Subjective satisfaction and objective electricity poverty reduction in Vietnam, 2008-2018.

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Abstract
We estimate the reduction of electricity poverty in Vietnam. The essential argument is that human development is about subjective feeling as much as technology and income. We use a self-reported satisfaction indicator as complementary to objective indicators based on national household surveys from 2008 to 2018.
We found that in 2010, the fraction of households with access to electricity was over 96%. However, over 24% declared their electricity use did not meet their needs. Since 2014 the satisfaction rate is around 97%, even if 25% of the households used less than 50 kWh/month. Today there is electricity for all in Vietnam, but electricity bills weigh more and more in the budget of households. Inequalities in electricity use among Vietnamese households decreased during the 2008-2018 period, but are not greater than inequalities in income, contrary to the findings of Son and Yoon (2020).
The subjective energy poverty measure allows better international statistics: unlike poverty or needs-based criteria, self-assessed satisfaction of needs compares across income levels and climates. Engineering and econometric objectivist approaches dominate the literature on sustainability monitoring. Out of 232 Sustainable Development Goal Indicators, only two are subjective. Yet our findings show that subjective indicators tell a different part of the story. Grid building is only a mean, the end is a meaningfull provision of power to satisfy the needs.

Keywords :
Electricity poverty, Vietnam, Sustainable Development Goals, Indicators

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Q41, Q48, Q56

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1. Introduction

The seventh United Nations Sustainable Development Goal (SDG7) is: *Ensure access to affordable, reliable, sustainable and modern energy.* In short, *Affordable and clean energy* is one of our overarching civilization goals this millennium. Statisticians usually measure progress towards SDG7 using objective indicators based on electricity distribution and consumption data. This text argues that objective indicators are not enough. Human development is an issue of subjective feeling as much as a question of technology or economics. Based on national household surveys, self-reported satisfaction indicators offer a complementary perspective to understand society's energy poverty situation more fully.

Vietnam is a Southeast Asia country comprising almost a hundred million people. Its GDP per capita, purchasing power parity, was 8 397 USD in 2019 (World Bank database, accessed 2021-05-22). Vietnam's development has been highly successful in economic terms. In constant local currency, GDP grew by 541% from 1986 to 2019. Table 1 provides more details on the country's trajectory. Vietnam's rural electrification program is oft-cited as an outstanding success in providing energy access (Đoàn 2010; Asian Development Bank. 2011). However, in the considerable academic literature on energy poverty, we found few studies about Vietnamese households among the reports on China, India, Brazil and South Africa (Li, Pan, and Wei 2015; Sovacool et al. 2011; Baltruszewicz et al. 2021).

Lê Việt Phú (2020) investigated the residential electricity demand in Vietnam using a different microdata source, the 2015 VHRS World Bank survey. He found that demand is elastic to average and marginal prices and confirmed that income elasticity is positive. We will look at the residential demand from a different perspective –energy poverty– using different data: the Vietnam Households Living Standard Surveys (VHLSS) from 2008 to 2018.

Son and Yoon (2020) examined the determinants of inequality in Vietnamese households electricity consumption, using VHLSS data from 1993 to 2004. Inequality can be defined, at the population level, by how much the statistical distribution of consumption deviates from the uniform distribution. They found that a) electricity consumption increased more than proportionally with income, and b) the inequality of electricity consumption was larger than income inequality. The grid expanded continuously from 1993 to 2004, increasing electricity access. Son and Yoon warned that increasing access could increase inequality as the wealthier households benefited more from the opportunity. Those who cannot afford to buy electric appliances benefit less from rural electrification. Our analysis of more recent data corroborates their first finding: electricity use increased faster than income between 2008 and 2018. We do not confirm their second finding. In 2018, electricity consumption inequality seemed comparable to or less than income inequality (see Supplementary_Figure 5).

Analyzing the evolution of Vietnamese households energy consumption from 2004 to 2016, T. T. Nguyễn *et al.* (2019) found that "*Electricity poverty has decreased, but energy-cost poverty has increased.*" Our analysis vindicates these findings. We clarify and confirm the discrepancy between electricity poverty and electricity-cost poverty using more recent data.

This manuscript's outline is as follows. We contrast the objective and subjective perspectives used to observe electricity poverty in section 2. Then we present the data and methods in section 3 before looking at Vietnamese households' electricity use over 2008-2018 from three points of view in section 4-6:

- The engineering perspective looks at grid access and kWh consumed.
- The economic perspective looks at income and expenditures.
- The subjective perspective looks at satisfaction with electricity consumption.

Then we discuss the interactions between the three perspectives ins section 7. Our findings highlight how much the subjective indicator complements objective engineering or economic indicators. Section 8 discusses the results and policy implications, comparing with other ASEAN countries. Finally, section 9 summarizes and concludes.

Table 1: Vietnam's economy and electricity conditions in 2008-2018.
Economic and political reforms launched in 1986 have transformed Vietnam from one of the world's poorest nations to a lower-middle-income country. Source GSO, accessed 2021-02-08, and World Bank for GDP PPP.

Year	2008	2010	2012	2014	2016	2018
Population (Thous. pers.)	85 119	86 947	88 809	90 729	92 695	94 666
GDP at constant 2010 prices, trillion Dongs	1 889	2 158	2 413	2 696	3 054	3 493
GDP per capita, PPP constant 2017 $	4 628	5 089	5 574	6 098	6 767	7 586
Consumer price index, base 100 in 2007	123	144	186	206	213	228
Share of population in urban areas	29.0 %	30.5 %	31.8 %	33.1 %	33.9%	34.5%
Electricity production, annual	71.0 TWh	91.7 TWh	115.1 TWh	141.2 TWh	175.7 TWh	209.2 TWh
Electricity production, annual per person	834 kWh	1 055 kWh	1 297 kWh	1 557 kWh	1 896 kWh	2 221 kWh

2. What is access to clean and affordable energy for all?

The Sustainable Development Solutions Network (SDSN 2015, 137–40) defined four performance indicators to assess progress towards the Sustainable Development Goal 7 « *Ensure access to affordable, reliable, sustainable, and modern energy for all* » :

- Indicator 50: Share of the population with access to modern cooking solutions (%)
- Indicator 51: Share of the population with access to reliable electricity, by urban and rural (%)
- Indicator 52: Implicit incentives for low-carbon energy in the electricity sector (measured as US$/MWh or US$ per ton avoided CO2)
- Indicator 53: Rate of primary energy intensity improvement

While all four dimensions of SDG7 matter, this manuscript focuses specifically on the aspect measured by indicator 51, about access to reliable electricity. We distinguish three perspectives on access to electricity. The engineering perspective sees access as the presence of the distribution network. The economic perspective focuses on affordability. Finally, the subjective perspective focuses on whether the users feel that their electricity needs are satisfied. This section argues that the subjective perspective answers many problems found in the economic literature on energy poverty.

Atkinson (1987) explains that poverty can be seen as a concern about basic needs, which are multidimensional: food, housing, and clothing. Under this viewpoint, energy poverty can be seen as deprivation of the energy needs for survival. Energy-poor households cannot afford to fight cold in winter or heat in summer. How can we measure the magnitude of energy poverty in a given country? In the subjective perspective, this is straightforward: use a survey asking if the household's energy use met their needs in the last month. The economic perspective is more complex than that. Consider three different approaches to define and measure energy poverty:

The first approach is to estimate "basic needs" directly by calculating the minimum energy services required for a household. Bravo *et al.* (1983), cited in He and Reiner (2016), enumerate energy needs to prepare and preserve food and supply of water; for space conditioning; personal cleanliness; and recreation and social communication. Pachauri *et al.* (2004) computed the power requirements for energy services of a five-member household such as "scooter 5km/day", "Lighting, one electric bulb (5h/day, 40W)" "Lighting, 1–2 kerosene lamps".

This basic needs direct estimate approach is appropriate on a case-by-case basis, at the scale of communities, but not for international statistics. Different societies have different views on what kinds of energy services constitute basic needs. Needs vary with climate,

region, household demography and even ethnocultural habits (Pachauri et al. 2004). Asking experts about the local conditions is open to subjectivity and lack legitimacy.

