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Mapping energy poverty measures during the COVID-19 pandemic: A new global panel dataset

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Abstract

This paper compiles and presents a global panel dataset of energy poverty policy actions spanning the period March 2020 and March 2021. It builds on the COVID-19 Energy Map that collects policies to ensure the affordability of energy supplies for households during the COVID-19 pandemic. The monthly-frequency dataset is organized in a user-friendly way, allowing not only experts and researchers, but also the broader non-expert public, to examine and analyse the month-by-month policy changes across countries. The panel dataset is widely applicable for future research, especially as other global or regional datasets pertaining to the early years of the pandemic become available.

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Background and summary

Over the last two decades, approximately 867 million people world-wide gained access to energy services through electrification[1]. This is a major gain, but also 775 million people are still without basic electricity access. Another 2.4 billion persons continue to rely mostly on solid fuels, such as wood, coal or dung, for cooking and warmth[2]. Energy poverty, defined as a person's inability to access or use the necessary energy services to meet basic household needs (including cooking, lighting, telecommunication, keeping dwellings adequately warm) is a major risk factor threatening people's well-being and the exercise of their human rights[3]. Lacking access to affordable, reliable modern energy services is one of the many faces of poverty. Energy poverty is widely acknowledged to be associated with low-income levels, high energy prices, poor energy efficiency and various deprivations related to other poverty dimensions. For instance, lack of energy access translates into poor access to education, information, unhealthy living conditions, malnourishment, and difficulties to generate income[4]. Thus, poor energy access, low incomes, combined with other social deprivations represent a re-enforcing vicious cycle for vulnerable populations[3–5].

The COVID-19 pandemic and the war in Ukraine demonstrate the hazard that unexpected events termed as "black swans" can pose to progress on global development goals. According to the 2021 Sustainable Development Goals (SDG) Report, in developing countries in Africa and Asia, at least 25 million people who enjoyed access to electricity before the COVID-19 pandemic, were unable to pay for a basic bundle of services after the outbreak and thus lost their access. A further 85-90 million people lost their ability to afford an extended bundle of services, made up of several hours per day of lighting, television, phone and refrigeration[2,6]. The International Energy Agency (IEA) estimated recently that due to the pandemic, the overall number of people without access to electricity, globally, was expected to rise rather than decline for the first time in 20 years[7].

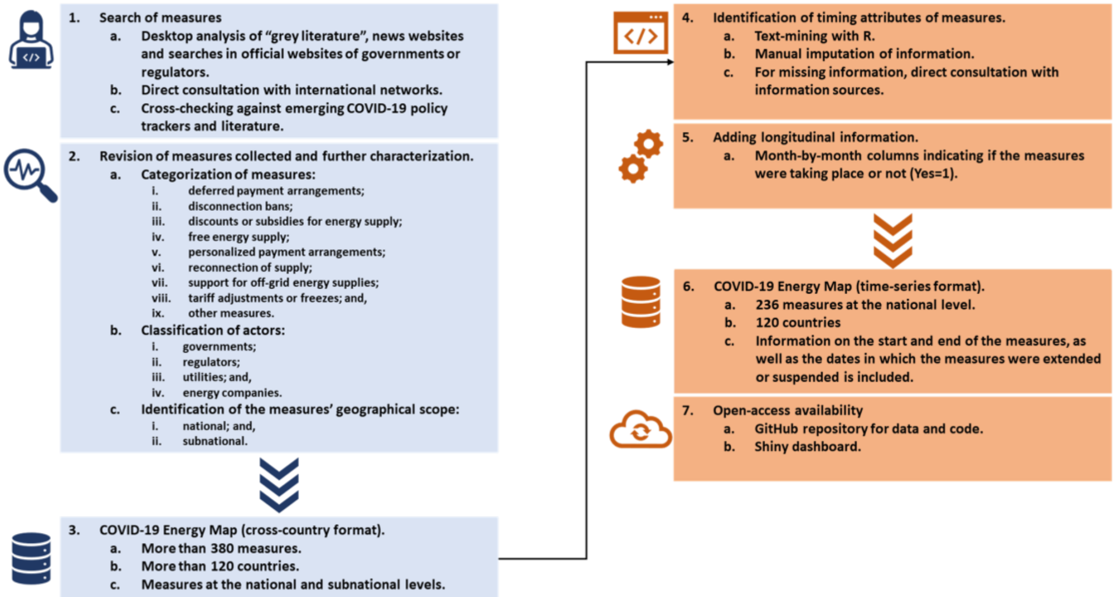
Broadly speaking, the deterioration of energy poverty conditions triggered by the COVID-19 crisis can be mainly attributed to three interlinked factors: loss of income, larger households' energy needs due to confinement policies, and higher energy prices[8–14]. At the same time, some households have greater energy needs or experience larger vulnerability to energy poverty due to factors such as age, disability, health-status, minority status, location, family size, dwelling type, or low energy efficiency[15–19]. Also, external events and certain political decisions can render people vulnerable to energy poverty. The war in Ukraine, for instance, came amid the COVID-19 emergency with cascading effects on the energy prices as a result of the disruptions and reductions in energy supplies[20]. Yet, even before the war, gas prices were rising due the economic fall-out from pandemic response and recovery, major planned and unplanned infrastructural issues (e.g. repairs, maintenance or closure of facilities), rising carbon prices in Europe, and various geopolitical tensions[10,21].

