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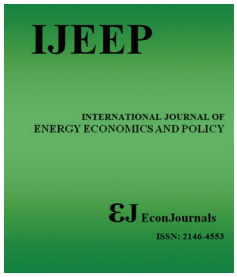

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Energy Poverty Clustering by Using Power-cut Job Order Data of the Electricity Distribution Companies

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ABSTRACT

The identification of the population suffering from energy poverty, which is more visible after Covid-19 pandemic following by the 2021 energy crisis, is an essential requirement for producing systematic and sustainable solutions. Although European Union approaches to the problem with a multi-indicator sets; this indicator sets have a large amount of secure and almost unreachable data, such as identity information, wage information, health information, asset information (title deed, rental income), expenditure information, debt information, credit information, bank records, etc. Experienced two long term projects between 2014 and 2016 (problem definition for energy theft and the best practices searching 13 different country examples including Brazil, Hungary, India, etc.) and 2016–2018 (energy poverty set and consumption characteristics in Turkey) over 6 million end-user consumption and payment data brings us to confirm that. The primary indicator of energy poverty is the arrears on utility bills. The arrears resulting from the affordability problem of the energy consumed trigger a power cut-off job order in the utility company. This research examines the literature and country social assistance implementation data to see how an energy poverty level can be identified using details on arrears and power-cut job orders. On this subject, power-cut job orders were constituted, because of arrears on utility bills, were subjected to statistical analysis, and the compatibility of the trend data with the socio-economic development index was investigated. Cities with a less indexes have more utility bill arrears in terms of both number and volume, according to correlation-test data. Urban cities are more visible in data since the non-urbanized cities have some energy theft activities which show us no efficiency target for the consumption! Hence one of the strategical step for decreasing the non-technical losses is having more registered customer, the relationship between the growth index and the number of customers is another intriguing finding. Separating the consumption levels of arrears, it is found that 63% of total non-payment is depending on 18% of consumers. Trend analysis confirmed that every energy consumption level has the absolute and fluctuated component inside. The number of people inside the absolute poverty cluster is coherent with national and international approaches almost in the same number. The findings revealed that arrears on utility bills can be used specifically to assess the population identified with energy dependency rather than relying on evidence from a variety of sources.

Keywords: Energy Poverty, Fuel Poverty, Arrears on Utility Bills, Power-cut Job Order
JEL Classifications: Q4, H43, I3

1. INTRODUCTION

Nowadays, there is a lot of research to ensure equitable access to energy, which is essential for life. It would be appropriate to consider the concept of Energy Poverty (EP) as an activity within these studies. “Energy poverty exists when a household lacks sufficient energy level and quality (Thomson, 2017), (Erdoğdu, 2020) services in the home,” according to the admitted description of EP (EU Energy Poverty Observatory, 2020). The certainness to be gained in identifying the Energy Poor will encourage preventative steps to be taken. Support structures can be established, for this reason, energy efficiency projects can be carried out, and public and private sector social projects in this field can be created. Failure to fully identify those who are in need leads to an attempt to address the problem through general social arrangements and assistance. The solution process is limited because the problematic cluster cannot be established. According to Boardman, who is associated with the EP concept, this section

spends more than 10% of the household's total income on energy (Boardman, Fuel Poverty: From Cold Homes to Affordable Warmth, 1991). The household's income cannot be accurately determined. The difficulties here stem from conditions as well as the need to register all members of the household, assessing the household's properties and income, and the presence of an unregistered, tax-free portion among them (Tax reports are usually the primary source). The accuracy of the collected data is often a real issue at this point. The current challenges can be tackled in the following ways:

a. Failure in data collection regarding the protection of personal data. In some country practices like Italy, as both pilot and the local studies, municipalities set up their informatics infrastructures by signing protocols for sharing this information with a common secure database for social assistance evaluation together this information and evaluate them (Emre, 2018). Although municipalities are the executives of almost all infrastructure issues, they keep such data as customers, addresses, contact details in separate databases, and combine them only with protocols; they have also difficulties with this operation
b. Failure in synchronized data and matching, even if all of the data is combined into a single channel, matching it is a huge challenge since the consumer in the household is not set. Each subscription may be on behalf of a different person in the household, or records may not belong to individuals in that household because of the flawed/missing data update
c. Failure in the reliability of the surveys or questionnaires. In case the data cannot be obtained, some methods like surveys or questionnaires come into play. When the subject is a sensitive and psychological word such as "poverty," the real needy hide the situation, and some parts of the non-needy part worsen it. The reliability of a questionnaire becomes unclear because it is declaration-based. It is not possible to observe the problem or produce a policy dependent on the declaration-based data. When such information is collected, the mass that is having constantly affordability problems can be determined (according to Moore's absolute poverty approach [Moore, 2012]). However, the fluctuating poverty section suffering from this periodically may cause an erroneous assessment. Having these three main problems, we need to develop a certain systematic methodology to set the people to the EP cluster.