The second approach sets up absolute thresholds for the total amount of energy consumption regardless of the consumption components. Energy-poor households consume less than *X* kWh per year, where *X* depends on the country's economic conditions. Foster et al. (2000) define the threshold as the average energy consumption of households having expenditure per capita within 10% of the official poverty line.

This approach is convenient. A poverty line is readily available in every country. However, the underlying assumption that income-poor households are also energy-poor households is not always valid (Khandker, Barnes, and Samad 2012).

The third approach sets up relative thresholds. Energy-poor households are those spending more than *X* % of their income on energy bills. DTI (2007) states that a household is in energy poverty if it spends more than 10% of its income on paying the energy bill, including electricity and fuel for heating and cooking, excluding transportation. This threshold has been set out officially in the U.K. Fuel Poverty Strategy 2001, according to the critical study by (Hills 2012). France also used this approach, according to ONPE (2016).

This approach is convenient. It allows assessing the magnitude of the energy affordability issue from national-scale statistics. Unfortunately, the approach has fatal flaws. The ratio is quite arbitrary; there are no universal norms on the share of electricity in a household budget. Moreover, many consumers with a relatively high energy bill are affluent households living large, while many poor households have a low energy bill because they use non-commercial biomass.

The three approaches to energy poverty reviewed above are based purely on energy quantities, monetary indicators or their combination. They all come from an engineering or econometric approach. In order to fix their theoretical problems, researchers and practitioners have proposed more sophisticated objective approaches. Hill (2012) led the U.K. to replace the 10 % of income criteria by a new definition under which households are considered fuel poor if a/ They have required fuel costs that are above the median level, and b/ Were they to spend that amount they would be left with a residual income below the official poverty line. Econometric approaches based on electricity demand elasticity were explored in Khandker *et al.* (2012) for energy poverty in Bangladesh, He and Reiner (2016) for electricity poverty in China, and Nguyen (2019) for electricity poverty in Vietnam. Finally, Multidimensional Energy Poverty Indices were proposed by (Nussbaumer, Bazilian, and Modi 2012; Foster, Tre, and Wodon 2000; Pachauri et al. 2004), and the Multi-tier Matrix for Measuring Access to Household Electricity Supply proposed by (Bathia and Angelou 2015).

In contrast to these objective approaches, the subjective perspective is more straightforward. It defines the quality of energy services by the satisfaction of their users, not in terms of electricity or money quantities measured from outside. We argue that concerning indicator 51, the definition *Share of households replying positively to the question "In the last month, did your consumption of electricity meet the needs of your household?"* is as operational as the classical definition *"Share of population with access to reliable electricity"*. The belief that objective engineering / economic indicators are more scientific than indicators based on subjective self-assessment is unfounded.

There is prejudice in the opposition between scientific approaches. The subjective definition prescribes a clear way to measure the phenomenon. Humanities and social sciences have long integrated the need to include the subjects' voice into their research methods, including subjective opinion surveys. Surveys provide objectively repeatable measurements: two independent survey companies applying the same method will find very close results.

The objective approach is not as unambiguous as it may seem. Engineering-based indicators also suffer from imprecision and declaration biases. This is true when collected from declarative surveys and also when collected from electricity bills (fraud exists). The concepts of "reliable" and "access" leave room for interpretation. It is unclear if "access" is only the physical connection to the grid or the economic means to pay for electricity. Furthermore, "reliable" is vague. Is there a threshold of outage minutes per year? As extreme weather can cause a blackout, at which probability shall access be considered reliable? Do we even have probabilities? Regarding the basic needs approach, to determine the adequacy of someone's habitat objectively, one has to examine its floorplan, building material, insulation, heating, ventilation systems, the local climate, and the age of the inhabitants. It is much simpler just to ask.

Leaving it up to respondents to assess the "needs of your household" resolves the central problem of defining a "basic needs" level. Households themselves know best if their electricity needs were met. Multidimensional Energy Poverty Indexes rely on normative aggregation methods that are hard to justify, whereas households have the legitimacy to integrate the different aspects of their energy consumption experience. Rebound effects in rural electrification projects show that needs are subjective and relative. Human needs expand with economic development.

Contrary to objective and absolute definitions of basic needs, indicators defined by self-assessed satisfaction of needs can be used at different income levels, within and across countries. Ensuring access to modern energy for all – the SDG7 – does not mean bringing the grid close to every house, as Indicator 51 measures. It means everyone actually receives a sufficient provision of energy services.

3. Data and method

In light of the previous discussion, we will examine progress towards SDG7 in Vietnam using three approaches. From an engineering point of view, we will look at access and quantity of electricity consumption. From an economic point of view, we will look at the share of electricity in the household budget. From a subjective point of view, we will look at the electricity customer satisfaction, in the form of the answer to the question *"In the last month, did your consumption of electricity meet the needs of your household?"*.

The data used to produce all results presented below come from periodic national population surveys: the Household Living Standards Surveys (General Statistics Office 2019). Conducted under the Ministry of Planning and Investment by the official national statistics office, the surveys aim to systematically collect basic information about population and housing as a basis for research and for assessing and formulating policy mechanisms, programs, targets and plans on national socio-economic development generally, and for the population and housing sectors in particular. It is independent of EVN, the national electricity company.

In 2008 the survey had two waves lasting two months each, starting in May and September. In 2014 there were four waves of one month, in March, June, September and December. This reduces the seasonality bias of energy consumption. Assignment of households into waves was random.

The question on needs met was asked in 2010, 2012, 2014 only.

We did not weigh answers, de-bias or otherwise adjusted the data except by clipping outlying values and dropping missing responses. Clipping does not affect the counts and quantiles, but non-responses are known to affect survey results. We were not involved in the data collection.

The results we present below are subject to systematic and random errors unavoidable in all survey data (Kasprzyk 2005). We did not attempt to quantify these errors formally, but we hereby forewarn that in the numbers presented below, the third digit is not policy-relevant. It is meaningful mathematically only.

We drew the maps in Figure 1 and 4 without tone intensity correction for province size and province population: they reflect energy poverty levels within a province. Thus, a large grey area does not imply that a large number of people are impacted since provinces in remote mountains are less densely populated than provinces in the river deltas.

4. The engineering view: is electrification complete?

Much has changed since (A. T. Nguyễn and Lefevre 1996) analysis of household energy demand based on a 1992 survey conducted in four provinces. At that time, 91% of the energy used by households was for cooking and pig feed. Cooking was mostly with coal and residues; electricity was used by less than 2% of rural households, 6% of urban households. Households commonly used both kerosene and electricity for lighting. This contrasts with the more recent survey by (V. T. Lê and Pitts 2019), which showcased air conditioning as the key driver of energy consumption for households living on Vietnam's South-Central coast.

Đoàn Văn Bình (2010) wrote about electricity access in Vietnam as follows :

> *Vietnam has gone through a rapid increase in electrification since 1990, where electrification levels jumped from a pre-policy reform rate of less than 50% in the late 1980s–early 1990s to 77% by 2001 and 96% by 2009. The Electrification Programme driven by the Vietnamese government has resulted in increased access for 82 million people between 1976 and 2009. One million people, primarily in the northern mountainous regions of Vietnam, are currently without access to electricity.*

To revisit these numbers in 2018, we used answers to the survey question: "What is the main lighting mean in your household?" with possible choices: 1. National-grid electricity, 2. Battery or generator or small-scale hydroelectricity, 3. Gas, oil lamps of various kinds, 4. Other. Figure 1 shows the percentage of households who did not choose option 1. This is a proxy for the state of electrification over 2008-2018. It shows that the situation in the northern mountainous regions of Vietnam has improved over the last ten years, without complete resolution. There are still not many roads in these areas. The cost of these grid connections is high compared to the number of households serviced.

Concerning the overall population, our analysis shows that in 2010, 96.5% of households in Vietnam used grid electricity for lighting. This number increased to 98.9 % in 2018. Our estimate for 2018 is close to the 99.1 % published in (General Statistics Office 2019, 500); and coherent with (EVN 2019, 14, 19) statement that "EVN provided 100% of communes, more than 99% of rural households, and 11/12 districts of islands with electricity access". Considering that the population is 94,7 million and that households without access are likely to have more members than the national average, we estimate that the number of people without electricity access in Vietnam was still about one million in 2018. The number of people without access has declined slowly over the period, as Doan Van Binh's statement remains relevant. The positive way to see the evolution is that the number of people with access increased as fast as the population, almost one million per year.

