellings with leaking roofs, damp walls and rot in window frames of floor.

The ETEPI score is computed as a geometric mean of the metrics assessing few of the causes of transport energy poverty including the share of transport energy expenditures for car-owning citizens, the share of the first income quintile citizens unable to afford public transport as well as the share of the first income quintile citizens with limited access to public transport. Due to the lack of data, none of the symptoms of transport energy poverty is included in the computation of the ETEPI.

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ACKNOWLEDGEMENTS

This report was commissioned by the European Climate Foundation and targets a broad range of actors interested by energy poverty including policy-makers and advocates at different levels of governance. The report provides limited and concise explanations of the work performed. For the academic community, the content of this report will be presented in a scientific article which is currently under preparation. The scientific article shall therefore be considered a most updated and accurate reference when referring to the results of this work.

The report is a joint effort of six experts from different disciplines working for three different research institutions in Europe.

Yamina SAHEB (OpenExp) was the project leader and had the overall responsibility for the design, the development, the coordination and the drafting of the report. Sofia CALCAGNO (OpenExp) developed the EEPI statistical model. Petre KOSTOV (OpenExp) developed the algorithms of OpenExp web platform dedicated to the European Energy Poverty Index: www.openexp.eu/eepi Katalin BODIS (European Commission, Joint Research Centre) contributed with data analysis and visualisation. Florin VONDUNG and Johannes THEMA (Wuppertal Institute) contributed with analysis of EUROSTAT micro-data.

Moreover, OpenExp has engaged in a collaboration with the Competence Centre on Composite Indicators and Scoreboards of the European Commission's Joint Research Centre, with a view to continue improving the indicator framework and the methodology behind the European Energy Poverty Index in future releases.

A special thanks go to Patty FONG and Ting ZHANG from the European Climate Foundation for their guidance in the drafting process and to Tim KNICKERBOCKER for editing the report and streamlining the text as well as to Alma OSORIO for the layout.

The report benefitted from the valuable input provided by many experts, including:

Brenda BOARDMAN (University of Oxford), Stefan BOUZAROVSKI (University of Manchester, EPOV), Raúl CASTAÑO-ROSA (University of Seville), Jean-François DALLEMAND (EC-JRC), Dušana DOKUPILOVÁ (Slovak Academy of Sciences), Ute DUBOIS (ISG), Vijoleta GORDELJEVIC (HEAL), Clémence HUTIN (Right to Energy Coalition), Ines IMBERT (EIFER), James KEERY (BEIS), Rod JANSSEN (Energy in Demand), Maria JELIAZKOVA (EAPN), Ioanna KYPRIANOU (Cyprus Institute), Régis LARGILLIER (Fondation Grenoble INP), Luca LAMONACA (Former EC-JRC), Giulio MATTIOLI (University of Leeds), Ettore MARCHETTI (EC-DG EMPL), Genevieve McInnes (OECD), Sandrine MEYER (ULB), Renata MIKALAUSKIENE (MCAST), Dunphy NIALL (UCC), Heinz OSSENBRINK (Former EC-JRC), Thomas PELLERIN-CARLIN (Jacques DELORS Institute), Dinko RAYTCHEV (EC-DG ENERGY), Charles ROARTY (Energy Action), Angela SANTANGELO (University of Bologna), Serban SCRIECIU (EC-DG EMPL), Marie SEVENET (EIFER), Sylke SCHNEPF (EC-JRC), Sandor SZABO (EC-JRC), Marilyn SMITH (The ENERGY ACTION Project), Sergio TIRADO (UAB), Stefan THOMAS (Wuppertal Institute), Valérie XHONNEUX (RWADE).

FOREWORD

First of all, I would like to thank Dr. Yamina Saheb for inviting me to contribute to this very important report, on a subject that I have fought tirelessly to bring to the forefront of European energy policy.

We know that our energy security is at risk, we know the threat posed by climate change and that the most vulnerable in our society struggle to pay their energy bills. So, it is crucial we keep improving energy policy at all levels.

When developing legislation, the EU needs to think how it will directly affect its citizens, and indeed its most vulnerable citizens.

As many as 80 million people live in damp and leaky homes. Implementing a meaningful level of ambition can help reform this crisis, boost employment and competitiveness. For every 1% improvement in energy efficiency, 3 million homes can be properly renovated, and 7 million people lifted out of energy poverty. Therefore, the solutions to energy poverty are structural and institutional, not individual.

Energy legislation must be taken as a package with consumers at its heart: because tackling climate change, ending energy poverty, providing training and finance for a just transition to a low-carbon economy and improving energy efficiency are all different parts of the same thing - securing energy justice. Europe needs to be a leader in tackling climate change, in revolutionising the way we use energy – and we can achieve this if we put our citizens first.

Consumers must be enabled to be "prosumers" and part of the market, but this must never come at the expense of our most vulnerable citizens.

A Europe that works for its citizens, allowing them to be part of the solution and empowering them to create their own energy in a just manner, while also protecting its most vulnerable consumers, benefits us all.

I hope you enjoy reading this report and join us in the fight to end energy poverty for all.

Theresa Griffin is a Member of the European Parliament and Vice-President of the European Forum on Renewable Energy Sources.

The Energy Union, that this Commission has promised and delivered, puts citizens, especially those facing energy poverty, at the heart of Europe's energy transition. This was at the heart of the Clean Energy Package but also measures on improving energy efficiency to reduce the energy bills and improve the quality of living. There are many manifestations to our focus on alleviating European citizens from energy poverty, including the newly adopted Governance regulation which requires an integrated reporting on the progress made by Member States in alleviating energy poverty.

The recast of the Directive on the Internal Electricity Market also recognises low income, high energy expenditure and poor energy efficiency of homes as relevant factors in designing indicators for the measurement of domestic energy poverty.

The recast of the Energy Performance of Buildings Directive and the Energy Efficiency Directive clearly spell out the need for prioritising the retrofit of dwellings occupied by citizens facing energy poverty. EU and national funds provide access to low cost finance, allowing owners to pay as they save and inhabitants to improve their quality of living.

However, more needs to be done to ensure access to essential services of energy and transport for each EU citizen.

I therefore welcome OpenExp's proposal of the European Energy Poverty Index (EEPI). The EEPI goes one step further and looks at both transport and domestic energy poverty. The combination of common metrics into one single figure will make cross-country analysis, for the combined effect of all the factors leading to energy poverty, doable. The EEPI results support the Commission approach developed under the Covenant of Mayors initiative to monitor progress made at local level in alleviating both transport and domestic energy poverty.

This first edition of the EEPI is a good starting point towards a more holistic approach to energy poverty. I highly encourage OpenExp to pursue its collaboration with DG Energy on the data needed to improve the EEPI and with our experts from the Joint Research Centre (JRC) on the improvement of the methodology and the conceptual framework.

I am convinced the instruments and provisions we included in the Clean Energy Package will play a major role in eradicating energy poverty and that the EEPI could contribute to monitoring this progress.

Maroš Šefčovič

Vice-President of the European Commission, Energy Union and Climate

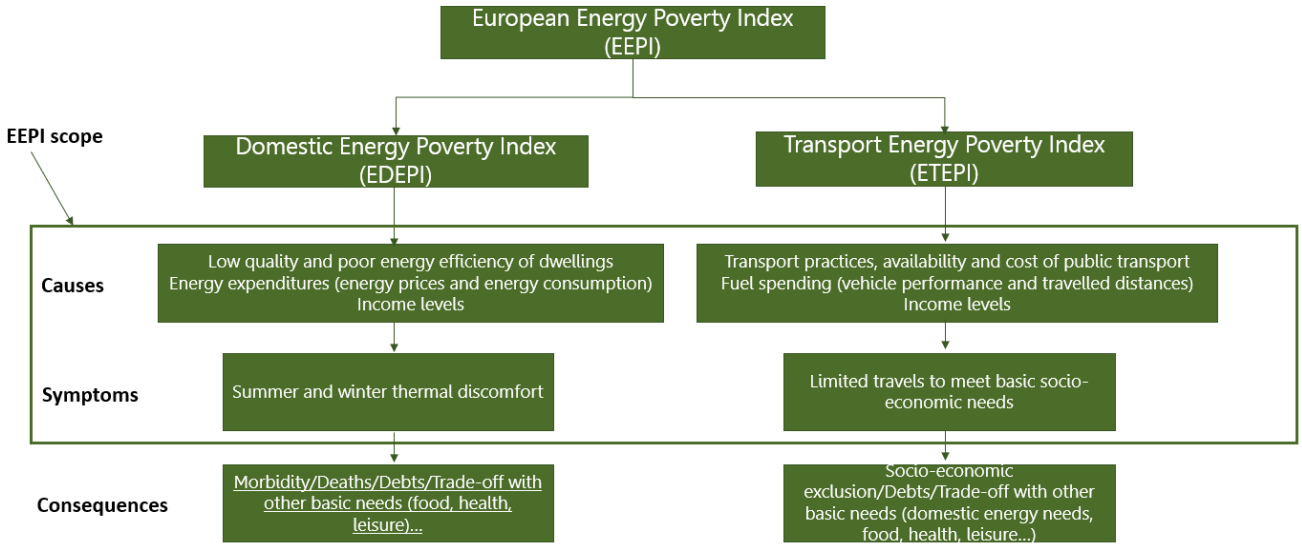
EXECUTIVE SUMMARY

Energy poverty, if not fully alleviated, will hinder the right of European citizens to access energy services and transport, which are demanded by Principle 20 of the European Pillar of Social Rights.