This study aims to contribute to the current literature by exploring the relationship between energy poverty and arrears on utility bills. Since the data availability problems limit all mathematical analysis to investigate and define the core problem, our study depending on the real commercial outputs of the utilities will reflect a clear approach.

2. RELATED LITERATURE

The first attempts to establish EP also attempted to set the criteria for EP detection. This threshold value for energy expenditure is approximately 12 percent of household income, according to Isherwood and Hancock, who are the first names we come across in the literature (Emre, 2020), (Isherwood, 1979), (Liddell et al., 2012). The 10% figure, which will unfailingly reach the same result in years of work, is in Boardman's book "Fuel Poverty, From Cold Homes to Affordable Warmth" published in 1991 (Emre, 2020), (Boardman, Fuel Poverty: From Cold Homes to Affordable Warmth, 1991), (Liddell et al., 2012). Bradshaw said in 2008 that 71% of EP was already poor (Emre, 2020), (Mahoney, 2020), (Bradshaw, 2008). This approach puts forward the idea that EP can be reached when the poor are detected. UK Department of Energy and Climate Change issued another document finding and using "the 10%" in 2010 (UK Department of Energy and Climate Change, 2010), (Emre, 2020). Although later, some specialists like Boardman and Dubois said that this study was a work that produced numbers to be nice, Hills said 10% criteria puts more population into the EP basket than reality and suggested additional criteria (Emre, 2020), (Boardman, Fuel poverty synthesis: Lessons learnt, actions needed, 2012), (Dubois, 2012), (Hills, 2012). Fahmy drew attention to his research about how many EP is in the category that meets the 10% criterion when pointing to Broadshaw's report, stating that 7% of consumers met the requirement (Fahmy, 2011), (Emre, 2020).

In today's circumstances, according to Boardman, real energy expenditure has risen uncontrollably, and even this threshold is difficult to meet (Boardman, Fuel poverty synthesis: Lessons learnt, actions needed, 2012). According to Boardman, the lowest-income 30% of households in England invested 70% of the "required" normal energy expenditure in 2009 (Emre, 2020), (Boardman, Fuel poverty synthesis: Lessons learnt, actions needed, 2012). In the following studies, we can see that the guidelines were looked at in order to assess the EP cluster and that similar programs and pilot applications were completed. Costa-Campi et al. confirmed energy poverty can be labelled through income level of the households (Costa-Campi, 2019). According to Li, Energy Development Index (EDI) and Multidimensional Energy Poverty Index (MEPI) were defined between 2002 and 2010 (Li, 2014). As a different approach, Dagoumas emphasized unpaid invoices in its 2014 article (Dagoumas, 2014). It is an important reminder that the main criterion should be the arrears on utility bills. Moore, for the 1st time, expressed the definition of absolute and relative poverty, which made him one of the most important names in the subject (Moore, 2012).

While there is a description of spending over 10% of household income on energy expenses in the literature, according to Bouzarowski, one of the leading names in the field, it will be more fitting to define indicators that would represent the real situation in Eastern Block countries rather than this difficult to identify situation (Bouzarovski, 2015). According to Bouzarovski, the energy-poor people spend more than usual on energy because of poor equipment (Bouzarovski, 2012). This situation is like the older model vehicles consuming more fuel. Such finding was confirmed by the afford of Emeç et al. of activities for the Turkish case (Emec, 2015).

The EU Energy Poverty Observatory (EPOV), which will operate under the leadership of Thomson and Bouzarowski in 2016, has officially been put into operation. Not only does this center have access to data on EP metrics, but it also shares recent literature (Emre, 2020). Thomson et al. (Thomson, 2017) identified three main methodologies of measurement:

- Expenditure – where examinations of the energy costs faced by households against absolute or relative thresholds provide a proxy for estimating the extent of domestic energy deprivation
- Consensual approach – based on self-reported assessments of indoor housing conditions, and the ability to attain certain necessities relative to the society in which a household resides
- Direct measurement – where the level of energy services (such as heating) achieved in the home is compared to a cluster standard (Thema, 2020).

According to them, researchers are mostly dependent on consensus evidence about the effects of energy poverty, such as power bill arrears and dampness in the household, and data accuracy must increase in order to progress the calculation of energy poverty on a European scale. This could involve amending existing variables so that they are more useful indicators, for instance changing from a binary response format to a Likert type scale to detect the frequency of the problems (Thomson, 2017). In a 2017 article, Lenz and Grgurev claimed that people in certain EU countries, especially Bulgaria, Croatia, and Romania, were unable to adequately heat their homes. There are households in the EP cluster with a rate of 45% in Bulgaria, 14% in Romania, and 10% in Croatia (Lenz, 2017: 7(2)). Bouzarovski, in his book published in 2018 (the book was written by Bouzarovski, Thomson, and Petrova and edited by Simcock), the subject was associated with energy prices, low household productivity conditions, and low income (Bouzarovski, 2018). With a more comprehensive approach, it is impossible to deny that the problem has socioeconomic, regional, and political dimensions (Emre, 2020). "Those who have an income below the threshold and consume above-average energy" (NEPIM, Wafzig, M., Zimper, J., 2018) are described as "energy poor" in Austria. Seebauer et al. studied on social housing policy to alleviate energy policy in Austria (Sebastian Seebauer, 2019). Lakatos and Arsenopoulas studied a swot analysis for potential financial supporting programmes for the energy poverty population (Lakatos, 2019). According to this study, 10%, etc. Such static methods can cause problems to be overlooked on a regular basis (Emre, 2020).