Figure 2 shows the amount of electricity the households declared using in the last month. In 2018, the median amount of electricity usage was 139 kWh per month, and the first quartile was 81 kWh. In other words, that year, out of four Vietnamese households, one

used less than 81 kWh per month, and another used between 81 kWh and 139 kWh. Over the 2010-2018 period, the distribution shifted to the right towards higher quantities. The median electricity consumption per Vietnamese household in the surveyed month went from 74 kWh to 139 kWh in these eight years.

Over that period, the use of electricity by Vietnamese households moved towards a more uniform distribution. As apparent in Supplementary_Figure 5, inequality in electricity use reduced faster than inequality in income during that period.

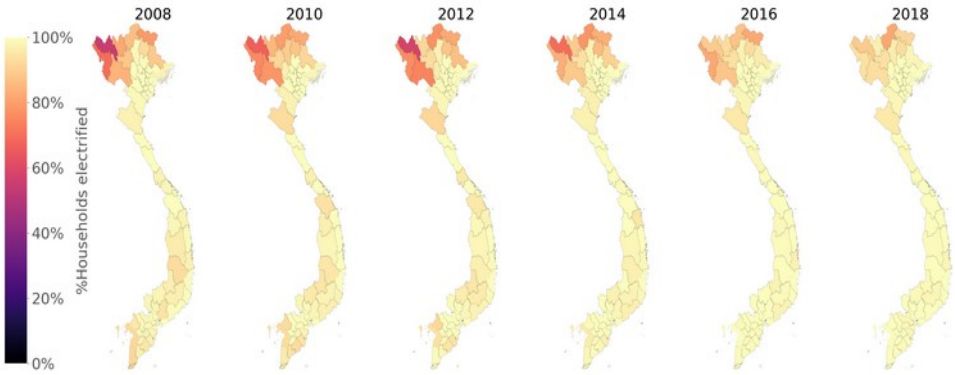


Figure 1: Progress of electrification. The share of households not relying on the national grid for lighting decreased from 2008 to 2018 in most provinces. Rural electrification challenges remain only in the most northern provinces. High resolution figure available as supplementary material.

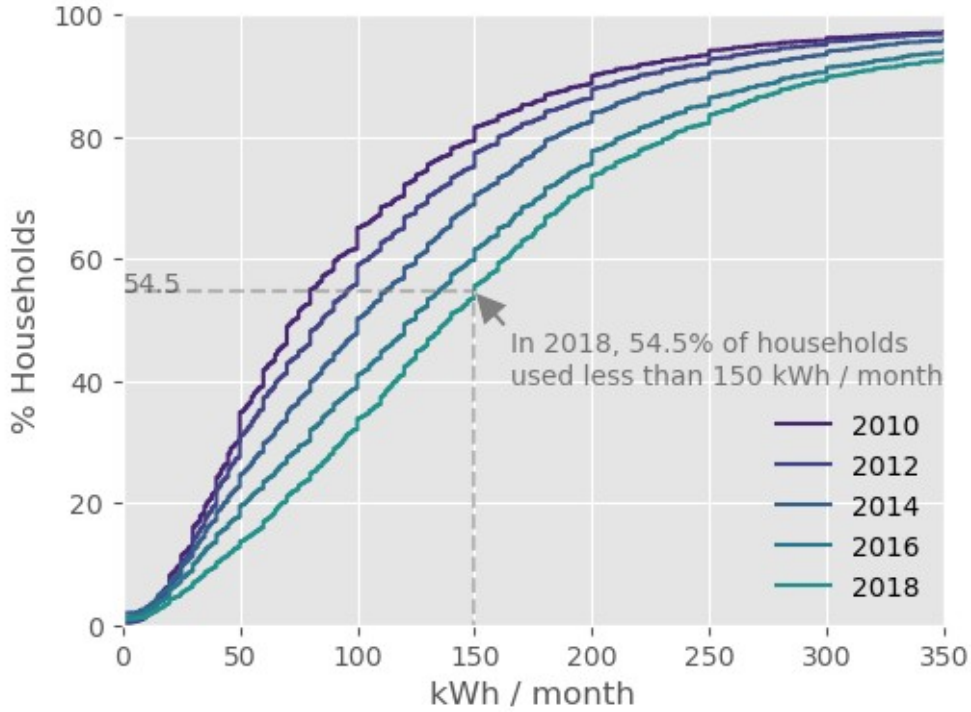


Figure 2: Monthly electricity usage by household in Vietnam, cumulative distributions. The curve moves to the right over time, as households used increasing amounts of electricity.

5. The economic view: is electricity affordable for all?

Figure 3 shows the electricity tariffs in Vietnam from 2004 to 2018. There are many curves because the tariff is an increasing staircase function: the more one consumes electricity, the higher the marginal tariff. In 2010, for example, consumers paid electricity 600 VND/kWh for the first 50 kWh, then 1004 VND/kWh from the 51st kWh to the 100th kWh, and so on (see Supplementary_Figure 1).

Increasing block tariffs for electricity, water, or gas are popular in many countries since they offer policymakers a tool to address equity and efficiency concerns. First, as far as power demand correlates with wealth, an increasing block tariff improves equity. It gives poor households access to electricity at a relatively low price. The first block can be provided at a tariff lower than production costs, enacting solidarity between users. Second, an increasing block tariff may improve energy efficiency. It presents higher marginal costs of electricity to households with higher electricity consumption. That tends to reduce wasteful uses and moderate the growth of their electricity demand.

The right panel in Figure 3 shows that the government kept electricity tariffs under control during the high-inflation years after the global economic crisis of 2008 (M. P. Nguyễn 2010). This contributed to protecting the poorer consumers and mitigated inflation. Tariffs eventually caught up when the inflation cooled down, but in real terms, Vietnamese households faced cheaper electricity in 2020 than in 2010.

The average electricity tariff in Vietnam is low compared to other countries. In 2014, for example, it was 0.08 US$/kWh. Amongst 29 major countries in Asia and the Pacific, only Buthan, Mongolia, and Myanmar had a lower tariff (World Bank 2020, page 68).

Table 2 displays the budget effort indicator, defined as the weight of the electricity bill in the households' budget (also Supplementary_Figure 2 and Supplementary_Figure 3). Electricity is affordable in Vietnam, meaning that the budget effort remains at a modest level. In 2018, the median household electricity budget effort was 2.4 % of income. This compares favourably with other countries. For example, according to (International Energy Consultants 2016), "*In the Philippines [...] the average size (170kWh/month) household spent an estimated 4.5% of monthly disposable income on electricity in January 2016 (down from >6% in 2012). The average spend of 44 markets surveyed was 3.9%, ranging from a low of 1.5% in Taiwan to a high of 8.2% in Portugal*". Supplementary_Figure 4 shows that 95 % of Vietnamese households devoted less than 7 % of their income to electricity.

However, Table 2 shows a trend suggesting that cheap electricity years may not last. The median budget effort was 1.5% in 2010 as a result of the 2008-2010 electricity price control. After that, the effort increased by fifty per cent between 2010 and 2018. As households become more affluent over time, it is normal that they consume more and that their bills

increase in nominal and in real terms. Here we saw not only that, but electricity expenses have increased faster than income.

Economists talk about a *luxury* or a *superior* good when the fraction of budget spends purchasing it increases when households income increase. However, this evidence does not imply that electricity is always a luxury/superior good for everybody. First, as exposed above, the relative price of electricity declined over 2010-2020, which can explain a part of the demand increase. Second, the econometric analysis presented in (H.-S. Nguyễn 2019, chap. 6) shows that for households in the lower-income quantiles, the electricity consumption is inelastic to income. Electricity is an essential good for poor households.

