Affordable and reliable power for all in Vietnam progress report

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Abstract

This statistical report contribute facts and numbers on the state of access to electricity for all in Vietnam, based on large-scale surveys conducted in the time period 2008-2014. Its theoretical contribution to debates on energy poverty is to account for the human dimension by using an self-reported satisfaction indicator. Surveys asked people if respondents had enough electricity to meet their households needs. We find that in Vietnam, the problem of providing access to clean energy for all is largely solved for now. The fraction of households without access to electricity is below two percent. This represents in the order of a million people. And the fraction of households declaring unsatisfied electricity needs is below three percent. The median level of electricity usage in 2014 was 100 kWh per month per household. An overwhelming majority of households spend less than 6% of their income on electricity, but the effort level is increasing.

Highlights

In 2014, 97.7 % of households in Vietnam used grid electricity for lighting.

In 2014, out of four Vietnamese households, one used less than 50 kWh per month, and another between 50 kWh and 100 kWh.

In 2014, 95 % of Vietnamese households devote less than 6.2 % of income to electricity.

Between 2010 and 2014, the share of income that Vietnamese households devote to electricity increased by about one third.

In 2010, one out of four households in Vietnam declared that their electricity use was insufficient to meet their needs. That ratio dropped under 3 % in 2014.

In 2014, half of the households in Vietnam who declared insufficient electricity used less than 22 kWh per month.

In 2014, among households using less than 22 kWh per month, only one out of six declared that their needs were not met.

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1. Introduction

Access to clean and affordable energy for all is the seventh United Nations Sustainable Development Goal, one of our overarching civilization goals in the beginning of this millennium. The present note offers some statistical observations on progress towards this goal in a middle income country comprising over ninety million people, the 14th most populated country in the world : Vietnam.

Vietnam's development is highly successful in economic terms. Its GDP per capita grew from 97.2 USD in 1989 to 2 110 USD in 2015 (World Bank database, accessed 2016-09-11). Table 1 provides more details on the country's conditions in recent years. Yet sustainable development also requires success in environmental and social terms. Assessing that requires more than GDP and electricity production growth numbers.

Vietnam's rural electrification program is oft-cited as a exemplary success of providing energy access (Doan Van Binh 2010; Asian Development Bank. 2011). Yet in the considerable academic literature on energy poverty (Li, Pan, and Wei 2015) it is hard to find any study about Vietnamese households among the reports on China, India, Brazil and South Africa. (Sovacool et al. 2011) includes Vietnam, but looks at small businesses rather than households. This statistical report contribute facts and numbers on the state of access to electricity for all in Vietnam, based on large-scale surveys conducted in the time period 2010-2014 independently from EVN, the national electricity company. We focus on electricity poverty, leaving fuel poverty questions for further research.

The outline and main results of the manuscript are as follows. Section 2 presents the scope relative to previous existing research, our data and methods. The main theoretical contribution of this study is to account for the human dimension of energy poverty by using an self-reported satisfaction indicator. One way to measure energy poverty is simply to ask people if they had enough to meet their needs.

Section 3 presents statistics on grid access and electricity usage, in kWh. Its main results are that 1/ Less than two percent of the population does not have access to the grid, and 2/ The median level of electricity usage in 2014 was 100 kWh per month per household.

Section 4 offers a more narrative historical perspective on energy affordability measures taken by the Government of Vietnam, in the form of a block tariff and direct subsidies. Our statistics find that households spend less than 6% of their income on electricity, but the effort level is increasing.

Section 5 presents statistics on the question about satisfaction. We show that it increased between 2010 and 2012. We conjecture that satisfaction is a measure of reliability, the absence of black-outs. Reliability increased due to having enough system wide generation capacity in that period.

The concluding section 5 summarizes the observed progress on the sustainable development indicators, and peeks at the challenges ahead : wealth and population growth ; urbanization and lifestyle changes ; clean energy generation and national independence.

2. Scope, data and method

Universal access to electricity is sought at the early stages of economic development because it is an enabler. Lighting and electric engines increases productivity. Radio communication connects people. Refrigeration allows to preserve vaccines and better store food for sale or consumption. An electric turbofan in advanced cook stoves reduces the indoor air pollution caused by inefficient combustion in traditional biomass. Full electric cooking in urban areas eliminates it.

To focus the attention of the international community on the need to provide these benefits to all humans, the United Nations have adopted « Ensure access to affordable, reliable, sustainable, and modern energy for all » as Sustainable Development Goal 7. To assess progress towards this goal (SDSN 2015) gives the following two Key Performance Indicators, the KPI #50 and #51 :

- Share of the population with access to modern cooking solutions (%)
- Share of the population with access to reliable electricity, by urban and rural (%)

These two KPI share a similar pattern. They each start from an aspect of energy poverty : respectively cooking with traditional solutions, and lacking access to reliable electricity. Then the indicator is constructed as « Share of the population not in that energy poverty situation ».The literature offers many others ways to recognize an energy poverty situation.