Utility bill arrears are once again being highlighted by current sources. EPOV Member State Reports on Energy Poverty underlined the correlation between arrears on utility bills and affordability (EU Energy Poverty Observatory, 2020). Regarding this report, it can be underlined that inability to keep the home adequately warm and arrears in utility bills trends are highly correlated. In this way, a simplification suggestion can be developed to focus on arrears on utility bills to catch the affordability cluster.

In Turkish literature, Bağdadioğlu analyzed the Household Budget Survey data in his report (Bağdadioğlu, 2009). He proposed a 10% investment criterion for electricity and gas, a 3–5% criterion for water, and a 25% criterion for overall energy poverty, with no electricity poverty value calculated outside of the Southeastern Anatolia Region (Erdoğdu, 2020). Kaygusuz stated that rural areas are the more vulnerable comparing economical conditions (Kaygusuz, 2010). Ozcan et al. offered a poverty cluster varying according to monthly income (Moore's perspective) (Özcan, 2013), (Eke, 2018). The World Bank's 2015 report shows that energy poverty can exist in any consumer category. The percentage share of household electricity expenditures was divided into approximate categories for each consumption category in this study, and consumers were grouped according to monthly electricity consumption amounts. In this study, it was stated that "electricity expenditure in the lowest income group, which is the lowest income group for 100 kWh per month, which is accepted as the lowest consumption level, is 11% of the total household income. For the 150 kWh consumption group, this ratio is over 15% and some note that these values were 12% and 18% in the previous years" (World Bank, 2015). The proposal to measure the threshold in terms of kWh electricity consumption was included in Tennakoon's report in 2008. In this study, the energy poverty threshold was found to be 120 kWh per month (Tennakoon, 2008), (Eke, 2018). Eke and Ayrancı devised an approach based on the provinces' average monthly consumption (Eke, 2018). The threshold for energy poverty was set at 100 kWh in this method, and six provinces in the east and southeast Anatolia were listed as being energy poor. Selçuk et al. stated accordingly the 2017 household budget survey data sets and their own survey results EP clusters cover ¼ of the total households, which means "Half of the lowest-income households face energy poverty." It has been said that this rate was 36% of households in 2003 and decreased to 23% in 2017 (Selçuk, 2019). PwC Report on EP stated each level of consumption has a unique EP threshold inside according to analysis through consumption data through 3 million consumers (Emre, 2018).

In 2017, the Turkish government launched a new version of an existing social support system based on previous examples and best practices (Republic of Turkey Ministry of Family and Social Policy, 2017). In 2019, Presidential Declaration derived support for about 2 million household electricity expenditure (Republic of Turkey Ministry of Family, Labour and Social Services, 2019). Erdoğdu concluded that this figure is below the calculated number of poor households in his calculation based on 2018 TUIK data (Erdoğdu, 2020). Parliamentary Records state that electricity utilities issued 330 million electricity bills to households in 2019. The 1.26% of this number was subject to power cut because of arrears. Utility bill arrears about 2 billion and 94 million TL (Grand National Assembly of Turkey, 2020). According to the Turkish Minister of Energy and Natural Resources, 3.7 million consumers (out of 45 million) have had their power turned off due to utility bill arrears. The results for 2020 can represent a fluctuating EP population as well as an absolute EP population with over-use[1] (Turkish Newspaper Sözcü, 2021).

EPOV uses 28 different standards to determine EP (Thomson, 2017). The number of criteria can be increased with today's technology, but their meaning should be questioned. The synchronicity of these data is a separate issue for indices like the European Union Statistics on Income and Living Conditions (SILC) and the European Energy Poverty Index (EEPI). The collection time of many evaluation criteria used from the

1 Turkish social support covers electricity invoices according to a cap since 2019 March. This 2020 results can reflect the fluctuated EP population and the absolute EP population with over-use.

relevant institutions and organizations is different and causes inconsistencies.

Thomson and Herrero stated that many data subject to be collected are not systematically evaluated. Moreover, "composite indices are hard to institutionalize both due to questions around how to assign weight-age and because the European Union (EU) policy-making environment prefers simplification of metrics" (Sareen, 2020), (Espeland, 1998), (Sebastian and Bauler, 2013). Mahoney (2020) stated that for EP level adjustment, which is tried to be determined over many indices, data collection is almost impossible and the accuracy of the collected data is questionable (Mahoney, 2020). The most basic question is "what is the number of households?" Even the answer to the question is based on the figures or approaches of the official statistical institutions of the countries and is assumed correct.