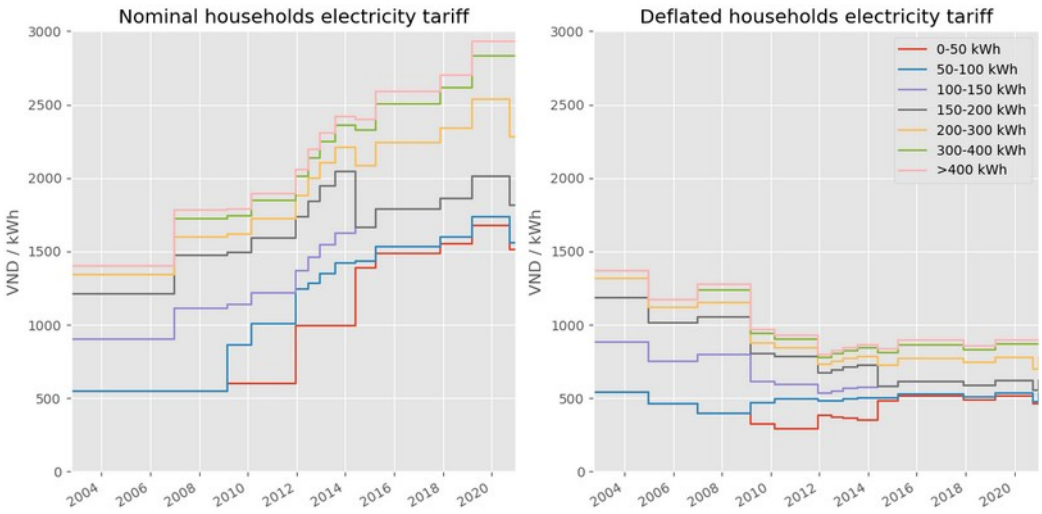


Figure 3: Electricity block tariff for households in Vietnam, in nominal terms (left) and adjusted for inflation (right). The real electricity price for households decreased from 2003 to 2018.

Year	2008	2010	2012	2014	2016	2018
Households not paying anything	3.5%	3.6 %	3.2 %	2.3 %	1.4 %	1.1 %
Households paying more than 6 % of their income for electricity bill	2.5%	2.3 %	3.0 %	5.1 %	6.2 %	7.9 %
Half of the households pay less than __% of income	1.6%	1.5 %	1.8 %	2.1 %	2.3 %	2.4 %
95 % of the households pay less than __% of income	4.7%	4.6 %	5.2 %	6.0 %	6.4 %	7.0 %

Table 2: Electricity bill as a fraction of income. Source: Authors, from VHLSS data.

6. The subjective view: are electricity needs met?

Table 3 summarizes the answers to VHLSS 2010/2012/2014 surveys Q12. *Has your electricity usage [....] been sufficient to meet needs over the last 30 days?* It shows that in 2010, one out of four households in Vietnam declared that their electricity use was not sufficient to meet their needs. That ratio dropped under 5 % two years after that and under 3% in 2014.

Figure 4 maps this rapid progress in satisfaction between 2010 and 2012. The subjective indicator shows that during the 2010-2012 time period, there was significant progress towards meeting SDG7. How can we explain it?

A systematic survey error may be present. However, according to the survey documentation, the question's wording was the same in 2010, 2012, 2014.

Expanded energy access is not the only explanation. There is a correlation between access and satisfaction; see Figure 1 and 4. Satisfaction increased much faster compared to the relatively slow progress of the grid.

Energy-using expectations and behaviours are known to adjust. Would it be that households were more able to meet their needs with what was provided? We believe this effect may rather play in the opposite direction, given that the equipment levels increased. Regarding the demand for electricity by households, (General Statistics Office of Vietnam 2015, 26) stated that:

> *The percentage of households with fixed or mobile telephones reached 85%, the rate of households using a computer was 25.1%, the rate of households using a washing machine reached 30.9%, and the rate of households using refrigerators was 59.0%. All of these were at least twice as high as the indicators in the 2009 Census. In addition, the rate of households using air conditioning stood at 13.3%, nearly three times higher than the rate in the 2009 Census.*

We cannot rule out a fluke due to needs variations. Energy demand is known to be sensitive to weather, which is random. The weather in 2010 was warmer than in 2012 and 2014. The heatwave could have led to exceptionally high cooling needs and shortages due to low flows to hydropower stations. A small fraction of households had air conditioning at that time, but fans also require electricity. However, we offer a simpler explanation.

We conjecture that satisfaction increased between 2010 and 2012 because the electricity supply reliability improved. In 2010 there were many shortages due to delays in adding new coal power plants. After that year, reserve generation capacity increased and that improved reliability. According to IEA (accessed 2021-02-08), the Vietnamese residential sector consumed 31.5 TWh in 2010, 38.4 TWh in 2012 and 45.7 TWh in 2014. The 50% growth in four years shows there was unsatisfied demand in 2010. Numbers for 2010 are not available, but according to EVN 2016 annual report, the System Average Interruption Duration Index went from 8077 minutes per customer in 2012 to 3134 minutes in 2014.

The subjective indicator provides an integrated measure of the quality of service. People's impressions are not so much based on averages of physical and economic flows than on extreme events: a power outage during a heatwave or coldwave will be remembered.

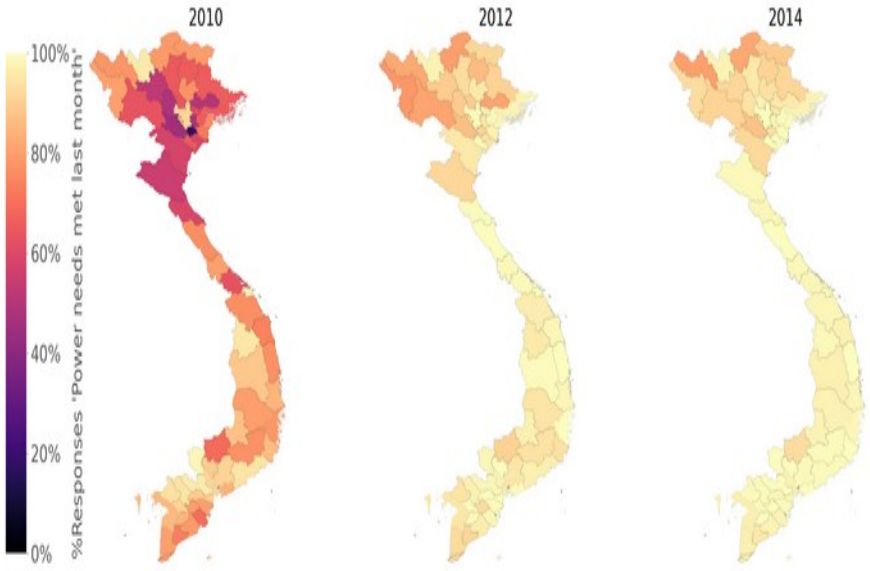


Figure 4: Satisfaction levels progress. The share of households declaring their electricity consumption was not sufficient to meet their needs in the previous month decreased rapidly between 2010 and 2012.

Table 3: Answers to question Q12: 'Has your household's consumption of electricity over the last 30 days been sufficient to meet its needs ?' in VHLSS 2010, 2012 and 2014.

Survey year	**2010**	**2012**	**2014**
	n = 9 251	*n* = 9 237	*n* = 9 266
Not sufficient	24.4 %	4.8 %	2.8 %
Sufficient	72.6 %	89.6 %	90.9 %
More than sufficient	3.0 %	5.6 %	6.3 %

7. Interactions between the three viewpoints

Section 4, the engineering viewpoint, looked at access to electricity and quantities consumed. Section 5, the economic viewpoint, looked at tariffs and the weight of the electricity bill in households' budget. Section 6, the subjective viewpoint, looked at the satisfaction of electricity needs. Only that viewpoint allowed us to see the qualitative jump between 2010 and 2012.

This section examines the interactions between the three viewpoints quantitatively. Figure 5 shows the number of respondents of the VHLSS 2014 meeting three different criteria of energy poverty: using less than 30 kWh per month, spending more than 6% of income on electricity, and declaring their electricity usage did not meet their needs. The first two are objective; the third is subjective. The precise limits for the objective criteria are somewhat arbitrary, but the qualitative result does not depend on it: there is little overlap between the three energy poverty indicators.

Consider first the interaction between the 'energy poverty bar' idea based on the quantity of electricity used and the subjective indicator of needs not met. Table 4 shows that in 2014, the electricity consumption of households with unsatisfied needs tends to be lower than in the rest of the population. In 2014, half of the households in Vietnam who declared insufficient electricity used less than 25 kWh per month.