Tracking progress in the delivery on the right to energy services for all is crucial for making Europe's energy transition a just transition. The European Energy Poverty Index (EEPI) allows, for the first time, assessing progress made by Member States in alleviating both transport energy poverty, domestic energy poverty and their nexus. It does so by combining, in one single figure, the common metrics used for assessing the alleviation of causes of energy poverty with those assessing the alleviation of its symptoms as described in the EEPI framework (Figure ES.1).

On one hand, progress made in alleviating transport energy poverty is assessed, for the first time, for citizens using public transport and those using their own cars for the daily travels needed to meet their basic socio-economic needs. On the other hand, progress made in alleviating domestic energy poverty is assessed, for the first time, for the combined effect of summer and winter domestic energy poverty. The EEPI complements existing metrics by allowing across country analyses of the progress made in alleviating all dimensions of transport and domestic energy poverty as well as their nexus.

Figure ES.1 The European Energy Poverty Index (EEPI) Framework



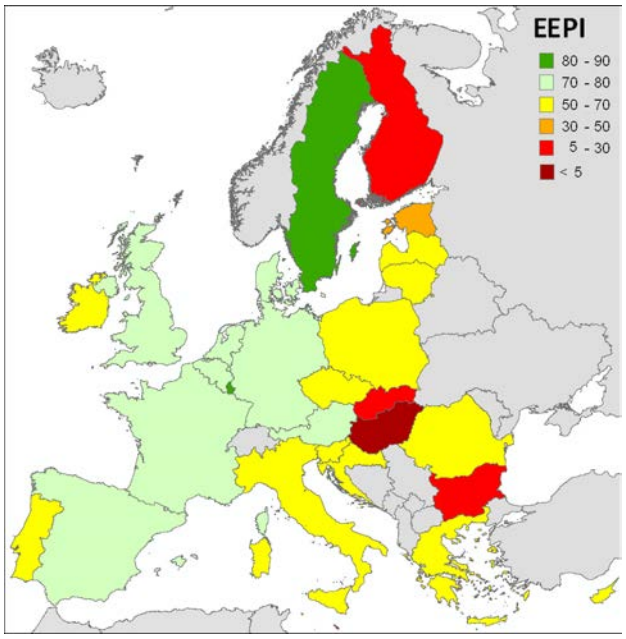
Key point: The EEPI framework allows assessing progress made in alleviating transport energy poverty, domestic energy poverty and their nexus.

The EEPI scoring of Member States' progress in alleviating energy poverty provides new insights on the domestic and transport energy poverty nexus.

Looking at the progress made in alleviating the combination of domestic and transport energy poverty reveals a more complex scenario. Member States progressing well in alleviating domestic energy poverty are not necessarily those who are progressing well in alleviating transport energy poverty (Figure ES.2). A clear divide exists, between Western/Northern and Eastern/Southern-Eastern countries, in the progress made in alleviating domestic energy poverty. However, the overall scoring changes when progress made in alleviating transport energy poverty is included (Table ES.1). The EEPI scoring argues for a better consideration of the transport and domestic energy poverty nexus in policy design.

The main factors explaining the progress made in Western/Northern countries in alleviating domestic energy poverty are the stringency of their building regulations, and their financial support to first income quintile citizens in order to compensate for high energy prices applied to those consuming less. On the other hand, the low reliance on private cars for the daily trips in some Eastern/Southern-Eastern countries explains the high performance of these countries in alleviating transport energy poverty.

Figure ES.2 Member States' progress in alleviating the transport and domestic energy poverty nexus.



Key point: EEPI results call for a paradigm shift in policy design to alleviate the transport and domestic energy poverty nexus.

Urban and land-use policies are the instruments to use for jointly alleviating domestic and transport energy poverty.

The EEPI scoring and ranking of Member States' progress in alleviating energy poverty (Table ES.1) calls for a paradigm shift in the design of urban and land-use policies. These policies have been instrumental in increasing the share of the European citizens at risk of facing the combined effects of transport and domestic energy poverty. On one hand, urban sprawl has increased the share of the population using private cars to meet their basic socio-economic needs. On the other hand, the exposure of the four walls of single-family homes to the outdoor environment increases their energy needs, compared to multi-family buildings, and consequently increases energy bills of their occupants. The driving effect of urban and land-use policies is particularly true with the exclusively high costs of dwellings located in urban areas, where public transport is likely to be available and accessible.

The transport and domestic energy poverty nexus requires a fundamental change in the design of housing and land use policies to avoid the trade-off between affordable housing and car dependency.

Renovation strategies should aim for positive energy buildings and consider alleviating both summer and winter domestic energy poverty.

Alleviating domestic energy poverty requires making each single building or cluster of buildings positive energy to ensure buildings produce more energy than they consume annually. Positive energy buildings: 1) reduce energy needs; 2) protect consumers from the rise of energy prices; and 3) protect first income quintile citizens from tariff design that penalise those consuming less energy. Overall, positive energy buildings will ensure access to domestic modern energy services for all regardless of income by reducing the annual cost of energy bills to zero. The expected global warming and its impact on summer domestic energy poverty must be seriously considered when buildings are made positive energy.

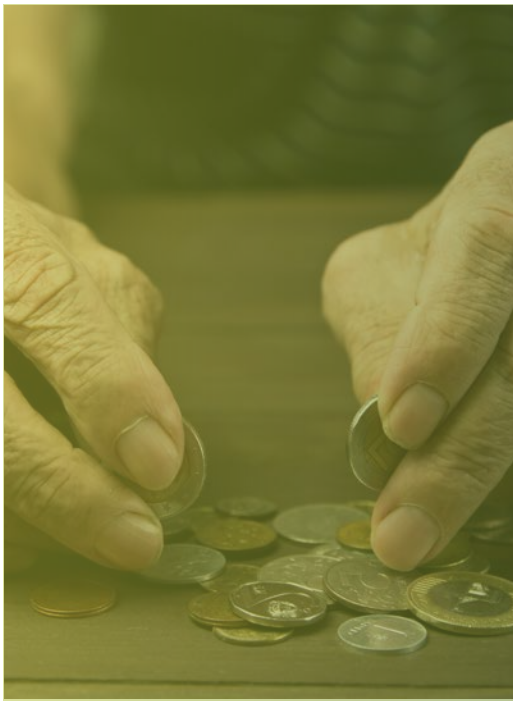
An important effort should be made by Member States to address the limitations of the existing metrics and to provide EUROSTAT on a regular basis the data needed to assess progress in alleviating energy poverty.

Paradigm shifts in transport policies are needed to ensure universal access to affordable mobility.

Alleviating transport energy poverty requires making mobility an affordable option for all. Public transport, car sharing, biking lines and other options of modal shift should be available, accessible and affordable for all. Moreover, Europe's policies related to private cars should focus on electric vehicles that can be recharged using solar panels installed on the roofs of positive energy buildings. As countries put in place policies to encourage market take up of electric vehicles, they should ensure subsidies do not only benefit the 'able-to-pay" citizens.

The use of public finance to accelerate the pace of the energy transition should primarily target alleviating domestic and transport energy poverty.

The use of public funding for energy renovation should require the transformation of EU buildings to positive energy standards, especially with the progress made in delivering cost-effective positive energy buildings. For those in need of using their private cars, public funding should provide support to facilitate the access to the most efficient and clean cars for the first income quintile citizens.



Allocating the human and financial resources needed to gather the data required to assess progress made in alleviating energy poverty is a paramount.