Price fluctuations due to COVID-19 have been observed in most regions of the world[8–12,22], particularly in the least developed countries[6]. As highlighted above, the COVID-19 pandemic and the war in Ukraine may reverse progress made in the 2010s, both by deepening and broadening already existing disadvantages faced by millions of vulnerable people. In this light, demands to support people deprived from energy services became urgent, and the pandemic, price crisis and war have each spurred governments, regulators, utilities and energy companies on to take protective measures[5,23–26]. A first initiative to comprehensively map the evidence of measures taken globally is the COVID Energy Map project, initiated by a group of researchers from the EU COST Action ENGAGER Energy Poverty during the pandemic[5]. Constructed based on a qualitative method of policy data collection, the map is a cross-country database capturing more than 380 emergency measures in more than 120 countries. Data are available at www.covidenergymap.com. It is still the most comprehensive global collection of emergency measures taken during the pandemic to ensure that energy supplies remain available and affordable for households. Measures are grouped into nine categories: disconnection bans, reconnection of supply, free energy supply, discounts or subsidies for energy supply, deferred payment arrangements, personalized payment arrangements, tariff adjustments or freezes, support for off-grid energy supplies, and other measures. The map comprises measures at the national, regional, and State/Province level, as announced by governments, regulators, utilities, and energy companies.

To date, little is known, however, about the effectiveness of different policy measures undertaken during the pandemic around the world,[27,28] in part because of the lack of available data on the timeline of their implementation. This paper is the first to use the original cross-country data from the map to generate a panel data set that incorporates information about the start and end dates of the measures, as well as dates on which the measures were extended or suspended. The paper thereby builds on the rich qualitative data of the map by filling in gaps for the period of March 2020-March 2021 especially. This period represents the first year of the pandemic, and the period for which data on the COVID-19 map is updated for all regions. To this end, information about dates has been extracted from the text description of each of the measures, and any gaps were filled as necessary through additional research (e.g., where measures originally applied until the end of states of emergency or lock down periods or start or end dates were not clearly stated). With this information, we created a longitudinal structure to indicate month by month whether a certain measure was in place. The data are organized in a user-friendly way, allowing not only experts and researchers, but also non-experts and those interested in general, to analyse the month-by-month policy changes across countries and link them to other socio-economic factors.

The dataset along with the R code to replicate the analysis is freely available from Figshare at https://doi.org/10.6084/m9.figshare.22652320 . We also developed an interactive graphical data visualization tool with maps to allow the users an easy exploration of the information https://jatorresmunguia.shinyapps.io/DashboardEnergyPov/. The processes of data collection, integration, and reshaping are described in Fig. 1 and are explained in detail in the Methods section below.

Fig. 1: Schematic overview of the data creation and reshaping from a cross-country to a panel data format.