Kose (2019) offered that poverty-health relationship id mostly related with the individuals economical conditions rather than regional conditions.

The situation that has to be noticed above and above both of these issues is "utility bill arrears," which is the official indication of inability. The direct use of this data is a more simple and precise method of calculating the EP since it is based on energy demand, which is considered one of the most important human needs (Himachal Pradesh High Court, 2018).

While no official federal agency can say how many households exist in a region, the number of customers and invoices produced by all infrastructure firms, whether public or private, is certainly on a monthly basis. In case it is not used for heating, the invoice amount for electricity consumption does not make up the largest percentage of household expenses. Therefore, a debt for electricity and a power cut from debt is a sign of absolute poverty.

2.1. Poverty - Energy Poverty Relation

In literature, there are observations about the association between the general state of poverty and energy expenditure affordability, and these clusters are not the same. Poverty describes a lower socio-economic situation than energy poverty in the context. "Energy Poverty" might represent absolute or periodic inability for each consumer. In EP circumstances, households reduce their consumption for making economy, and this may affect their health since the living room temperature reduces in the cold winter days and nights. It should be understood that this state is long-lasting in cases of absolute poverty and absolute energy deprivation and that this situation periodically exits in the fluctuating state. Aside from the Law on protecting personal data, poor people do not want to be grouped psychologically. As a result, there are difficulties in reaching the list of the absolute poor. Since household income and expense statistics cannot be accessed simply, easily, or specifically due to secrecy concerns, and in order to avoid violations, absolute poverty reports are typically created by field visits and information gathering. The most obvious of these shreds of evidence are the debt bills.

Turkey, with its comprehensive social assistance program, must be one of the best examples of poverty/energy poverty support in the World. The boards of trustees founded in the provinces create the poor family list in the state registries, which is then created by local executive councils after on-site determinations (Republic of Turkey Ministry of Family and Social Policy, 2017). The problem is all the personal information is secure even though the information allows bodies to support the families in possible needs. This means it is not possible to access data such as identity information, wage information, health information, asset information (title deed, rental income), expenditure information, debt information, credit information, bank records, which can be collected separately, within the same date range. Even if this data of all household members can be accessed, unregistered data are quite high. Non-public companies (distribution companies – DisCo) do not disclose certain types of information, especially trade secrets. Consumer payment habits, in their opinion, are an indication of a company's valuation process, which is very safe for an individual. We need to simplify the methodology and generate some policy-making activities in order to make the energy poverty cluster simpler, more basic, and comparable. The EPOV study emphasizes this condition, stating that debt bills are a significant source (EU Energy Poverty Observatory, 2020).

Confirming the "problem of developed countries" approach (Bouzarovski, 2018) for EP, other problems may arise in distribution regions, which have heterogeneous socio-economic structures. In these regions, illegal electricity consumption (non-technical loss & theft) is a problem. Psychologically, the inability afford to the energy used can turn into abuse and, the abuse can turn into habits and disrupt payment habits. This is how the proper payment habit turns into illegal electricity usage. The customer who cannot pay the electricity bill at the 1st time will make economy from consumption for a while, then accept that he cannot pay and switch to normal use, if he encounters an opportunity, he will start illegal use and eventually will come to the point of making illegal consumption more than he needs and wasting. This situation is a serious obstacle to determining the real need level.

Official statistical institutes prepare the socio-economical index of the regions. These indexes are useful for expressing poverty and EP for methodological purposes (EU-SILC is one of them (Sareen, 2020). In the Turkish case, the Turkish Ministry of Industry and Technology has released a study report with the name "2017 in the Provinces and Regions of the Socio-Economic Development Ranking Study-SEDI" (Regional Indicators of socioeconomic well-being) (Acar, 2019). The Strong Principle Components Analysis approach was used to perform detailed analyses on 52 variables in the social, housing, education, health, competitive and creative capability, financial, accessibility, and quality of life clusters, and the provinces' growth indices were presented. This report is used in related studies as the most up-to-date and scientific source. According to this report, the development index of the provinces is between 4.051 points and –1.788 points.

2.2. Definition of Electricity Arrears on Utility Bills and "debt" Data

The term "debt" for electricity represents the receivable whose consumption is measured by a registered device, the invoice of which is made but not paid. The meter of an energy customer is

read once a month, and an invoice is given. The invoice released has a 10-day due date. At the due date, the "receivable," which is the equivalent of consumption, becomes a "debt." After this date, a power-cut notice order is issued for the unpaid debt. According to the Electricity Distribution Company (DisCo) application, the notification can be sent using SMS, e-mail, etc. or the hard copy can be delivered to the address. If the debt has not been paid 10 days after the notification job order is issued, a power-cut job order is generated. According to this job order, when paying a loan, an individual whose power has been turned off will be charged an extra cut/open fee. Even then, if he does not pay his debt, execution proceedings are started.