The 2018 EEPI edition combines indicators from several years, depending on the latest available year for each identified metric used to assess different dimensions of energy poverty. For future releases of the EEPI, metrics used to assess progress made in alleviating energy poverty should, ideally, be from the same and most recent year. One obvious place to begin is to update existing metrics related to summer domestic energy poverty and to gather the missing data related to some of the dimensions of transport energy poverty. Another way to ensure that these data will be gathered is to embed the identified data needed to assess progress made in alleviating both transport and domestic energy poverty into existing EU regular data gathering and assessments of various targets such as those related to the Sustainable Development Goals (SDGs) and those related to National Energy and Climate Plans (NECPs).

Table ES.1 EEPI scoring and ranking of Member States' performance in alleviating domestic energy poverty, transport energy poverty and their nexus.

Country	European Energy Poverty Index EEPI		European Domestic Energy Poverty Index EDEPI		European Transport Energy Poverty Index ETEPI	
	Rank	Score	Rank	Score	Rank	Score
Sweden	1	86.34	1	95.41	7	78.13
Luxembourg	2	83.97	5	80.88	1	87.19
Austria	3	79.58	4	81.21	8	77.99
Denmark	4	78.94	3	81.88	13	76.10
Netherlands	5	77.25	8	78.09	12	76.42
France	6	75.35	10	73.33	11	77.43
United Kingdom	7	74.98	6	80.54	16	69.79
Belgium	8	73.26	11	67.62	5	79.37
Germany	9	72.32	9	75.77	18	69.02
Spain	10	71.80	12	64.67	4	79.72
Czech Republic	11	68.99	15	60.21	6	79.05
Poland	12	64.45	14	61.01	19	68.08
Romania	13	62.40	13	64.23	20	60.63
Cyprus	14	62.27	21	46.23	2	83.90
Slovenia	15	62.05	20	51.34	14	74.99
Lithuania	16	57.42	23	42.37	10	77.82
Croatia	17	57.19	16	58.79	21	55.64
Greece	18	56.70	22	43.69	15	73.58
Ireland	19	55.86	7	79.29	25	39.35
Portugal	20	53.42	25	36.67	9	77.83
Latvia	21	52.55	24	40.01	17	69.03
Italy	22	52.09	19	52.10	22	52.08
Estonia	23	48.65	18	58.02	23	40.80
Slovakia	24	26.33	26	8.35	3	83.04
Finland	25	18.38	2	85.56	27	3.95
Malta	26	15.56	17	58.56	26	4.13
Bulgaria	27	5.30	28	0.71	24	39.55
Hungary	28	4.57	27	6.19	28	3.38

Key point: Member States performing well in alleviating domestic energy poverty are not necessarily those who are progressing well in alleviating transport energy poverty.

UNDERSTANDING EEPI SCORING AND RANKING

The 2018 EEPI edition combines common metrics used to assess progress in alleviating both transport and domestic energy poverty and has the flexibility to include additional data as it is made available.

EEPI scoring

The EEPI ranks Member States based on their progress made in alleviating energy poverty (Table ES.1). Despite current shortcomings in the data related to transport energy poverty and to summer domestic energy poverty, the 2018 EEPI edition combines common metrics used to assess progress in alleviating both transport and domestic energy poverty (and it has the flexibility to include additional data as it is made available). The aim is to unleash an EU level discussion on transport energy poverty and its effects that, when combined with domestic energy poverty, speaks directly to Europe's Pillar of Social Rights and the Energy Union target of a just energy transition.

The objectives are simple: 1) to fundamentally rethink energy poverty; 2) to identify and include all dimensions of it and ; 3) to develop a holistic energy policy approach to alleviate it.

Sweden has the highest score and Hungary has the lowest score when progress in alleviating both domestic and transport energy poverty are assessed jointly and given equal weights in the computation of the index (Table ES.1). Progress is needed to alleviate transport and summer domestic energy poverty in Sweden while in Hungary progress is needed to alleviate both transport and domestic energy poverty. Importantly, the overall score of each Member State is impacted by its performance in alleviating transport energy poverty despite the equal weights considered for each dimension of energy poverty.

Finland and Ireland provide a good illustration for the need to consider the transport and domestic energy poverty nexus. Finland ranks 25th when progress in alleviating both transport and domestic energy poverty are considered despite of being ranked 2nd for the progress made in alleviating domestic energy poverty. Similarly, Ireland ranks 19th when progress in alleviating both transport and domestic energy poverty are considered despite of being ranked 7th in the progress made in alleviating domestic energy poverty.

Top ten countries include Sweden, Luxembourg, Austria, Denmark, Netherlands, France, United Kingdom (UK), Belgium, Germany and Spain. In these countries, progress made in alleviating energy poverty is rather balanced between its two dimensions (domestic and transport). The ten most lagging countries include Hungary, Bulgaria, Malta, Finland, Slovakia, Estonia, Italy, Latvia, Portugal and Ireland. Apart from Finland and Ireland described above, these countries are behind in alleviating both domestic and transport energy poverty (Figure 1).

Moreover, frontrunner countries, apart from Spain, are Member States with a GDP per capita higher than the EU average, while lagging countries, apart from Finland and Ireland, are Member States with a GDP per capita lower than the EU average.

Figure 1 Contribution of transport and domestic energy poverty to the EEPI ranking

Key point: Member States with a balanced progress in alleviating domestic and transport energy poverty are those scoring high.

EDEPI scoring

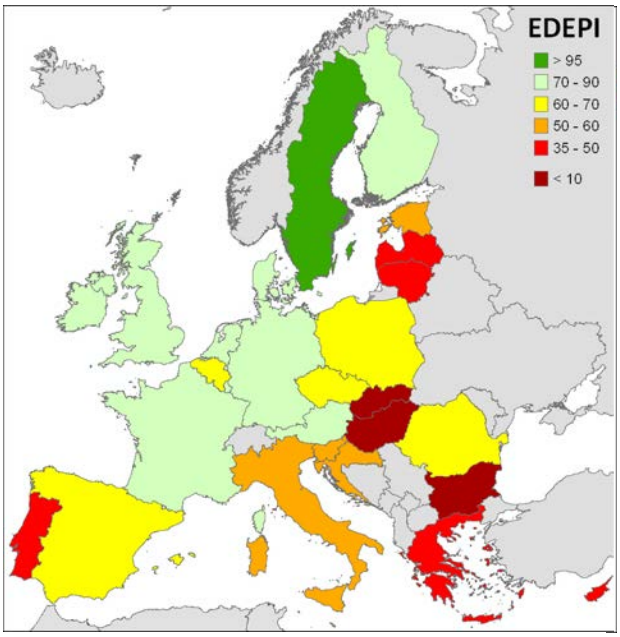
The EDEPI ranks Member States based on their progress made in alleviating domestic energy poverty (Figure 2 and 3). Despite current shortcomings in data assessing summer energy poverty (2012 is the only year for which data is available), the 2018 EDEPI edition combines common metrics used to assess progress made in alleviating both summer and winter domestic energy poverty. The objective is to stress the importance of summer domestic energy poverty, especially with the expected heatwaves which may result from global warming (IPCC, 2018, S. Russo & al, 2015).

Metrics considered in the computation of the EDEPI capture all the causes of domestic energy poverty considered in the recast of the Internal Market in Electricity Directive (EC, 2019-A) as well as the symptoms of domestic energy poverty described in the literature (Hill 2012, Thomson & al 2013, Insight 2015, S. Bouzarovski & al 2017, B. Boardman 1991 and 2010, Trinomics, 2016, H. Thomson & al, 2017 and EC, 2019-b). “Low income, high energy expenditure, and poor energy efficiency of homes” are the three relevant factors the recast of the Internal Market in Electricity Directive (EC, 2019-A) suggests to Member States to consider when designing indicators for the measurement of energy poverty.

These three factors are captured by the share of energy expenditures out of total expenditures. Additional metrics considered in the computation of the EDEPI include the quality of dwellings regarding leaking roofs, damp walls and rot in windows frames as well as the inability to keep homes warm in winter and comfortably cool in summer.

Sweden ranks first and Bulgaria ranks last when Member States are ranked exclusively for the dimensions of domestic energy poverty (combined and equal weights are given to each dimension during the computation of the index). The EDEPI scoring confirms the progress made in alleviating winter domestic energy poverty in Sweden, with less than 5% of the first income quintile population reporting their inability to keep their homes warm in winter (the second lowest share after Finland).