What does 25 kWh per month mean in terms of basic needs? It amounts to about 830 Wh per day. This is more than enough to charge many telephones since a phone battery contains about 5 Wh. It is also enough for lightning, as a modern light bulb is about 10 W, a few hours per day. A TV and fans can also fit within this energy budget. However, it does not go far into modern comfort appliances. This amount of energy is not enough to run an air conditioning unit, refrigerator, electric cooking or heating.

While households who declared that their electricity usage did not meet their needs tend to use little electricity (in 2014), the converse is not true. Using small quantities of electricity can satisfy needs. In our sample, among the households who used less than 30 kWh of electricity, most did not declare their needs unsatisfied (see Figure 5). This shows that the absolute amount of energy used is not a sufficient indicator to determine satisfaction. It is the perceived comparison of the energy used with the needs of the household, determined by the appliances it owns, that determines sufficiency.

Second, consider the interaction between the 'high electricity cost' ideas based on the share of income devoted to electricity and the subjective indicator. In 2014, about 6% of Vietnamese households had 'high electricity cost', defined as an electricity bill larger than 6% of their income. Survey results show a very small overlap between that population and the households declaring that their needs were not met (see Figure 5). Furthermore, respondents declaring their electricity use did not meet their need tended to spend less on

electricity than the general population. The share of income devoted to energy is not a sufficient indicator to determine satisfaction. (Vignon 2014) also found a low correlation between objective and subjective energy poverty indicators. More specifically, in continental France, only 20% of the households spending more than 10% of their income on energy also declare suffering from cold.

Third, the high electricity cost (budget effort > 6%) subsample also has very little overlap with the 'low electricity use' subsample. This survey confirms that the 'high electricity cost' definition of energy poverty is problematic, as discussed in section 2.

Table 4: Households declaring their electricity use did not meet their need, compared to the general population. Source: VHLSS (GSO, 2014)

	All households (*n* = 9 359)	**Households declaring electricity use did not meet their needs (*n* = 235)**
Median electricity used in the last month	100 kWh	25 kWh
Interquartile range	52 – 168 kWh	0 – 87 kWh
5 – 95 centile range	16 – 325 kWh	0 – 200 kWh
Median effort (ratio electricity bill/budget)	2.1%	0.9%
Interquartile range	1,3% - 3.2%	0% - 2.2%
5 – 95 centile range	0.6% - 6%	0% - 5.7%

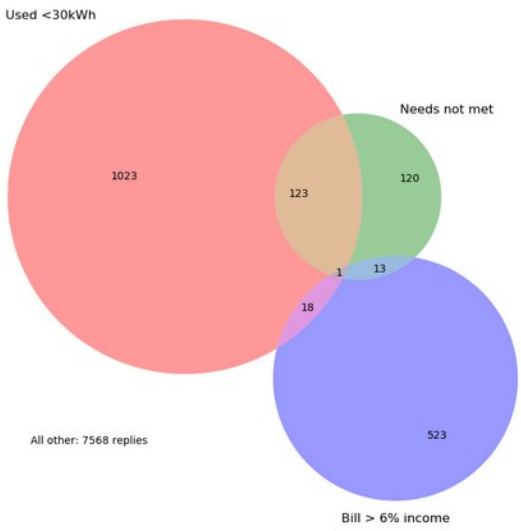


Figure 5: Interactions between the electricity poverty criteria in VHLSS 2014: 'Used < 30 kWh last month', 'Bill > 6% income', and 'Needs not met'.

8. Discussion

This section discusses Vietnam's progress towards SDG7 and the policy implications on energy poverty. It contextualizes by comparing with ASEAN countries, refer to (IEA, IRENA, UNSD, World Bank, WHO 2020, 7; Roseberry 2020) for comprehensive data on electricity poverty and SDG7.

Based on VHLSS survey data, Table 5 summarizes four indicators related to SDG 7 *access to clean, reliable and affordable energy for all*. The first row is a proxy for SDSN Indicator 51 discussed Section 2, access to reliable electricity. The next three rows correspond to the three viewpoints discussed in sections 4, 5 and 6.

The first row shows that Vietnam has mostly achieved SDG7 *access to clean energy for all*. Vietnam has a lower-middle-income economy. According to World Development Indicators (World Bank, accessed 2021-02-18, statistics for 2018), 86,3% of the population had access to electricity in that country group. Vietnam scores above its peers. Its access indicator compares with upper-middle-income countries, where 99.4% of the population had access (World Bank, *op. cit.*). Historically within ASEAN, Vietnam reached electrification after Brunei Darussalam, Malaysia, Singapore and Thailand, but before the Philipines, Indonesia and the Lao PDR (Gu, Yan, and Nuki 2020). Cambodia and Myanmar have yet to reach a 95% electrification rate as of 2019.

The Philippines and Indonesia have a higher income than Vietnam but lots of isolated islands, making electrification more difficult. Lao PDR is a continental country well endowed in hydroelectric resources and income per capita comparable to Vietnam's. Nevertheless, its electricity use per capita is much lower, maybe because it has a higher fraction of rural households living in mountain areas. Cambodia and Myanmar are behind Vietnam in electricity access because they have lower income per capita. The same logic applies when comparing Vietnam with Brunei Darussalam, Malaysia, Singapore and Thailand.

That second row shows the share of households using less than 30 kWh per month. The percentage of households below an electricity poverty line is an energy poverty indicator. We choose 30 kWh here because it is the amount subsidized in official Vietnamese policies. However, the group covers a diversity of situations, the first three levels in Bathia and Angelou's (2015) multi-tier matrix for measuring household electricity consumption. The 'less than 30 kWh'group goes from households without any electricity access to households using about 1 000 Wh per day, which is enough for lighting, charging phones, running fans and television. By 2018 this under-30 kWh/month group comprised less than 7% of households, declining by about one percentage point per year during the period.

Considering the electricity consumption per capita, (Gu, Yan, and Nuki 2020) classify ASEAN member states into four groups. The first is Singapore, Thailand and Brunei

Darussalam. Vietnam is in the second group, with Malaysia and Indonesia. The third is Lao PDR and the Philippines. The fourth is Cambodia and Myanmar.

Row three shows the share of households spending less than 6 % of income on electricity. The conclusion that the burden is increasing fast does not depend on the precise 6% value, as Supplementary_Figure 2 shows. Do rows two and three confirm that "*Electricity poverty decreased but electricity-cost poverty increased*" (T. T. Nguyễn et al. 2019)? Spending more on electricity is not necessarily a welfare loss. Electricity can substitute other forms of energy, reducing their cost, particularly for rural and less wealthy households, which were still a majority of the population at the start of the period. Biomass use did decrease at the same time as electricity use increased. According to the International Energy Agency (Data and statistics, accessed 2021-02-10), in 2018, the total final energy consumption by the Vietnamese residential sector (households) was 10 059 ktoe, of which 5 352 ktoe (52 %) was as electricity and 2 213 ktoe (22 %) was as biofuel and waste. In 2008 the total was 15 110 ktoe, of which electricity was 2 241 ktoe (15 %) and biomass 11 086 ktoe (73 %). Most of the costs of using biomass energy are non-market. It would be difficult to quantify the welfare gains of using the electric rice cooker over the traditional wood stove, but given a choice, many households choose the first option.

Electricity is affordable for most households, but energy poverty remains for many. According to the General Statistics Office (2019, 435), air conditioner ownership per 100 households increased from 5.5 to 35.1 between 2008 and 2018. For urban areas, it went from 17.3 to 70.1. The statistic only increased from 0.1 to 3.3 air conditioner per 100 households for the lowest income quintile. Not being able to protect against extreme heat fits with the first definition of energy poverty presented in Section 2.

The barrier to air conditioning is not only capital but also operating costs. During the 2020 summer heatwave, several mass media raised the issue of cooling affordability for the poorer households (B. Lê 2020; Thương and Hà 2020). The monthly income per capita in 2018 for the first quintile was 923 000 VND, about 41 USD (GSO 2019, p.22). For the underprivileged households, each kWh counts. Using 1 kW for 100 hours in a month costs about 200 000 VND at the third tariff block. To compound the problem, many landlords charge high rates for electricity. If the government gave appliances for free, there would still be energy poverty in the sense of the fourth criteria discussed in section 2.