Own elaboration based on the COVID Energy Map[5].

In the following sections, we describe the main patterns of the national emergency responses to mitigate energy poverty during the COVID-19 pandemic and present an illustration of the potential uses of this dataset to the research community.

Methods

This section offers a more detailed explanation of the dataset. Fig. 1 depicted a schematic overview of the steps involved in the creation of the longitudinal global dataset, comprising a collection of national emergency responses to mitigate energy poverty during the COVID-19 pandemic. Fig. 1 is divided in two parts. In blue on the left-hand-side, we outline the steps taken to build the COVID-19 Energy Map. On the right-hand-side of the figure, in orange, we show the process of transforming the COVID-19 Energy Map into a panel dataset spanning March 2020 to March 2021.

The COVID-19 Energy Map is a cross-country database capturing more than 380 emergency measures applied between March 2020 and March 2021 in more than 120 countries. It contains the following typology of measures: deferred payment arrangements, disconnection bans, discounts or subsidies for energy supply, free energy supply, personalized payment arrangements, reconnection of supply, support for off-grid energy supplies, tariff adjustments or freezes, and other measures. The measures included in the database were largely adopted at the national level by governments, regulators, utilities, and/or energy companies. In countries with highly decentralized decision-making on energy, measures at sub-national level (e.g., province-level, state-level or large metropolitan areas) were also included. Examples include the USA, India, Pakistan, or Belgium.

The COVID-19 Energy Map provides some text qualitatively describing each measure with information about the dates of implementation and duration. The descriptions are generally built up by listing: (a) the date the measure was first adopted or announced; (b) the actor announcing it; (c) a description of the measure, including its initial duration; and (d) any extensions or amendments of the measure over time. Labels for each measure separately highlight as visible categories: (i) the geographic scope of the measure (location); (ii) actor; (iii) measure description; (iv) type of measure; (v) data sources. The original map does not include formal end dates of measures, because in several cases, the duration of the measures was tied to the (then unknown) length of states of emergencies or lockdown periods, whilst the map was also regularly updated. The map is complete for all regions until March 2021. For several regions, e.g., Asia, Europe or Latin-America, the measures reflect research until March 2022 or September 2022. Due to the qualitative nature of the descriptions and information asymmetries in relation to different measures (e.g., more or less complex criteria for eligibility, the type of protection offered, number of people served by the measure, the size of budgets, the number of extensions and aforementioned lockdown periods) the descriptions contain different types of information, hampering easy accessibility of information about when measures were in place in certain countries.

These data have been improved through additional research and coded to generate the panel dataset in several steps. First, we extracted the information via text mining techniques. Since not all implementation dates were available, we manually imputed the information when missing. This information was collected for 13 months, over the period between March 2020 and March 2021. Second, we added a longitudinal structure by including separated columns, one for each month in this period. Each entry was then coded as a 1 if the specific measure was taking place in each month, and 0 otherwise. The unit of observation of our database is the country and includes the same categories of measures as the cross-country COVID-19 Energy Map. Finally, we constructed the database, and a visualization tool in the form of a Shiny dashboard, freely available at https://doi.org/10.6084/m9.figshare.22652320 and https://jatorresmunguia.shinyapps.io/DashboardEnergyPov/ (see Fig. 2). The visualization tool allows users to access and filter the data in a different manner.