Figure 2 Member States' progress in alleviating domestic energy poverty



Key point: There is a clear divide between North/Western countries and Southern/Eastern-Southern countries in the progress made in alleviating domestic energy poverty.

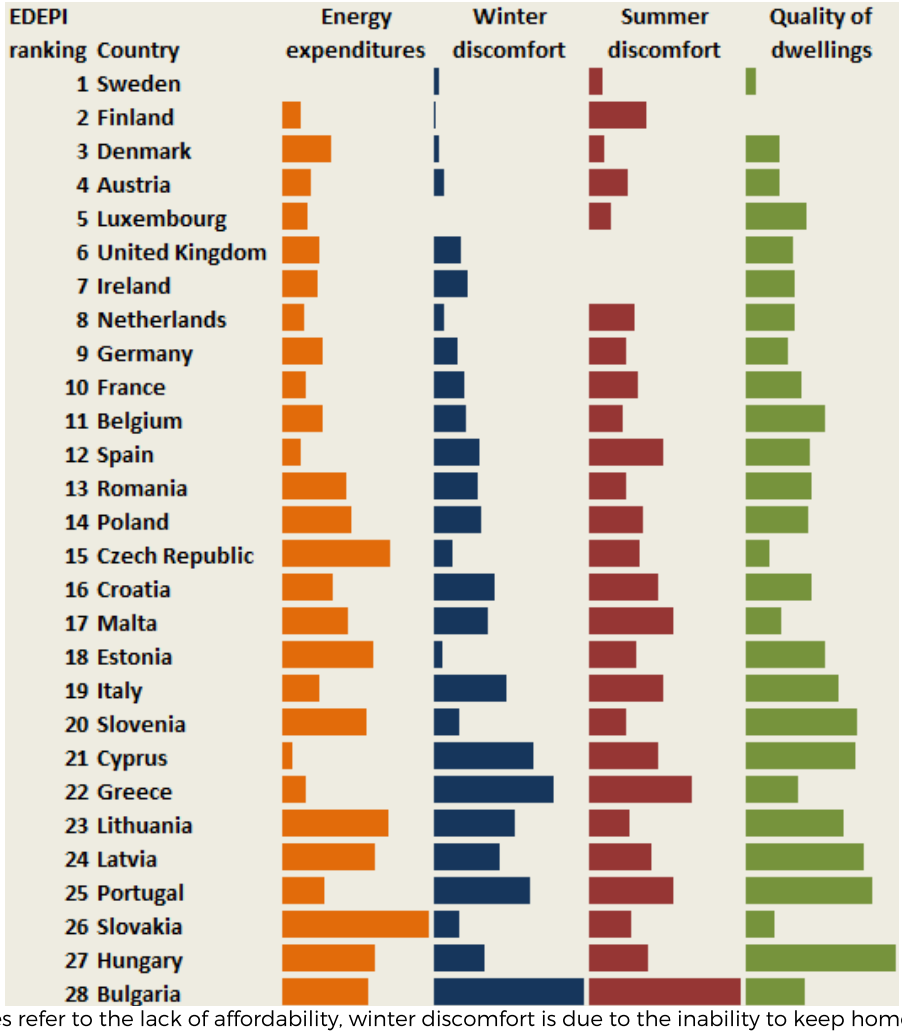
However, the EDEPI scoring points out to the need for Sweden to consider tackling summer domestic energy poverty given that almost 10% of the first income quintile population lives in dwellings not comfortably cool in summer. This reflects the country's strategy of highly insulating dwellings, which began in the fifties. Given a well-documented anticipation in rising temperatures (IPCC, 2018, S. Russo & al, 2015), the EDEPI scoring calls for a holistic building design for new buildings and renovation strategies which include features such as efficient ventilation, passive cooling solutions and solar shading.

On the contrary, an important progress is needed in Bulgaria to alleviate both summer and winter domestic energy poverty. In fact, first income quintile population in Bulgaria face almost equally summer and winter domestic energy poverty. Bulgaria is the country with the highest share of the first income quintile citizens living in dwellings not comfortably cool in summer (71%) and the EU Member State with the highest share of the first income quintile citizens unable to keep their homes warm in winter (64%). Moreover, first income quintile population in Bulgaria suffer heavily from the weight of their energy expenditures, which represent more than 14% of their disposable income.

Overall, the EDEPI scoring of Member States shows a clear divide in the progress made in alleviating domestic energy poverty between Western/Northern countries and Eastern/ Southern-Eastern countries as well as the Baltic States (Figure 2). The former group of countries includes those with high scores and rankings while the latter group of countries includes those with low scores and rankings.

The top ten countries (when considering only the progress made in alleviating domestic energy poverty) include Sweden, Finland, Denmark, Austria, Luxembourg, the UK, Ireland, Netherlands, Germany and France. These countries are Member States with a GDP per capita higher than the EU average and with long-standing building regulations and policies to tackle domestic energy poverty. As a result, first income quintile population in these countries allocate less than 10% of their disposable income to their domestic energy expenditures.

Figure 3 Contribution of each dimension of domestic energy poverty to the EDEPI ranking



Energy expenditures refer to the lack of affordability, winter discomfort is due to the inability to keep homes warm, summer discomfort is due to the inability to keep homes cool and the quality of dwellings is due to the presence of leaks/damp.

Key point: Member States should work towards alleviating all dimensions of domestic energy poverty.

The ten most lagging countries include Bulgaria, Hungary, Slovakia, Portugal, Latvia, Lithuania, Greece, Cyprus, Slovenia and Italy. These countries are Member States with a GDP per capita lower than the EU average and which are relatively new to building regulations as well as to policies tackling domestic energy poverty. As a result, first income quintile citizens in these countries spend more than 10% of their disposable income for their domestic energy expenditures.

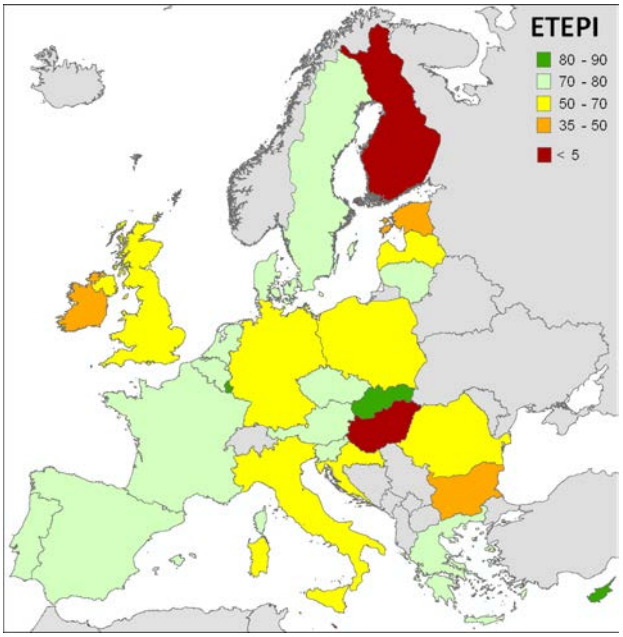
The Western/Nordic geographical location has given a clear advantage in policy design for policy makers. First income quintile populations living in Northern/Western Europe were at risk of facing mainly winter domestic energy poverty while those living in Southern/Eastern-Southern Europe have been at risk of facing both summer and winter domestic energy poverty (Figure 3). The former is addressed by insulating homes and by improving energy efficiency of heating systems while the latter requires a smart combination of insulation, passive cooling solutions and efficient cooling/ventilation systems.

The UK and Ireland illustrate well the advantages of the Nordic geographical location. The former is ranked 6th and the latter is ranked 7th, which seems relatively better than many other EU countries. In actuality, winter energy poverty is a serious concern in both countries whereas summer energy poverty is not a concern at all due to their relatively cool, wet climate. The shares of the population living in dwellings not comfortably cool in summer in these two countries are the lowest ones in Europe. When the indicators for winter and summer energy poverty are weighted equally, these two countries perform better than their Southern/Easter-Southern counterparts.

Similarly, Portugal, Italy and Spain have low scores and rankings as these countries have to alleviate at the same time summer and winter domestic energy poverty. Portugal, which ranks 25th, has an equal share (41%) of the first income quintile citizens living in homes not comfortably warm in winter and homes not comfortably cool in summer. Italy which ranks 19th, is the sixth-highest country for the share of the population facing winter domestic energy poverty with 32% of the first income quintile citizens unable to keep their homes warm in winter. Italy is also the 5th worst country regarding the progress made in alleviating summer domestic energy poverty with 37% of the first income quintile population reporting living in dwellings not comfortably cool in summer. Spain which ranks 12th comes just after Italy for summer domestic energy poverty and is the 12th worst country regarding winter domestic energy poverty. It is worth noting that the share of the first income quintile citizens unable to keep their homes warm in Spain is almost equal to the one in Poland.