3. DATA AND METHODOLOGY

As mentioned in the previously, the main obstacle of the identification is data privacy. Almost all of the information registered as indicator of energy poverty is quite secure information stored or created by different entities. Even for the Governmental companies there is no exception for sharing data. In 2016, Italian Regulatory Body Commissioner informed us that Italy has prepared a model for common file sharing securely in the same municipality. In this section details of the data available and the approach is explained in details.

3.1. Data Available for this Research Study

In this study, we observed the trends of the arrears on utility bills through the 7-year power-cut data of 8 DisCo's' which includes payment characteristics of 33 provinces. Since this information is very secure, study was conducted by closing all data including the name of the cities and the companies.

3.2. Tools and Methodology

This study is intended to assess the population in need of resources, with just the state of electricity debt and the details on the power-cut job order. Other data that can be compared for this purpose are the numbers calculated according to the literature and the figures of the people receiving social assistance. SPSS was used to perform statistical analysis with big data such as electricity consumption and bills, normal distribution, correlation, tests were performed.

In this study, analyzes were carried out for customers who could not pay their bills and were subject to power cuts in the DisCo-2 region (City-26, City-36, City-53, City-64, City-49) and DisCo-4 region (City-42, City-44, City-59, City-71). The study was carried out by scanning a 7-years data set as 2013,14,15,16,17,18,19 and reflects the payment habits after the privatization period. In this analysis, only residential customers were considered. Periodic tariff values for kWh conversions are determined using an average estimate since the data is on a TL basis.

Many structural characteristics of the region, such as economic, demographic, and cultural factors, as well as DisCo practices, can influence the numbers related to power-cut notifications, job orders, and execution procedures. Each region's invoice rate is different from one another. For example, in the DisCo-2 area in 2018, the number of things canceled after a power-cut was about 50% (Figure 1). It would be incorrect to interpret this data based solely on the presumption that the cancellation was due to a lack of funds. Because of the problems in the automatic payment systems of the bank, problems in the communication channels, etc., the customers who make regular payments and do not have any payment difficulties may receive power-cut notifications. The cancellation and implementation of the power-cut, on the other hand, sends a message about affordability levels. Almost half of the power-cut orders are subject to cancellation, which may include total and fluctuating EP.

3.3. Power-Cut Job Order

It is a job order created for customers whose deposits have not been made after notice of a power-cut. This job order may also be canceled without completing a transaction, such as a notification, although the cancellations in this section are mainly due to reimbursement and are not contingent on mistakes that could exist in external services.

In a deeper examination, the normal distribution for the payment cycle is another important factor to consider when determining the degree of inability. Figure 2 shows that the average payout cycle is about 25 days. On the other hand, in the DisCo-2 area, the number of cancelled power-cuts is double, which can be discussed at the inability level as well.

In another perspective, although there can be a level in each consumption group (which should be searched deeply), generally people consume what they need and as much as they can in inability case.

Figure 3 shows the DisCo-2 Pareto graph. The kWh consumptions the region which is subject to power-cut job orders are examined.

Figure 1: DisCo-2 power-cut execution

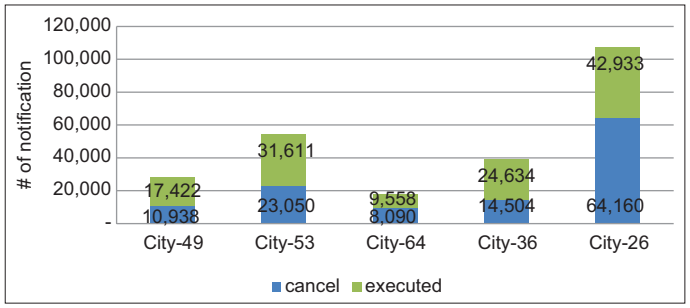
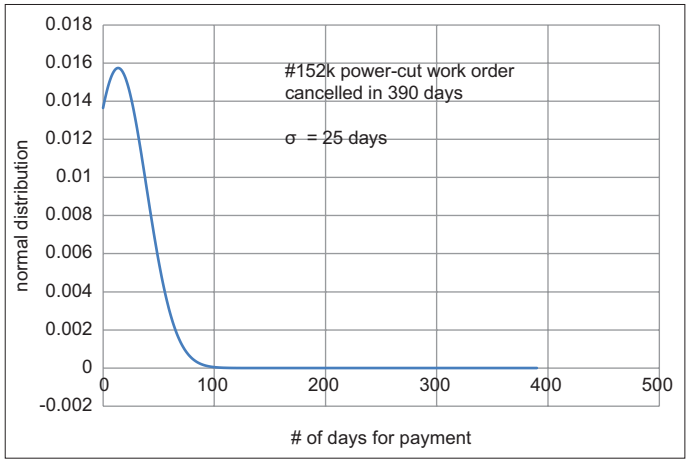


Figure 2: DisCo-2 payment period for the debt



Most people who are "in debt" are those who use 100–200 kWh per day. On the other hand, each consumption category, as might be predicted, has some affordability issues due to the fragility of all consumption.