Fig. 2: Illustration of the new Shiny Dashboard

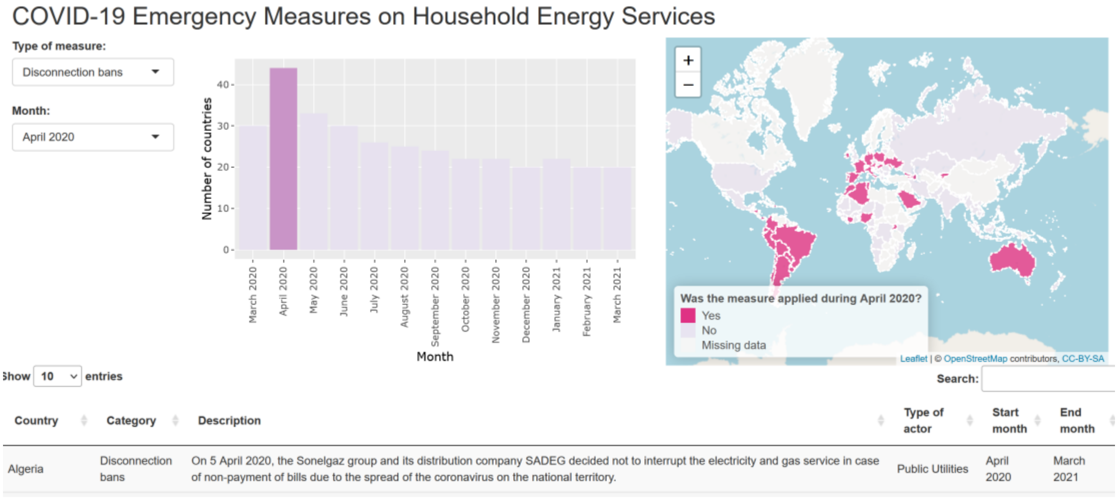


Fig. 3: Visualization of the existing COVID Energy Map on Google Map Platform

Data Records

The data are available from https://doi.org/10.6084/m9.figshare.22652320 . The website provides the file "MonthlyData.csv", with the following columns:

"Country": Name of the country.
"iso2": Alpha-2 country code from the ISO 3166.
"iso3": Alpha-3 country code from the ISO 3166.
"Category": Type of measure adopted against poverty energy as classified by the COVID-19 Energy Map (deferred payment arrangements, disconnection bans, discounts or subsidies for energy supply, free energy supply, personalized payment arrangements, reconnection of supply, support for off-grid energy supplies, tariff adjustments or freezes, and other measures)
"Description": Text providing detailed information about the measure.
"Type of actor": Actor implementing the measure (governments, regulators, utilities and energy companies)
"Start Month": Month in which the measure began.
"End Month": Month in which the measure ended.
"Start Extension 1": Month in which the measure was first extended.
"End Extension 1": Month in which the first extension of the measure ended.
"Start Extension 2": Month in which the measure was extended for the second time.
"End Extension 2": Month in which the second extension of the measure ended.

"Start Extension 3": Month in which the measure was extended for the third time.
"End Extension 3": Month in which the third extension of the measure ended.
"March 2020"-"March 2021": Binary variables indicating whether the measure is active in the given month (Yes = 1) or not (No = 0).

Technical Validation

All the information collected was cross-checked. The dataset with the energy measures has a link to the website where the information is located and, in this way, we were able to corroborate it.