The fourth, bottom row is about satisfaction, the share of households stating that their electricity use did not meet needs last month. We regret that the 2016 and 2018 households surveys did not measure this indicator. As a regulated monopoly provides electricity, it remains useful that national statistical offices provide the government with independent performance indicators. National electricity policies have many objectives. Goals for the energy sector as a whole include independence and sustainability. Objectives facing households include universal access to electricity, affordable tariffs, and a satisfying quality

of service. We believe that these three objectives require different indicators. Energy poverty must be measured and discussed with engineering, economic and subjective data. The subjective energy indicator –designed from surveys asking people they had enough electricity to meet their households needs– provides essential customer satisfaction feedback that cannot be obtained by looking only at kWh and money flows.

For policymaking, the discussions on SDG7 and energy poverty indicators lead to operational criteria defining which households should be eligible for support. Section 7 found that the three different approaches point to different households. We argue that the subjective indicator is the more theoretically satisfying measure of progress towards SDG7. However, when it comes to identifying which households should receive money, subjective declarative criteria are challenging to trust. Furthermore, the 'high electricity cost' budget effort indicator has problems. Three approaches remain operational to define households eligible for electricity subsidies: a) low income, b) low electricity use, or c) both. The Vietnamese support scheme uses option c). A household with an income poverty certificate could get a subsidy of 30.000 VND/household/month if it consumed less than 50 kWh.

The VHLSS 2014 survey explicitly asked questions about electricity subsidies and poverty certificate. Figure 6 shows how the subsidy mechanism performed. Three-quarters of poor respondents declared they received the electricity subsidy. The Figure shows that only 37% of households using less than 30 kWh did receive the subsidy. The reason is that most of those households do not have a poverty certificate. Finally, only 23% of households who declared their electricity needs not met received a subsidy. The subsidy mechanism worked more to alleviate poverty (SDG 1) than to satisfy electricity needs (SDG 7).

Table 5: Evolution of performance indicators towards access to clean and affordable energy for all in Vietnam (less is better). Source: Authors, VHLSS data.

Year	2008	2010	2012	2014	2016	2018
Share of households not using grid electricity for lightning, rural/urban	4.3 % 0.3 %	4.7 % 0.3 %	4.4 % 0.3 %	3.3 % 0.1 %	2.0 % 0.1 %	1.6 % 0.0 %
Share of households declaring less than 30 kWh of electricity use within the last 30 days	NA	12.9 %	11.9 %	11.2 %	8.8 %	6.2 %
Share of households paying more than 6 % of their income for electricity	2.5 %	2.3 %	3.0 %	5.1 %	6.2 %	7.9 %
Share of households declaring their electricity use within the last 30 days did not meet their needs	NA	24.0 %	4.7 %	2.7 %	NA	NA

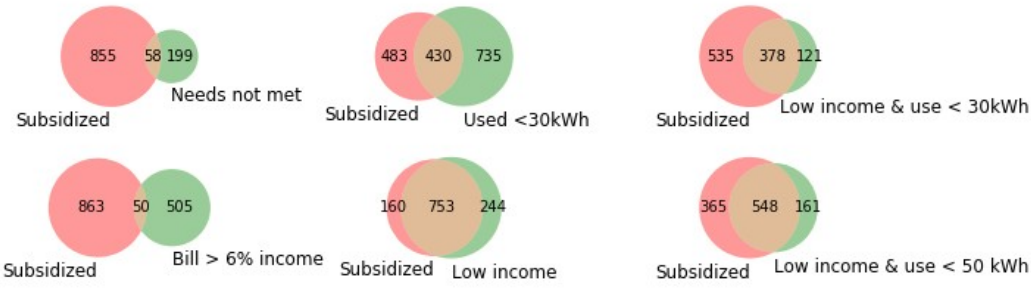


Figure 6: Overlap between households receiving electricity subsidy and subsamples of households matching different electricity poverty criteria in VHLSS 2014.

9. Summary and concluding remarks

Engineering and econometric objectivist approaches dominate the literature on sustainability monitoring. Out of 232 Sustainable Development Goal Indicators, only two are subjective (10.3.1 and 16.7.2). The case of Vietnam during 2008-2018 shows that the subjective and objective energy poverty indicators can tell different sides of the story. In 2010, the fraction of households with access to electricity was over 96%, but over 24% of households declared their electricity use did not meet their needs. Since 2014 the satisfaction rate is over 97%, even if 25% of the households used less than 50 kWh/month.

The subjective measure of energy poverty could be handy for macro scale international comparisons. The share of households satisfied with electricity service may be a more informative political indicator than the electrification rate. To target households eligible for energy subsidies, income and electricity consumption indicators may be more operational than personal declarations at the micro-scale. That may explain why the Vietnamese electricity subsidy works more to alleviate economic poverty than satisfy energy needs.

The three points of view explored in this paper converge to indicate that Vietnam progressed very close to the SDG7 – *Affordable and clean energy for all* – over the 2008-2018 period, and that electricity poverty is not an acute social issue in 2018:

- Vietnam achieved close to universal access to electricity. The expansion of the grid matched the demographic expansion. It should exceed it to bring electricity to all (World Bank Group and International Energy Agency 2013). About one million people remain to be electrified, mostly in remote areas in the Northern mountains.
- The quality of service, defined as the satisfaction of customers, has improved to a high level. Between 2010 and 2014, the share of households declaring that their electricity use did not meet their need dropped from 24% to 2.7%.
- Inequalities in electricity use among Vietnamese households decreased during the 2008-2018 period. Inequalities in electricity use are not greater than inequalities in income, contrary to the findings of Son and Yoon (2020) for the 1993-2004 period.
- Electricity is affordable in Vietnam. The electricity tariffs declined in real terms during the last ten years. They are lower than other ASEAN countries, and households spend a smaller share of their budget on electricity.

As the amount of electricity used increase, the cost of electricity weights in the budget of Vietnamese households is rising. Raising further the price of electricity may be necessary at some point to pay for imported fuels, finance investments in capital-intensive solar and wind power plants, reinforce and modernize the grid. As long as the government regulates the retail tariffs, it retains the possibility to share the costs between the different categories of electricity consumers. It could, for example, charge less the households and more the

industrial, commercial and institutional consumers. The increasing block tariff is not the only tool to protect households from electricity poverty.

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NHS provided the initial idea and the data, HDM directed the research. The two authors contributed to statistical analysis and writing. This work was started while the first author was visiting professor at the Clean Energy and Sustainable Development Lab (CleanED/USTH). We gratefully acknowledge comments from our colleagues Audrey Berry, Franck Nadaud, Nguyễn Trinh Hoang Anh, Rodica Loisel and anonymous reviewers. The authors declare no conflict of interest.