ETEPI scoring

Figure 4 Member States' progress in alleviating transport energy poverty



Key point: Some Southern and Eastern-Southern countries perform better in alleviating transport energy poverty than some of the Northern and Western countries due to lower dependency on cars for daily trips.

The ETEPI ranks Member States based on their resulting scores related to the progress made in alleviating transport energy poverty (Figure 4 and 5). However, given the current shortcomings in data assessing all dimensions of transport energy poverty, the 2018 ETEPI edition captures only few of the causes and none of the symptoms of transport energy poverty identified in the literature (G. Mattioli & al, 2018, A. Leung & al, 2018, A. Berry, 2018). Thus, the reliability of the ETEPI scoring and ranking is low compared to the results from the computation of the EDEPI. The ETEPI scoring is included in this report to provide a starting point, and to raise awareness about the lack of data to better assess progress made in alleviating transport energy poverty.

Causes of transport energy poverty captured by the 2018 ETEPI edition include: 1) the share of transport energy expenditures out of the total expenditures for car-owning first income quintile citizens which captures at the same time the cost of petrol, the efficiency of the vehicle owned and distance travelled; 2) the level of difficulty in accessing public transport; and, 3) the affordability of public transport which captures the cost and the distance travelled.

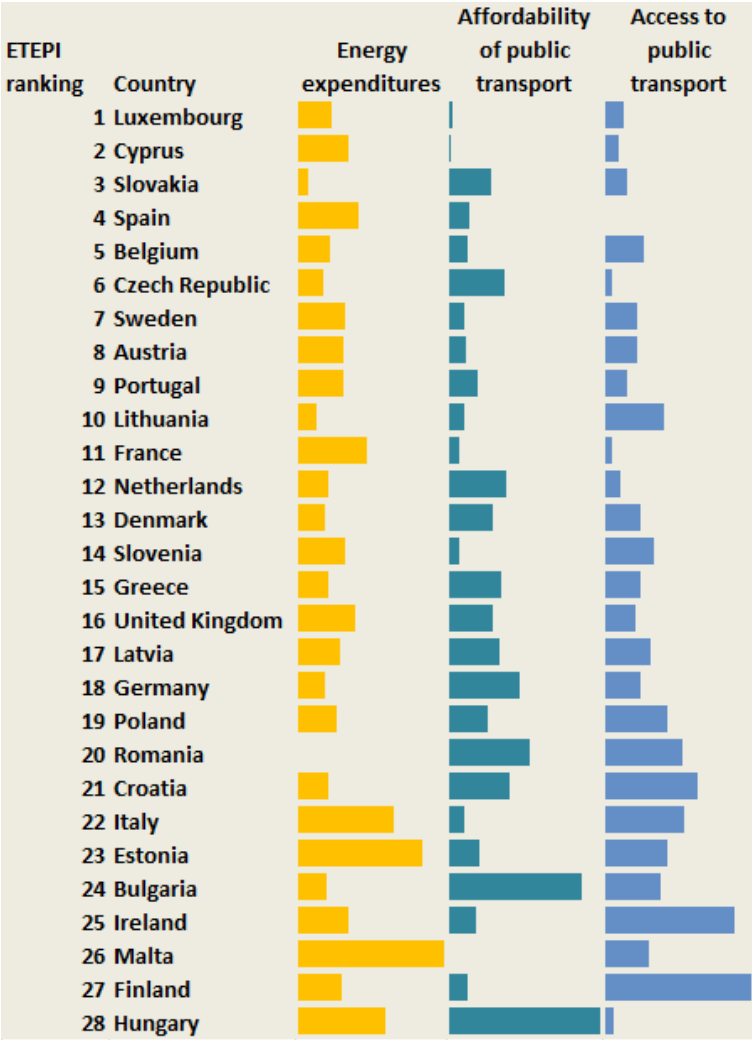
When all dimensions considered are equally weighted in the computation of the ETEPI, Luxembourg ranks first, and Hungary ranks last (Figure 4 and 5). The ETEPI scoring of Hungary is due to the low-affordability of transport energy expenditures, both for car owning citizens and those using public transport. In fact, the share of transport energy expenditures out of total expenditures of the first income quintile citizens in Hungary is more than double the one in Luxembourg. Furthermore, 21% of the first income quintile population in Hungary reported its inability to afford public transport against 0.5% in Luxembourg. Regarding the access to public transport, 4% of the first income quintile population in Luxembourg reported low access against 2.9% in Hungary (Figure 5).

Ireland ranks 25th and Finland ranks 27th due to the limited accessibility to public transport (Figure 5). In fact, these two countries have the highest shares of the first income quintile citizens reporting low access to public transport with 16% in Ireland and 18% in Finland. This reflects the urban and land-use policies in these two Member States which encourage the construction of single-family homes located far from urban centres where public transport is likely to be available and accessible.

The top ten countries include Luxembourg, Cyprus, Slovakia, Spain, Belgium, Czech Republic, Sweden, Austria, Portugal and Lithuania. While the ten most lagging countries include Hungary, Finland, Malta, Ireland, Bulgaria, Estonia, Italy, Croatia, Romania and Poland (Figure 5). The ETEPI scoring shows a different picture of the progress made in Europe in alleviating energy poverty. Some of Southern/Eastern-Southern countries perform better than some of the Western/Northern countries in alleviating transport energy poverty given the limited use of private cars for daily trips in these countries and the high use of public transport and other modal shift options (Special Eurobarometer, 2014).

France ranks 11th while the UK ranks 16th and Germany ranks 18th. Progress made in these three countries, with a GDP per capita higher than the EU average, in alleviating transport energy poverty transport varies based on the urban and transport policies implemented in the last decades. France has encouraged urban sprawl leading to an increase of car dependency and consequently the heavy weight of transport-energy related expenditures for the first income quintile citizens. In other words, those living in lower cost housing outside the city centre often have less access to frequent and accessible public transportation links, which means there is a trade-off between lower cost of housing and car dependency. The UK privatisation of public transport made their use as costly as the use of private cars. Moreover, the UK provides financial support for the use of public transport. However, the subsidy targets vulnerable people (such as the elderly) instead of strictly first income quintile populations. In Germany, almost 10% of the first income quintile citizens reported their inability to afford the use of public transport on regular basis.

Figure 5 Contribution of each dimension of transport energy poverty to the ETEPI ranking



Energy expenditures refer to fuel spending for car-constrained citizens.

Key point: Member States should work towards the alleviation of all dimensions of transport energy poverty.

POLICY IMPLICATIONS

Energy poverty has recently gained wider attention as a priority policy issue at the EU and national levels. However, transport energy poverty and the domestic/transport energy poverty nexus are yet to be considered. In fact, at the EU level, at least four instruments include provisions aiming at alleviating domestic energy poverty (Table 1) while no instrument with provisions aiming at alleviating transport energy poverty was identified.

Table 1 EU instruments and provisions aiming at alleviating domestic energy poverty

EU policy instrument	Aspect of domestic energy poverty tackled
Internal Market in Electricity Directive (EC, 2019-A)	Providing protection to energy poor population (Article 28)
	Definition of the factors leading to domestic energy poverty (Article 29).
	Citizen empowerment through citizens energy communities (Article 16).
Energy Performance of Buildings Directive (EC, 2018-a)	Improving energy performance of existing buildings and including, in the renovation strategies, planned measures to tackle domestic energy poverty (Article 2a).
Energy Efficiency Directive (EC, 2018-b)	Explicit requirements to tackle domestic energy poverty (Article 7).
Governance regulation (EC, 2018-c)	Integrated reporting on energy poverty in the National Energy and Climate Plans (NECPs) (Article 21a).
Renewable energy directive (EC, 2018-d)	Citizen empowerment through renewable energy communities (Article 22).

Key point: The new provisions proposed in the Clean Energy for all Europeans Package are an important step forward from reporting and planning perspectives.