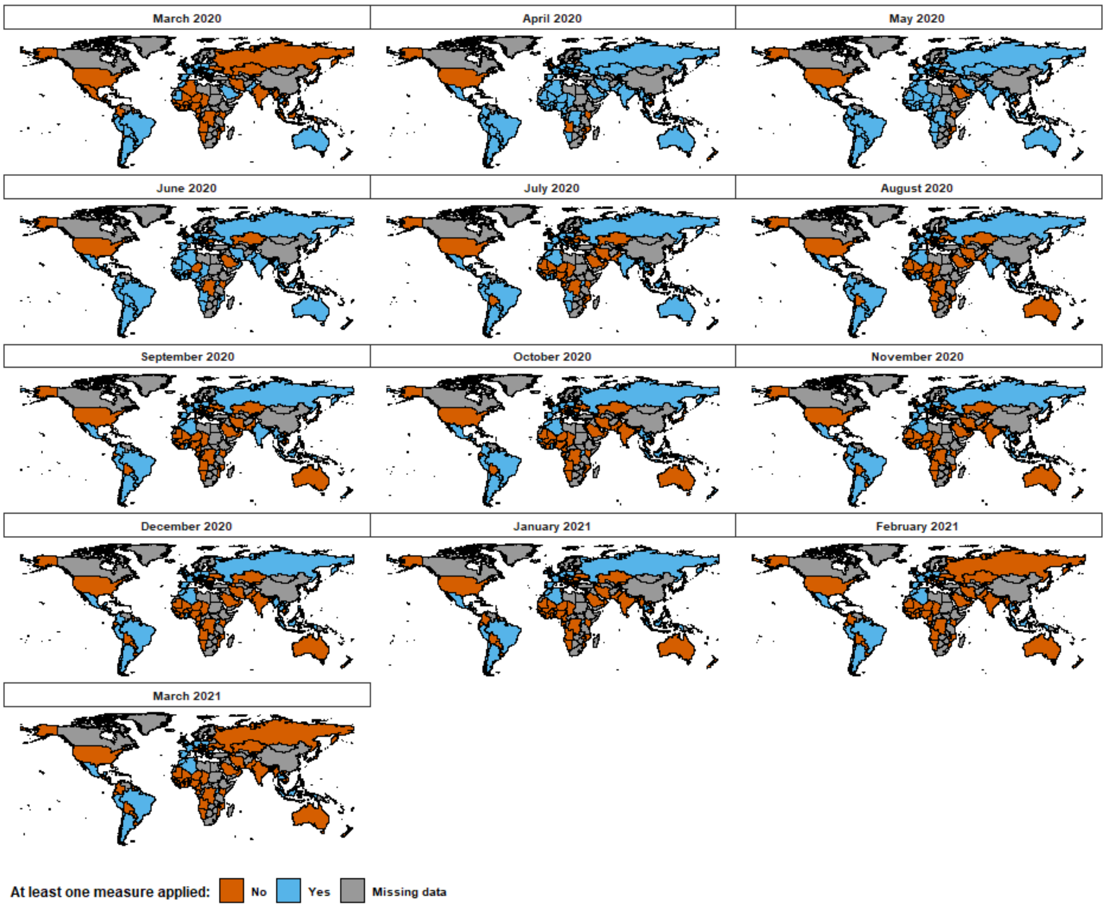
Usage Notes

The panel format of the national emergency measures on a monthly basis enables potential users to examine the timing of the country responses taken to mitigate energy poverty during the COVID-19 pandemic. This information is key to enhance knowledge on the types of measures adopted in different phases of the pandemic, and their duration, as economic and social impacts became visible.
The potential uses of the dataset are manifold. For example, it can be used in combination with economic data on household expenditure to investigate whether the policy measures have been effective in helping individuals to afford the increase in the energy bills. Another use, in the field of political science, is to examine whether countries with democratic regimes have introduced more measures than autocratic countries, and how countries with varying levels of energy access have acted differently. Moreover, an interesting question that could be addressed is whether the typology of the measures is also determinant in relation to their effectiveness. That is, whether some measures, such as free energy supply or personalized payment arrangements, are a better option than discounts or subsides for energy supply. The panel dataset greatly enhances the ability to generate various comparative insights across a broad range of countries, to zoom in on regional approaches and cross-country analysis. Additional qualitative research may also reveal how households have benefitted from protective measures in their day-to-day practice of life. Finally, the timing of the measures and the length in which they are maintained could provide relevant information to feed into the design of policies aimed at reducing (energy) poverty among some vulnerable groups. These insights take on new meaning in light of the measures currently also still being designed in response to the energy price crisis, and for future reference, as attention to energy poverty may increase.
To illustrate the potential use of our dataset to the research community we provide both a descriptive illustration of the global patterns in the timing of national emergency responses to mitigate energy poverty and an empirical analysis of the association between the poverty measures adopted and the time spent at home.

Descriptive illustration: Global patterns in the timing of national emergency responses to mitigate energy poverty

An important question that arises from the timing attributes of the data is whether there is a given time pattern according to which countries implemented the emergency measures. To explore this, Fig. 4 shows the monthly geographical distribution of countries in the world applying at least one measure against energy poverty at national level. This map provides the dynamics of how the measures developed throughout the study period. It should be noted that some countries, such as the United States of America (USA) or Belgium, do not seem to have any measures, even though measures are visible on the COVID Energy Map. This is because in some countries decision-making on energy takes place to a large extent or only at sub-national level. In other countries, measures were adopted both at national and sub-national levels, as in Australia, India, or Pakistan.