For a general assumption, we can divide the numbers as: 500 thousand electricity bills are generated per month for DisCo-2, 70 thousand notification for power-cut, 10 thousand power-cut orders.

In the region that can be considered being homogeneous and not behind in the development index;

- 10/500 ~ 2% power-cut job order (corresponding to absolute energy poverty)
- 70/500 ~ 14% notice (energy poverty problem cluster) are produced.

These figures, previously with studies related to Turkey (Bağdadioğlu, 2009), Appendix A (World Bank, 2015), (Emec, 2015) Emeç World Bank [21]) are compatible figures.

In light of all of these metrics, we came to the conclusion that electricity debt (as a result of power-cut job orders) can be used to diagnose energy poverty. A holistic replication of this research performed across individual companies is needed. In further analysis, we investigated a relationship between the development index, # of population, # of consumer, # of power-cut, # of power-cut (DONE), power-cut performance (PCP), arrears to utility bills subject to power-cut, non-technical power-loss (NTL), and loss per consumer (LPC). While the TR-2018 line reflects an analysis based on media information, the provinces line covers all provinces participating in the analysis, and the region's lines only cover the provinces under their jurisdiction. The data sample represents approximately 10 million DisCo customers from 33 Turkish cities.

4. RESULTS

Table 1 represents the correlation test results for the variables. In the first raw we search the general statistical data with the all sample city data. On "Samples" row, we searched the correlation among all 33 cities. "H-Samples" raw represents us the correlation results of the cities which have positive development index which is the ideal case. "nH-Samples" raw represents the correlation test results between the cities having negative development index. By these four calculations, we try to understand the strong drivers of the correlation also in different clusters.

According to the table;

C1 investigates the correlation between the development index with the # of power-cut job orders (issued). There is a reverse correlation discovered between these variables. However, it is strong in some specific DisCos.

C2 investigates the correlation between the development index with the # of power-cut job orders (DONE). There is a reverse correlation between these variables.

C3 is investigating the correlation of the development index with the arrears on utility bills subject to power-cut. There is a reverse correlation discovered between these variables. However, likewise the C1 and C2, it is strongly correlated in some DisCo's'. Potentially this variable offers if city is more developed, there are less arrears on utility bills. However, it is not strong enough to offer there is much more affordability problem in such cities.

C4 examines the relationship of the development index with LPC. This test offers how developed city; that less NTL related with the loss & theft. Expecting a negative correlation, there is a reverse correlation in negatife for the non-Homogenous DisCo's which is not that high. On the other hands, some DisCo's have more negative correlation scores in this manner.

C5 means the relationship between the development index and the consumer density (number of customers per population). Since only one registration for each consumption point, we expect a certain value due to the average number of households in the countries. However, according to the climate, households have more than one provinces to live in different seasons. Although homogenous samples are not correlated, we observe a weak correlation in total together with some strong correlation results of the cities'.

C6 offers a general relationship between the development index and # of people in the cities. It's a common proportion. In

Table 1: Correlation analysis results

Correlation Analysis Results										
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	A/H	A/B	A/C	A/D	A/E	A/K	A/F	B/G	B/D	H/G
TR-2018	−0.6991	−0.5826	−0.6991	−0.5677	0.7170	0.3312	0.2662	0.9995	−0.0523	0.9985
Samples	−0.6972	−0.5229	−0.6798	−0.5804	0.7665	0.6298	−0.0686	0.8396	−0.0018	0.9270
H-Samples	−0.7158	−0.6877	−0.7243	0.3653	0.1631	0.6186	0.6471	0.8566	0.0640	0.9420
nH-Samples	0.2203	0.1469	0.1909	−0.6900	0.8601	0.3685	−0.5080	0.7877	0.2612	0.7211
DisCo-2	−0.8228	−0.9084	−0.8163	−0.0884	0.6848	0.7828	0.6973	0.9918	−0.0885	0.9918
DisCo-4	−0.8740	−0.6147	−0.8288	−0.4118	0.5303	0.6650	0.5234	0.9785	0.3119	0.9795
DisCo-8	0.0839	0.0512	0.3641	−0.7530	0.8533	0.2058	−0.6376	0.9420	0.2770	0.9420
DisCo-14	−0.7489	−0.7884	−0.4078	0.1140	0.0096	0.3047	0.3771	0.9894	−0.1977	0.9894
DisCo-18										
DisCo-1	−0.8816	−0.7473	0.6110	−0.9043	−0.2605	0.9890	0.9865	0.8175	−0.9487	0.8175
DisCo-13	−0.5929	−0.5922	−0.8738	0.0530	−0.8572	0.6692	0.7621	0.8998	−0.1258	0.9532
DisCo-20	0.3570	0.3669	−0.2408	−0.2956	0.5132	0.4053	0.2500	0.7599	−0.8103	0.8654

industrialized provinces, we can assume that the population is larger. There is a weak correlation.