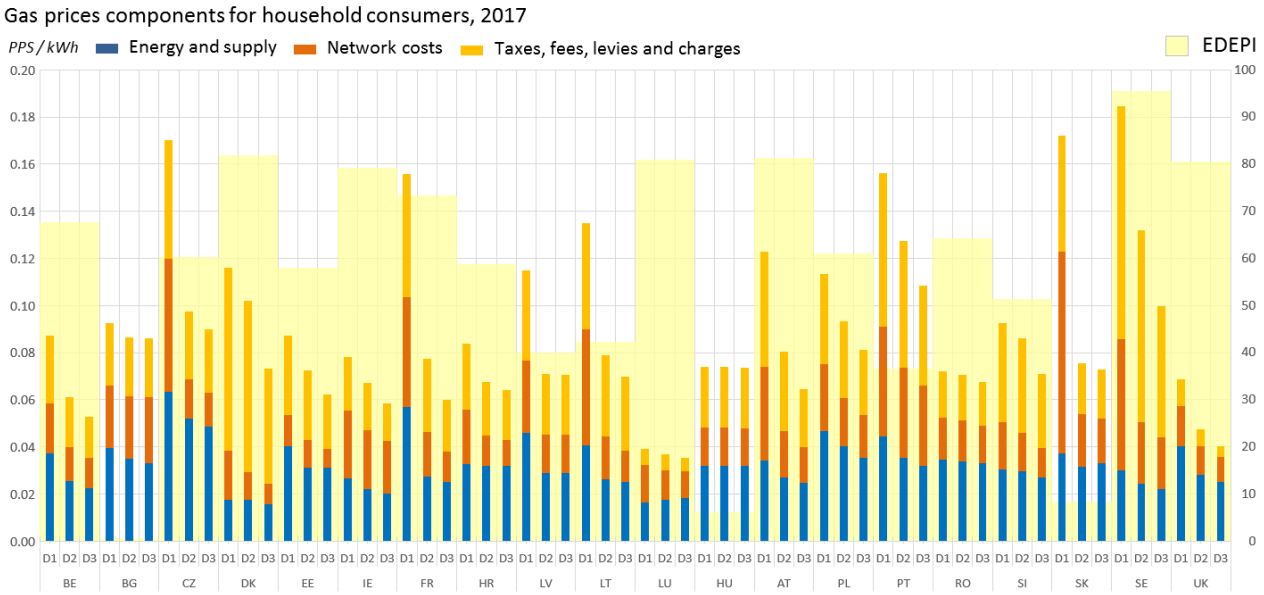
Provisions adopted under the Clean Energy Package for all Europeans are an important step forward in terms of planning and reporting on actions implemented by Member States in tackling domestic energy poverty. However, progress in reporting will not necessarily mean progress in alleviating domestic energy poverty.

As described in the recast of the Internal Market for Electricity Directive (EC, 2019-A), the two energy factors leading to domestic energy poverty are poor energy efficiency of dwellings and high energy expenditures which result from energy prices and energy consumption of dwellings. The latter being driven by the energy efficiency of dwellings, appliances and equipment as well as consumers' behaviour.

Winter domestic energy poverty has recently gained wider attention as a priority policy issue at the EU and national levels. However, summer domestic energy poverty and transport energy poverty are still overlooked.

The level of energy efficiency of dwellings is tackled in the Energy Performance of Buildings Directive (EC, 2018-a) by requiring all new buildings to be nearly Zero Energy Buildings (nZEB) by 2021. The Directive also requires Member States to develop renovation strategies aiming at decarbonising the building stock by 2050. However, the current and forecasted low construction rates in Europe are unlikely to significantly increase the market share of nZEB. Similarly, in the absence of a clear energy performance target for renovated buildings to make them positive energy, it is unlikely that the renovation strategies developed by Member States will effectively contribute to alleviating domestic energy poverty.

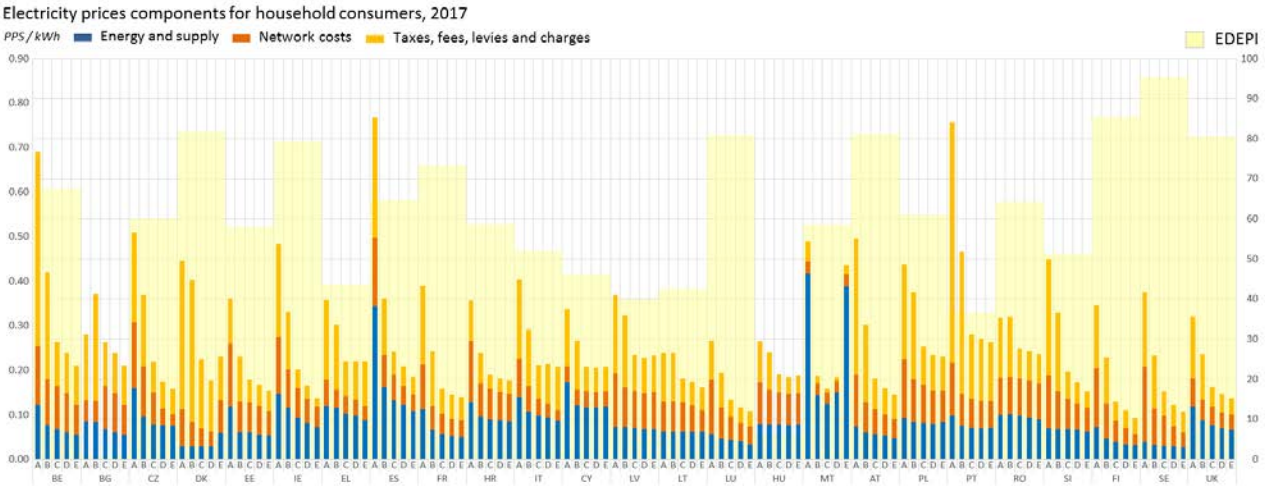
Figure 6 2017 Breakdown of domestic gas prices per consumption bands and EDEPI scoring



D1: Consumption <20 GJ, D2: 20 GJ < Consumption < 199 GJ, D3: Consumption > 200 GJ

Key point: It is likely that energy poor household pay a higher price for each unit of gas consumed as gas prices are higher in the lowest consumption band in almost all Member States.

Figure 7 2017 Breakdown of domestic electricity prices per consumption bands and EDEPI scoring



A: Annual consumption < 1000 kWh, B: 600 kWh < Annual Consumption < 2499 kWh, C: 2500 kWh< Consumption <4999 kWh, D: 5000 kWh < Consumption < 14999 kWh, E: Consumption >15000 kWh

Key point: It is likely that energy poor household pay a higher price for each unit of electricity consumed as electricity prices are higher in the lowest consumption band in almost all Member States.

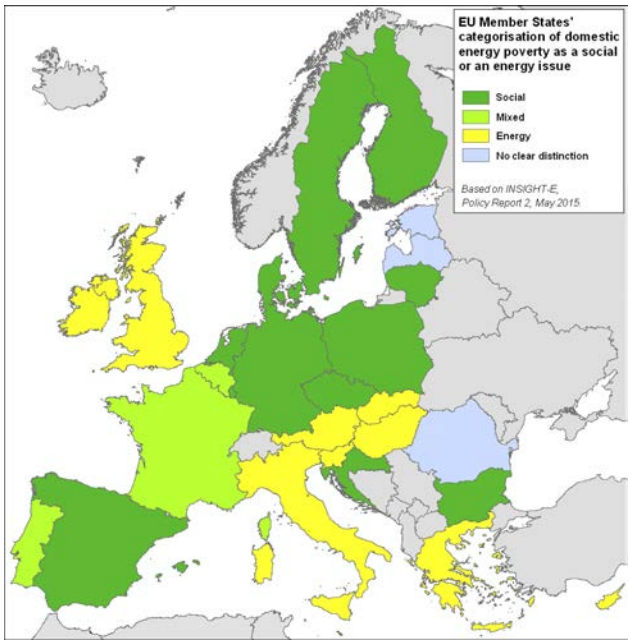
Furthermore, the concept of energy communities introduced in the Renewable Energy Directive (EC, 2018-d) and in the recast of the Internal Market for Electricity Directive (EC, 2019-A) may well empower citizens. However, alleviating domestic energy poverty requires producing more energy than needed by these communities. Unfortunately, this is unlikely to happen if Europe's buildings are not first made highly energy efficient and if public finance continues to support low-hanging fruit solutions when buildings are renovated. Overall, the lack of a clear energy performance target to achieve when buildings are renovated will hinder EU citizens' right to access energy services for all, as called for in Principle 20 of the European Pillar of Social Rights.