Fig. 4: Monthly geographical distribution of countries in the world implementing at least one measure at the national level against energy poverty.

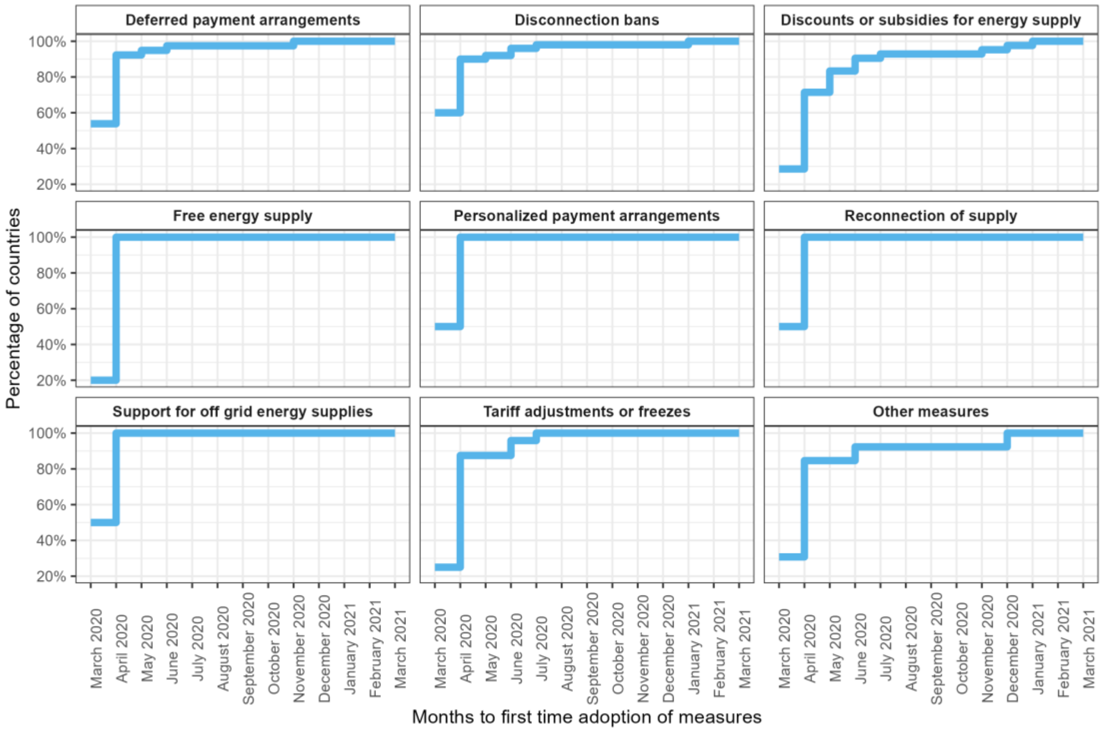


Missing data indicates that no information on national measures was found.

As Fig. 4 shows, in some regions of the world, particularly in the Global South, measures supporting households to afford their energy needs increased in the first month of the health emergency. However, in subsequent months some countries in Africa started lifting their measures rather quickly. Similarly, in Eastern Europe, the measures were mostly applied in the first months. By contrast, measures stayed in place nearly throughout the whole first year of the pandemic in some regions, especially in Latin/South America and in South-East Asia.

A noticeable pattern is found when observing the time elapsed in months until the first measure was taken. The data suggest the existence of a pattern in national responses to mitigate energy poverty. As can be seen in Fig. 5, most of the countries adopted at least one measure in the first months, mainly by establishing disconnection bans, support for off-grid energy supplies, deferred payment arrangements, personalized payment arrangements, and/or reconnection of supply.