C7 symbolizes a more fundamental analysis of the previous indicator. The correlation of energy lost, which is the difference between purchased energy and invoiced energy by the utility, and development index has been found to be positively correlated weakly. The amount of energy lost increases as the degree of growth rises.

C8 and C10 searches a correlation between # of power-cut job orders and the # of consumer which is highly correlated for all provinces.

C9 offers a relationship between # of power-cut and LPC. It is not related even for the non-homogenous cities.

The outrageous amount of debt in developed regions shows that the power-cut order can be used in detecting energy poverty in developed regions. Another question is whether the affordability level is stable. In the analysis made for this, the consumption quantities subject to the power-cut order were divided into groups and analyzed the changes.

The number of consumers facing power-cuts due to debt is not as high as predicted. The amount of debt varies according to the consumption behavior of the household, which means the lifestyle. In 2018 figures, 500 consumers made up 95% of the total debt among two hundred thousand consumption points (DisCo-2). The Average Power-cut Amount Per Installation (APAPI) was calculated over the years (Figure 4). According to the analysis, evaluation should be over an average APAPI value in order to minimize the socio-economic, political, cultural, and psychological effects. This value is a virtual threshold.

In Figure 4, APAPI is increasing continuously in DisCo-2. However, APAPI shows greater variation over the years in DisCo-4. Because the development index of DisCo-4 is smaller than DisCo-2, We arrive at the conclusion that the amount of debt held by each borrower can be a useful measure of affordability. The decrease in average debt indicates that the number of consumers who are under indebted has risen. The increase will not show the opposite of this discourse, however; this may show that the amount of debt has increased too much, that the amount of repeated or one-off debt has increased (increase in fraud). From this point of view, APAPI should be accepted as a threshold value showing those whose payment habit is disrupted. The part above this debt points to the consumer, which has broken the payment habit and has taken an attitude towards wasting.

In the analysis, we examined whether the total amount of debt and the number of consumers represent significant clusters of the half, a third, a fourth, 2 times, 3 times, and 4 times the APAPI value. Figure 4 shows the outputs for the DisCo-2 and DisCo-4 regions. As per our analysis, we see that the <APAPI section represents a group of 45% in number and 37% in the amount over the years. An average of 53 thousand people create a debt of approximately 8.5 million, and there are energy-poor people in this section. It turns out that 63% of the debt is carried out by the 18% installation. In this section, we understand that there are cases of abuse. In contrast to many installations with less debt, there are a few installations with high debt. It showed the ratios in terms of number and amount of debt in the graph in the stratification of the sections below and above the average to 2 times, 3 times, and 4 times. While the overall volume of debt is small, the percentage of borrowers consuming less than half of the average valuation is significantly high. This is a price-effective indicator. The results of the analysis are unique in terms of their socio-economic, cultural, and psychological characteristics, but also in accordance with Disco 4. The NTLs are also different between these two regions. The assessment of the APAPI has the potential to present the solvency problem more clearly according to these results.

The result for two different regions gave a similar result almost superimposed (Figure 5). At the point of absolute energy poverty visible in blue, there are dwellings that cannot pay their bills despite low consumption. This case is not greatly influenced by