Regarding energy prices, it is worth noting that the cost of the unit of both electricity and gas is higher for those consuming less in almost all Member States (Figure 6, 7). This penalises first income quintile citizens. In fact, the shares of the EU population unable to keep their homes warm in winter and/or comfortably cool in summer suggest that first income quintile populations have low energy consumption, which means they pay the highest cost for each unit of energy consumed. Furthermore, the Internal Market for Electricity Directive (EC, 2019-A) allows for financial support to energy poor citizens. However, it is unlikely that this financial support, through social tariffs and other means, would compensate for the injustice of the current tariff design.

At the Member States level, policies aiming at alleviating domestic energy poverty vary upon the categorisation of domestic energy poverty at national levels (Figure 8). Member States categorising domestic energy poverty as an energy issue usually provide financial support to renovate buildings occupied by energy poor households and introduce social tariffs to compensate for the injustice of current tariff design.

Member States categorising domestic energy poverty as a social issue only provide mainly financial support to pay for energy bills. Member States categorising domestic energy poverty as a social and an energy issue usually combine the measures listed above. However, whatever categorisation decided at the national levels, the lack of ambition regarding the level of energy performance buildings should achieve and the lack of awareness about the injustice of tariff design may well hinder Europe's target to ensure access to energy services for all. Overall, the EEPI scoring of Member States progress in alleviating energy poverty brings new insights. It provides evidence for the need for a more holistic approach to energy poverty which considers the transport and domestic energy poverty nexus. Urban and land-use policies are the policy instruments where the nexus could be addressed. Regional funds could contribute in tackling the transport and domestic energy poverty nexus. The tracking of energy poverty at local level introduced by the Covenant of Mayors initiative is a good step forward. However, metrics considered should include all the dimensions of both transport and domestic energy poverty.

Figure 8 Member States' categorisation of domestic energy poverty



Key point: Measures implemented to alleviate domestic energy poverty vary upon Member States' categorisation of energy poverty.

CONCEPTUAL FRAMEWORK

The EEPI addresses the data gap and creates an environment in which all dimensions of both transport and domestic energy poverty can be continually evaluated.

Rationale

Energy poverty is a complex and multi-dimensional phenomenon at the crossroads of several scientific disciplines and policy areas. Domestic and transport energy poverty are dual facets of it. First income quintile citizens, especially those living in peri-urban and rural areas, are at a considerable risk of facing both domestic and transport energy poverty. Domestic energy poverty increases the risk of long-standing health problems which may lead to premature deaths (G. Forzieri & al, 2017). Transport energy poverty increases the risk of socio-economic exclusion, especially in the case of elderly and/or disabled people who cannot drive, use public transport, walk and/or bike to meet their basic socio-economic needs such as work, leisure, health and education.

Measuring progress made in alleviating all dimensions of energy poverty is not straightforward, especially if cross-country analyses are needed. Common metrics used to assess energy poverty levels treat dimensions of energy poverty separately. While these indicators are useful to understand the progress made in alleviating each dimension individually, the multi-dimensionality of energy poverty is not captured by existing metrics. Hence, a composite indicator is needed to track and understand the progress made by Member States in alleviating energy poverty when all of its dimensions are considered. The EEPI addresses this data gap and creates an environment in which all dimensions of both transport and domestic energy poverty can be continually evaluated.

The EEPI framework (Figure ES.1) includes the causes and symptoms of both transport and domestic energy poverty identified in EU policy instruments and/or in the literature. It provides a tool for policy-makers and advocates for assessing progress made in alleviating transport and domestic energy poverty at the same time. The EEPI combines in one single figure the common metrics used for assessing the progress made in alleviating the causes of energy poverty with those assessing the progress made in alleviating its identified symptoms. Thus, capturing all dimensions of energy poverty. Alleviating the consequences of energy poverty, described in the EEPI framework (Figure ES.1), are not included in the computation of the index and its sub-indexes as they are addressed by non-energy policies.

Importantly, the EEPI and its sub-indexes do not replace existing metrics. This is particularly true if the assessment of the impacts of national policies focuses on only the progress made in alleviating one of the dimensions of energy poverty. On the contrary, the EEPI and its sub-indexes complement existing metrics by allowing across country analyses of the progress made in alleviating all dimensions of the transport and domestic energy poverty and their nexus.

EEPI Metrics

The EEPI framework (Figure ES.1) allows calculating three metrics, 1) the overall EEPI, 2) the European Domestic Energy Poverty sub-Index (EDEPI) and 3) the European Transport Energy Poverty sub-index (ETEPI). The EEPI and its sub-indexes are developed using the international OECD/JRC methodology for composite indicators (OECD, 2005) and are computed as geometric means of the metrics used. The 2018 edition of the EEPI and its sub-indexes include data from different years, depending on the latest available year for each given metric (Table 2 and 3). The EDEPI is comprised of four metrics that capture the causes of domestic energy poverty described in the recast of the Internal Market for Electricity Directive (EC, 2019-A) and the symptoms of domestic energy poverty identified and described in the literature (Trinomics, 2016, H. Thomson & al, 2017 and EC, 2019-b).

Causes of domestic energy poverty considered in the EU legislation (EC, 2019-a) include income levels, the efficiency of homes and the share of energy expenditures out of households' disposable income. The weight of the latter in household budgets may lead to low energy affordability which is defined as households' inability to pay for their energy expenditures (OECD, 2017). In recent years, the share of energy expenditures out of total households' expenditures has risen in Europe, especially for low-income households (EC, 2019-b). Moreover, low energy affordability was identified in the literature as an important driver of domestic energy poverty (Hill 2012, Thomson & al 2013, Insight 2015, S. Bouzarovski & al 2017, B. Boardman 1991 and 2010).

Symptoms of domestic energy poverty identified in the literature (Trinomics, 2016, H. Thomson & al, 2017 and EC, 2019-b) include indoor discomfort which is caused either by high indoor temperature in summer or low indoor temperature in winter. The level of humidity also plays an important role in occupants' comfort. Energy use patterns determine the level of indoor comfort needed while the quality of the building envelope (including walls, roofs and windows) and the efficiency of cooling and heating systems determine the level of comfort achievable in each room and consequently affect energy consumption and energy bills.

Transport energy poverty (car-constrained citizens and those using public transport) has attracted less policy attention at the EU level than domestic energy poverty.

Transport energy poverty has attracted less policy attention at the EU level than domestic energy poverty has. Indeed, transport energy poverty is not yet recognised as an issue to address in EU legislation despite the impacts of mobility on the socio-economic exclusion of first income quintile citizens. This contrasts sharply with the Energy Union's objective to be inclusive and the Principle 20 of the European Pillar for Social Rights.

Building on the implicit analogy between domestic and transport energy poverty, a framework capturing at the same time the symptoms and the causes of transport energy poverty identified in the literature (G. Mattioli & al, 2018, A. Leung & al, 2018, A. Berry, 2018), is included in the EEPI (Figure ES.1)

Limiting travels to meet various basic socio-economic needs is a clear symptom of transport energy poverty. While causes of transport energy poverty include: 1) the affordability of transport which is related to the level of incomes, public transport spending which is based on the cost of public transport and the distances travelled and/or fuel spent which is based on the distances travelled and the energy performance of the vehicle; 2) the availability of public transport which allows capturing the existence of alternatives to the use of private cars, and; 3) transport practices which reflect the spatial distribution of each type of transport (cars, bikes, buses, trains, motorbikes, ride sharing…). The 2018 ETEPI edition is comprised only of three metrics that capture the causes of transport energy poverty. Due to data availability, symptoms of transport energy poverty and transport practices are not fully captured in this edition. Future releases of the index will include additional data if made available by Member States.

Indicators used for the development of the EEPI

Metrics used to assess progress made in alleviating each cause and each symptom identified of domestic and transport energy poverty are those available in EUROSTAT databases complemented by DG Energy ad-hoc data collection for the share of energy expenditures out of total expenditures (Table 2 and 3).

Unfortunately, not all the identified indicators were available nor gathered in recent years. This is especially true when it comes to indicators related to summer domestic energy poverty and to transport energy poverty. Moreover, some of the indicators are provided per income quintile while others are provided per poverty thresholds. For the purpose of the 2018 EEPI edition, all indicators have been converted into per income quintile indicators using EUROSTAT micro-data (see Annex) and the index was computed for the first income quintile citizens.

All indicators needed to assess progress made in alleviating both domestic and transport energy poverty should be reported by Member States in their NECPs to make cross country analysis possible.