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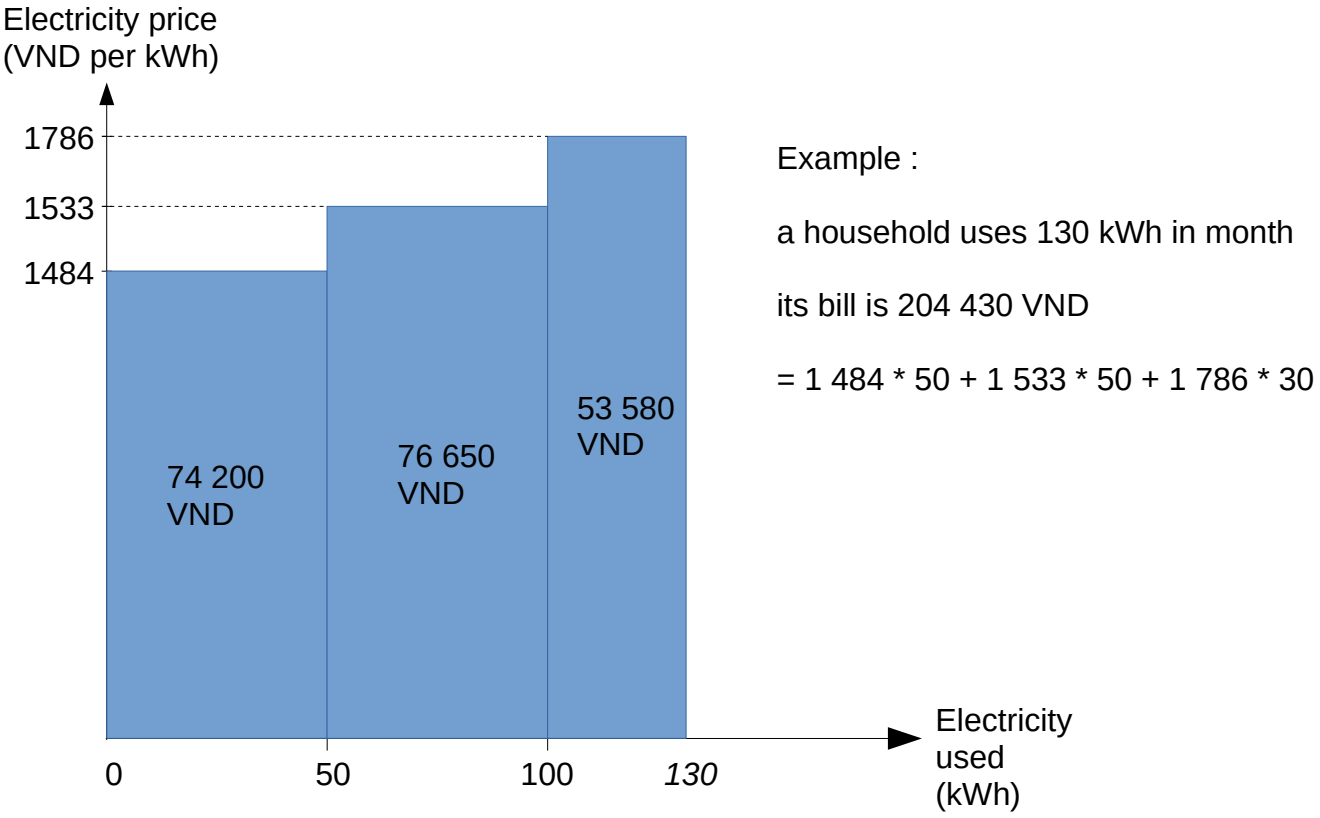
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Supplementary material to
Subjective satisfaction and objective electricity poverty reduction in Vietnam, 2008-2018.

Ha-Duong Minh Nguyen Hoai Son

2021-03-03

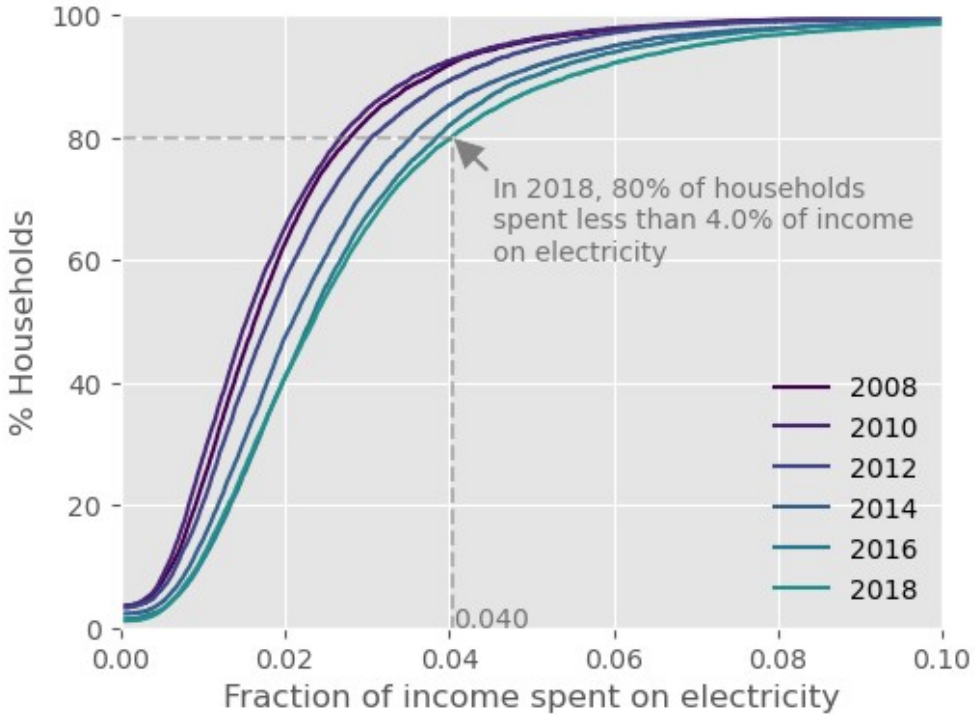


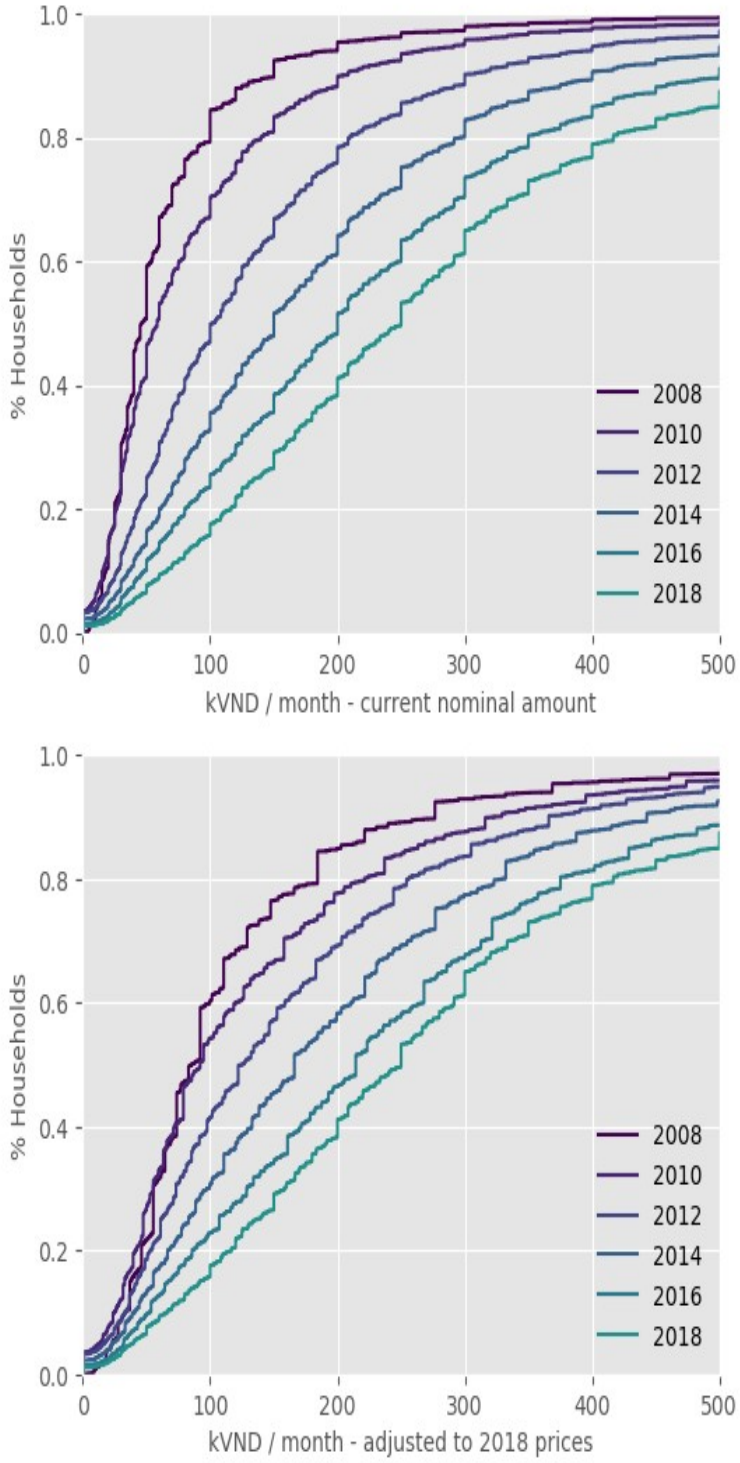
Supplementary_Figure 1: Principle of a block tariff. The history of the tariff used in Vietnam is shown in Figure 3 and Supplementary Table 1.