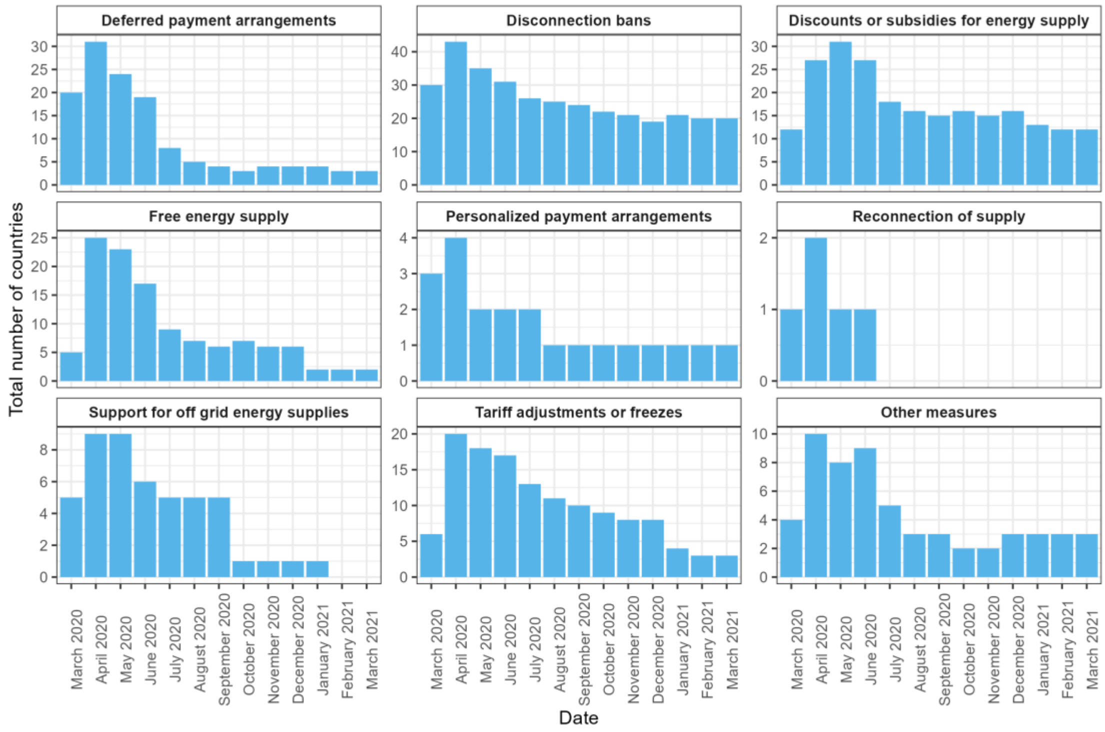
Fig. 5: First time adoption of measures. Percentage of countries that have adopted a measure and months to first adopting it by category of measure.



Percentages are calculated considering the total number of countries that had in place measures between March 2020 and March 2021. In total, there were 36 countries with deferred payment arrangements, 50 with disconnection bans, 41 with discounts or subsidies for energy supply, 25 with free energy supply, 6 with personalized payment arrangements, 2 with reconnection of supply, 8 with support for off-grid energy supplies, 24 with tariff adjustments or freezes, and 11 with other measures.

Other specific patterns are also observed during the first months of the pandemic. Fig. 6 suggests that countries tended to adopt measures primarily during the first three months of the health crisis, approximately between April – June 2020, with April 2020 being the month with the largest number of countries adopting a measure against energy poverty. After this month, the number of countries with active measures started to decline significantly.

Fig. 6: Number of countries having in place a measure by month and by type of measure adopted.



Empirical illustration: Energy poverty measures adopted, and time spent at home

In order to showcase a potential use of our newly constructed panel dataset, we present an analysis that combines the latter with other related datasets - particularly data on mobility[29] and income [1] - to study whether the energy poverty measures implemented during the COVID-19 pandemic around the world are associated with the time people spent at home.

To answer this research question, we estimate a fixed effects linear regression model for panel data, clustering standard errors by country and time, and controlling for countries' income level (using the World Bank Income Group Classification). Consider Y_{it} indicating the average change in time people in country i spent at home during month t, with the reference being the median time spent at home during the 5-week period from January 3 to February 6, 2020 in the same country[29]. The formal expression of the model is as follows:

$$Y_{it} = \beta_0 + \sum_{k=1}^{m} \beta_k X_{k,it} + \sum_{l=2}^{n} \gamma_l D_{l,i} + \varepsilon_{it} \qquad (1)$$

where β_0 is the model intercept, X represents the k explanatory variables whose coefficient is captured by β_k. Explanatory factors include our variables of interest, that is, dummy variables for each measure applied, and income group categories as controls with high income countries as base. D_l are dummy variables to capture the country fixed effects, and the γ_l are the country-specific intercepts capturing heterogeneities across countries, having as reference the β_0. ε_{it} is the model error term. Summary statistics are shown in Table 1.