A snapshot of the indicators used to assess the progress made in alleviating each symptom and each cause, their last year of availability as well as their use for various EU initiatives which track progress in alleviating energy poverty is provided in Table 2 and 3. Despite the limitations of individual metric described in the literature (H. Thomson, 2017), the EEPI provides new insights regarding the progress made by each Member States in alleviating both transport and domestic energy poverty and their nexus.

Table 2 Domestic Energy poverty indicators: Availability and use in various EU databases, instruments and targets

Indicator	Domestic energy poverty cause/symptom captured by the indicator	Availability in EUROSTAT	Use of the indicator for SDGs	Availability in the EPOV
Share of housing energy expenditures out of households' expenditures, for the 1st income quintile households	Causes: -Poor energy efficiency of dwellings leading to high energy consumption -Energy prices -Income levels	Yes, but updated every five years by EUROSTAT and every two years by DG ENERGY	Not included	Yes, but as a secondary indicator.
Share of the population, with income below 60% of median equivalised income, living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor	Cause -Low quality of dwellings	Yes, updated every year	SDG 1 and SDG 11	Yes, but as a secondary indicator
Share of the population, with income below 60% of median equivalised income, unable to keep their homes warm in winter	Symptom -Basic standards of living (thermal winter discomfort)	Yes, updated every year	SDG 1 and SDG 7	Yes, as a primary indicator
Share of, the first income quintile, population living in dwellings not comfortably cool in summer	Symptom -Basic standards of living (thermal summer discomfort)	Available only for 2012.	Not included	Yes, but as a secondary indicator

Key point: Member States should be required to include in their NECPs all indicators needed to assess progress in alleviating domestic energy poverty

Table 3 Transport energy poverty indicators: Availability and use in various EU databases, instruments and targets

Indicator	Energy poverty cause/ symptom captured by the indicator	Availability in EUROSTAT	Use of the indicator for SDGs	Availability in the EPOV
Share of transport energy expenditures out of households' expenditures, for the 1st quintile of car-owning households	Causes: -Poor efficiency of vehicles -Travelled distances leading to high energy consumption -Fuel prices -Income levels	Not included in EUROSTAT but provided every two years by DG ENERGY.	Not included	Not included
Share of the population, with income below 60% of median equivalised income, who cannot afford regular use of public transport	Causes: -Income level -Cost of public transport. -Travelled distances	Available only for 2014	Not included	Not included
Share of the, 1st income quintile, population, with limited access to public transport	Cause: -Availability of public transport	Available only for 2012.	SDG 11	Not included
Modal split of passenger transport	Cause: -Transport practice due to the degree of urbanisation	Yes, updated every year but the breakdown per income quintiles is not available	SDG 9 and SDG 11	Not included

Key point: Member States should be required to include in their NECPs all indicators needed to assess progress in alleviating transport energy poverty

CONCLUSIONS AND NEXT STEPS

The EEPI and its indexes provide, for the first time, a snapshot of the progress made in alleviating both domestic and transport energy poverty in EU Member States. It scores and ranks Member States using existing metrics and data supplied to EUROSTAT. The EEPI goes one step beyond common assessment of energy poverty alleviation by considering alleviating the transport and domestic energy poverty nexus. Moreover, it looks at the combined effect of summer and winter domestic energy poverty. Regarding transport energy poverty, the index looks at car-constrained first income quintile citizens as well as those using public transport for their daily trips needed to meet their basic socio-economic needs.

Most importantly, a comprehensive framework which includes all the causes and symptoms of both transport and domestic energy poverty identified in EU policy instruments and/or in the literature (Figure ES.1) is proposed for the 2018 EEPI edition. The EEPI framework captures all dimensions of both transport and domestic energy poverty. Moreover, it provides a tool for policy-makers and advocates for assessing progress made in alleviating energy poverty.

The methodology and the conceptual framework proposed for the development of the EEPI have been discussed with experts from the Composite indicators and Competence Centre on Composite Indicators and Scoreboards of the European Commission's Joint Research Centre as well as with experts and stakeholders involved in energy poverty. Unfortunately, due to the lack of data, not all the suggestions to improve the framework and the methodology were considered for the 2018 EEPI edition. However, the EEPI will undergo continuous improvement in the upcoming years and new datasets will be included, when available, in the computation of the index. The first step towards this improvement is to re-compute the index after the release of more recent micro data by EUROSTAT.

The EEPI framework captures all identified causes and symptoms of both transport (car-constrained and users of public transport) and domestic (summer and winter) energy poverty.

An interesting follow-up to this work would be to use the EEPI framework to assess energy poverty alleviation at local and/or regional levels. This would require EUROSTAT to provide a breakdown of the metrics used at the NUTS2 level. Local authorities overseeing housing and transport should be interested in assessing transport and energy poverty nexus in their territories. At the EU level, such analysis would allow for a better targeting of EU financial support for alleviating energy poverty at local/regional levels as well as the EU support for housing and transport infrastructures. Given the role EU financial support is playing in shaping European cities and rural areas, it is of a high importance to consider alleviating both transport and domestic energy poverty in the upcoming EU investments in the decarbonisation of Europe's energy system.

Annex: Methodology

The development of the EEPI follows the steps described in the OECD/JRC methodology for composite indicators (OECD, 2005). The first step consists in the development of the conceptual framework based on the existing literature and stakeholders' input. The EEPI conceptual framework includes causes and symptoms of both domestic and transport energy poverty. Thus, all dimensions of the two facets of energy poverty are included in the proposed conceptual framework (Figure ES.1).

Conceptually, all the indicators identified present a negative direction (the lower the raw value the better is the performance). To ease the interpretation of the progress made in alleviating energy poverty, the direction of the indicators was reversed during the normalisation process. The following normalization formula, which considers the desired direction of the indicators: (max. value – original value) / (max. value – min. value) was used. As a result of this transformation, the better the performance of the country in an indicator the higher is the normalised score obtained.

The sub-indexes are calculated as a geometric means using equal weights. The purpose of introducing a geometric average is to limit the ability to compensate for good and bad performance in any of the individual indicators to be aggregated. Similarly, the overall index is computed as a geometric average of its sub-indexes and using equal weights.

The next step consists in analysing pairwise correlations on the 28 Member States. All correlations measured for domestic energy poverty, using the normalised variables and aggregated scores, are positive and each indicator fits statistically into the sub-index. The division between causes and symptoms in the variables seems justified by this analysis, as the largest measured correlation (0.79) is between the two variables linked to domestic energy poverty symptoms, which are self-reported indicators, while lowest correlations (0.15, 0.16 and 0.27) are observed between expenditure data and self-reported data. The lowest correlation between the primary indicators and the EDEPI is 0.54 and occurs for the share of the population living in leaky homes while the expenditure indicator has the highest correlation (0.73) with the EDEPI.

Correlations between primary indicators used for assessing the alleviation of transport energy poverty are relatively low compared to those observed for domestic energy poverty. However, each indicator correlates well with the overall sub-index. The highest correlation observed was with expenditure data (0.56). The correlation between the EEPI and its sub-indexes is significantly high with 0.71 for the EDEPI and 0.81 for the ETEPI despite the low correlation between the two sub-indexes.

A multivariate analysis was conducted to compare the statistical structure of the dataset to the theoretical framework. The first and second component of the EDEPI explain 78% of the variance while the first and second components explain 72% of the cumulative variance of the ETEPI. Two principal components of the EDEPI have an eigenvalue higher than 1 while only one latent dimension of the ETEPI has an eigenvalue higher than 1.

At the end of the process, a sensitivity analysis was conducted to test the robustness of the indicator. To do so, the indicator was computed several times (1000 simulations) after integrating various sources of data uncertainties. Countries are then ranked according to the disturbed indicators scores. The sensitivity analysis shows that countries such as Malta, Cyprus, Greece, Slovakia, Slovenia and Czech Republic are those with the highest uncertainty regarding their scores while countries such as Sweden, Netherlands, Denmark, France, Luxembourg and Austria are those with stable rankings.

List of figures and tables

List of acronyms

EEPI	European Energy Poverty Index
EDEPI	European Domestic Energy Poverty Index
ES	Executive Summary
ETEPI	European Transport Energy Poverty Index
EU	28 Member States
GDP	Gross Domestic Product
IPCC	Inter-governmental Panel on Climate Change
JRC	Joint Research Centre
NECAPs	National Energy and Climate Action Plans
nZEB	Nearly Zero Energy Building
OECD	Organisation for Economic Co-operation and Development
SDGs	Sustainable Development Goals

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ISBN: 978-2-9564721-5-5
EAN : 9782956472155

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