Supplementary Table 1: History of the electricity increasing block tariff in Vietnam.

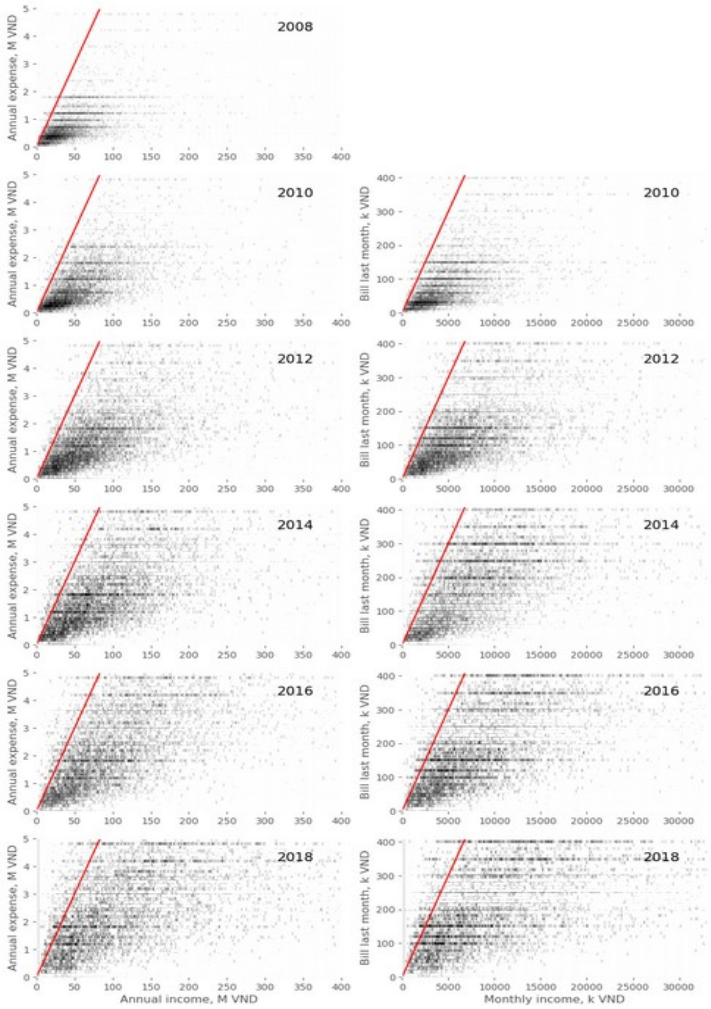
1994	First established with three blocks – the first block is 150 kWh
1995	The first block is split into 100 kWh for the new first block and 50 kWh for the second block.
1997	New blocks are added at the top, not touching the first two blocks.
2009	The first block is split into two blocks. The first 50 kWh is priced at 35 – 40% of the average electricity supply cost. The second 50 kWh is priced at the average supply cost.
2011	The first two blocks are amended. The first block is 0 – 50 kWh and priced at the average supply cost. This price is only for low-income households registered with EVN, which consume less than 50 kWh per month. All other households pay the second block price from 0 to 100 kWh. Its price is set to the average approved price of electricity. A household that has an income poverty certificate and uses less than 50 kWh can get a subsidy of 30.000 VND/household/month.
2014	More households can get the subsidized price. The household must meet the criteria that the Prime Minister define and use less than 50 kWh per month. The subsidized amount equals the consumption of 30 kWh at the price of the first block.
2020	The price of the first three blocks is reduced by 10% from September to December to support households during the second wave of the COVID-19 crisis.

Supplementary_Figure 2: Cumulative distribution function of the fraction of income spend on electricity by Vietnamese households. These curves are summarized in Table 2.

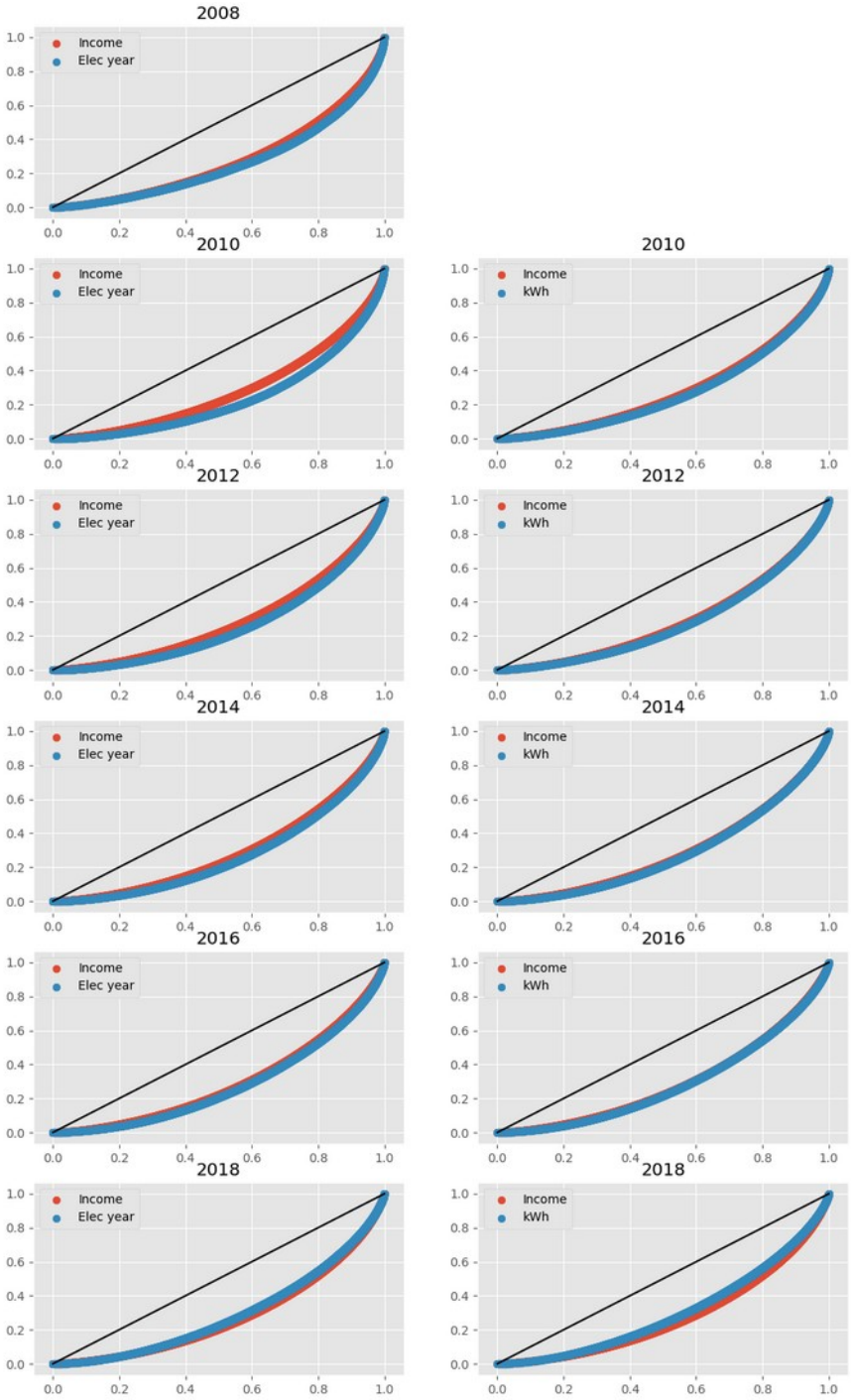




Supplementary_Figure 3: Distribution of electricity expense by Vietnamese households. Expenses almost doubled in real terms between 2008 and 2014. Curves jump at multiples of 50.000 VND because this is declarative survey data, not observed electricity bills.



Supplementary_Figure 4: Electricity budget as a function of the total income. Most Vietnamese households spend less than 6% of their income on electricity – they are below the red line. The fraction of households above the red line is increasing.



Supplementary_Figure 5: Comparison between income and electricity inequality in Vietnamese households. Electricity use is measured by cost on the left and by quantity on the right. The Lorenz curve for income is in red. The Lorenz curve for electricity use is in blue. During the period, the blue curve got closer to the diagonal than the red curve. This means that the inequality in electricity use reduced more than the inequality in income.