Table 1. Summary statistics for variables in Model 1.

		Mean	Std. Dev.
Monthly average change in time spent at home		0.10	0.08
	Category	**N**	**Pct.**
Deferred payment arrangements	No	1310	84
	Yes	134	8.6
Disconnection bans	No	1123	72
	Yes	337	21.6
Discounts or subsidies for energy supply	No	1212	77.7
	Yes	230	14.7
Free energy supply	No	1430	91.7
	Yes	117	7.5
Tariff adjustments or freezes	No	1409	90.3
	Yes	130	8.3
Personalized payment arrangements	No	1478	94.7
	Yes	21	1.3
Reconnection of supply	No	1542	98.8
	Yes	5	0.3
Support for off-grid energy supplies	No	1487	95.3
	Yes	48	3.1
Other measures	No	1471	94.3
	Yes	58	3.7
	Category		
Country income group	Low income	130	8.7
	Lower middle income	429	28.7
	Upper middle income	494	33
	High income	442	29.6

Table 2 summarizes the results obtained from the empirical analysis. Code to replicate this analysis is available at https://doi.org/10.6084/m9.figshare.22652320 in the R project "Energy Poverty.Rproj".

Table 2. Estimation results from Model 1.

Variable	***Estimate***	***Std. Error***	***Pr(>|t|)***	
Deferred payment arrangements	**0.013**	**0.006**	**0.03**	*
Disconnection bans	**0.009**	**0.004**	**0.01**	*
Discounts or subsidies for energy supply	**0.013**	**0.006**	**0.04**	*
Free energy supply	-0.003	0.004	0.46	
Personalized payment arrangements	**-0.075**	**0.018**	**0.00**	***
Reconnection of supply	0.029	0.022	0.19	
Support for off-grid energy supplies	**0.009**	**0.003**	**0.00**	**
Tariff adjustments or freezes	0.020	0.011	0.07	.
Other measures	-0.016	0.013	0.25	

Independent variable is the monthly average change in time spent at home. '***', '**' and '*'denote significance at the 0.001, 0.01, and 0.05, respectively. Inference is based on robust standard errors clustered by country and time. Cross-sectional and serial correlation method proposed by Driscoll and Kraay[30] is applied for obtaining heteroskedasticity and autocorrelation consistent errors that are also robust to cross-sectional dependence.

The time individuals spent at home is found to be significantly associated with five measures, namely deferred payment arrangements, disconnection bans, discounts or subsidies, personalized payment arrangements, and support for off-grid energy supplies. The largest coefficient is obtained for deferred payment and discounts or subsidies for energy supply with a 1.3% increase in the duration of time spent in residential places relative to a baseline day (median value for the 5-week period from January 3 to February 6, 2020)[29]. In decreasing order, it is followed by disconnections bans and support for off-grid energy supplies (0.1%), and personalized payment arrangements (-7.5%).

It is important to highlight that we are able to identify the correlation between time at home and the existence of measures, but our estimates do not indicate causality. There are many potential sources of endogeneity, which could come from relevant omitted variables (for instance, whether lockdowns were in place and strictly enforced) that must be considered when the researcher's main interest is a causal analysis.

Code Availability

Code in R language to replicate the motivating example is available from https://doi.org/10.6084/m9.figshare.22652320 .

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Author contributions

Original idea conceived and designed by: MH, IMZ, IR. Development of the R code for data extraction, validation, visualization, and analysis: JATM. Contributed to the writing and editing of the manuscript: JATM, MH, IMZ, IR. Approved final version of the manuscript: JATM, MH, IMZ, IR.

Competing interests

The authors declare no competing interests.