Figure 3: Consumption pareto of power-cuts in DisCo-2

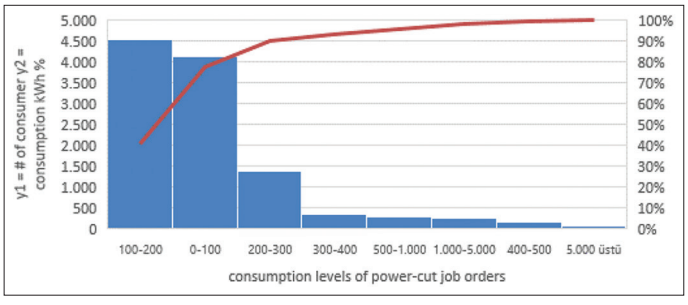


Figure 4: APAPI amounts consumption pareto of power-cuts in DisCo-2

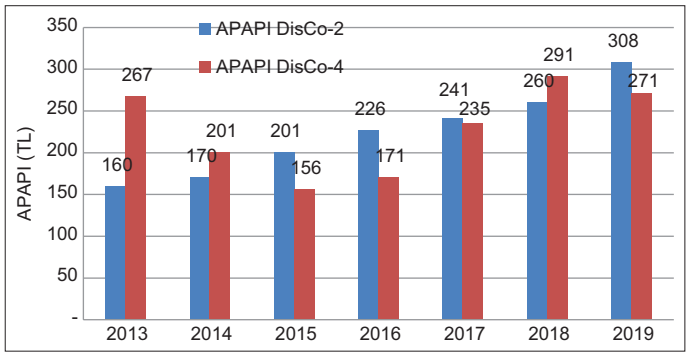
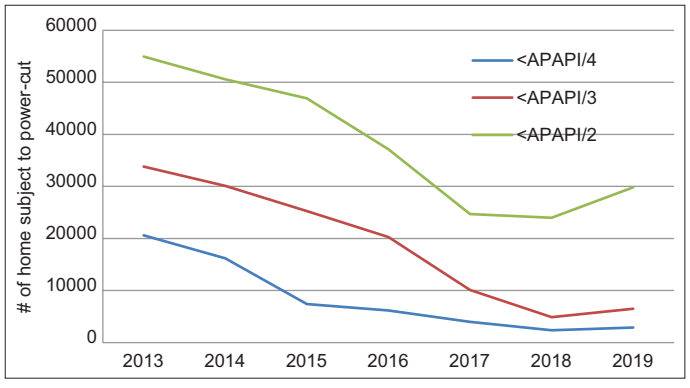


Figure 5: APAPI cluster trends in DisCo-2



the circumstances. The red and green lines represent the fluctuating value of energy poverty at different levels. Accordingly, to the Figure 5, we understand that while the number of consumers in the APAPI/3 cluster remained very constant, it in APAPI/2 and APAPI/3 cluster increased over the years. Here, APAPI/3 shows the absolute affordability level, while APAPI/2 level is the variable affordability level.

According to the findings in Figure 5, we might build a hypothesis that the ratio of debt at each stage to the number of borrowers affected by a power-cut is a constant that does not vary from region to region. According to the results, the APAPI/2 consumption level corresponds to a monthly consumption of 110 kWh, while the APAPI/3 consumption level corresponds to a monthly consumption of 80 kWh.

The monthly intake of 110 kWh sets the affordability limit, regardless of area or socioeconomic status. Consumers in this section pay bills when they can afford them, and in case of not paying the bill, they go as far as power cuts. The consumption group below 80 kWh per month is absolutely EP and they cannot afford to use electricity and cannot afford to pay bills.

5. DISCUSSION AND CONCLUSION

EPOV Indicator Dashboard Methodology Guidebook refers to Simsock that "Energy poverty is a culturally sensitive, multi-dimensional concept that varies over time and by place and is thus not easily captured by a single indicator (Thema, 2020), (Simcock, 2016). However, the EU policymaking environment prefers the simplification of metrics (Sareen, 2020), (Espeland, 1998), (Sebastian and Bauler, 2013). According to our findings, one of the key indices of EP—utility bill arrears—is strong enough to identify the energy insecurity cluster in the population.

We discover that 15% of the energy bills are making arrears in general.

We investigated the payment-non-payment characteristics as well as the existing state of power-cuts in this report. Analysis of 5 years – 6 million consumer data summarized by using normal distribution figures as per consumption levels and arrears on utility bills. We found that many non-paid utility bills refer only 10-15% of total debt which can potentially reflect the affordability problem in the absolute or fluctuating form. An average of 1.5–2% of bills are affected by power-cuts. The number of power cuts is proportional to the growth index, which is inversely proportional to the LPC value. We created an index called APAPI to reflect the severity of the power-cuts. Confirming the literature, APAPI has a constant driver inside it for representing the absolute EP. We observed the absolute driver as a constant for the sample data as 80 kWh/month electricity consumption. Since fluctuating drivers inside the APAPI, the 100-200 kWh/month non-payment bills are the biggest in number for all distribution companies. This result is obvious for the more developed cities. Then we looked for a link between the cities' socioeconomic development index and power-cut job orders, which are generated after a process if the consumer does not pay the utility bill.

According to correlation-test results, cities with less development indexes have more arrears on utility bills in number and amount. Less developed characteristics are in a weak correlation with NTL (loss & theft). Another interesting outcome is the relation between the development index and the number of the customer. Separating the consumption levels of arrears, it is found that 63% of total non-payment is depending on 18% of consumers. Trend analysis confirmed that every energy consumption level has the absolute and fluctuated component inside. All these numbers are in parallel with the coherence with literature and national/international approaches.

In order to develop a social tariff, to make applications related to energy efficiency, and to plan strategies, it is necessary to identify the consumer suffering from energy poverty. For this determination, special data such as household income, expenditure items must be provided in a suitable period for analysis. However, the most serious criterion that reveals the amount of debt, payment patterns, and willingness to afford is energy use. The study found that an analysis based on power-cut job order records can reveal the EP cluster without the need for additional data. The certainty of the data is very high comparing the real numbers from the site applications. In fact, this data allows setting the absolute and variable fragility level. Developing social policies for clusters determined based on the results with no additional information access will increase the welfare level of the EP cluster.

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