- Not having access to enough energy to meet the basic needs, defined according to human and environmental considerations. For example the official French definition according to the « Loi Besson du 2010-07-12 », also known as « Grenelle 2 law » states that "is in energy precarity a person who experiences in her house special challenges to have the necessary energy supply to satisfy its basic needs because of the inadequacy of its resources or its habitat."
- Spending more than 10 % of the income to pay the energy bill, including electricity and fuel for heating and cooking excluding transportation. This definition has been set out officially in the UK Fuel Poverty Strategy 2001, according to the critical study by (Hills 2012). According to ONPE (2016), this is also used in France as a convenient rule of thumb to assess the magnitude of the issue from national-scale statistics.
- Hill (2012) led UK 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. This is also used in France (Didier Chérel 2014).
- An energy poverty line can be econometrically estimated as “the threshold point at which energy consumption begins to rise with increases in household income”. At or below this threshold point, households consume a bare minimum level of energy and should be considered energy poor. (Barnes, Khandker, and Samad 2011) (He and Reiner 2016)

To better focus on the facets of energy poverty related to electricity usage, we set aside aspects related to fuels for cooking, transportation or heating. The present note leaves KPI #50 out of its scope. On the other hand, we go beyond KPI #51 by looking not only at electricity access, but at electricity usage.

Year	2008	2010	2012	2014
Population[a]	85 118 700	86 947 400	88 809 300	90 728 900
GDP at current prices, billion Dongs[a]	1 616 047	2 157 828	3 245 419	3 937 856
Price index, base 100 in 2008[a]	100,0	116,9	151,1	167,7
Share of population in urban area[a]	28,99 %	30,50 %	31,83 %	33,10 %
Electricity final consumption, annual[b]	67,8 TWh	86,9 TWh	105,4 TWh	130,9 TWh
Electricity final consumption, annual per capita[c]	797 kWh	999 kWh	1 187 kWh	1 443 kWh

Table 1 : Vietnam's economy and electricity conditions in 2008-2014.
[a] Source GSO, accessed 2016-10-10, [b] Source IEA, accessed 2016-10-10 [c] In 2014, includes industry 54%, household 36%, services 5%, agriculture 2% and other 4% (Solidiance 2015).

We argue that the approaches based purely on energy quantity and/or monetary indicators can only provide a structurally incomplete view of energy poverty, because they all come from an engineering or econometric approach. This remark also includes composite indices such as those proposed in (Nussbaumer, Bazilian, and Modi 2012; Foster, Tre, and Wodon 2000; Pachauri et al. 2004). Sustainable development has a social pillar, and social sciences have long integrated the need to include the voice of the subjects into its research methods. (Jérome Vignon 2014, 16) argues that in Europe, a subjective indicator of "being cold in winter" is relevant, and has been use in France and in Ireland.

Consequently, this report describes the situation of Vietnam with respect to the electricity part of SDG 7 from three perspectives. Section 3 is about access, section 4 is about affordability, and section 5 is about satisfaction levels. We complement the energy quantity and energy economics indicators with a satisfaction indicator.

Section 5 is based on replies to the question *"In the last month, did your consumption of electricity met the needs of your household?"* A clear-cut Yes/No question directly related to the variable being estimated has methodological advantages. Households themselves are best placed to judge if their electricity needs are met. This reduces error compared to indirect measures of energy poverty based on income, expenditure, or basic needs. Surveys are an objectively repeatable measurement: two independent survey companies applying the same method will find coherent results. And while indicators based on energy quantity or income are theoretically based on precise objective numbers rather than subjective self assessments, in practice they are also collected by declarative survey and suffer from the same kind of imprecision. A theoretical drawback of the question is that respondents may not make a difference between needs, basic needs, and desires.

The data used to produce all results presented below come from of four large sample surveys conducted in 2008, 2010, 2012 and 2014 : the Intercensal Population and Housing Surveys (General statistical office 2015). Conducted under the Ministry of Planning and Investment with support from the United Nation Population Fund, 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.

The methods for analyzing the data are ordinary, based on simple robust estimators : counts and quantiles. All Stata and Python scripts we used are published as an electronic supplementary material, with open access under creative commons license. The dataset extracted from the primary survey files is also published.

We did not weigh answers, de-bias or otherwise adjust 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. We believe that the surveys were organized in the best possible conditions for the context. The results we present below are subject to systematic and random errors unavoidable in all survey data (Daniel Kasprzyk 2005). We did not attempt to quantify these errors formally, but hereby forewarn that in the numbers presented below the third digit is not policy-relevant, it is meaningful mathematically only.

3. Grid access and electricity usage

Surveys asked “Which Is the main lighting in your household”, with possible answers: 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 declare using national-grid electricity for lighting. This is a proxy for the state of electrification over 2008-2014. It shows that the grid was already operational in most of the territory in 2008, but problem areas remain in the remote villages of the northern mountains are slow to disappear. The cost of these grid connections are high compared to the number of households serviced, in these areas there are not many roads.

The maps 1 and 4 are drawn without correction for province size and province population : they reflect energy poverty levels within a province. Thus, a large gray 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. With respect to the overall population, our data shows that:

In 2014, 97.7 % of households in Vietnam used grid electricity for lighting.

This number is consistent with the estimate of (Doan Van Binh 2010) who wrote that :

> *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.*

Other estimates are also about one million without access. (EVN 2015) reports that by the end of 2014, as much as 98.22 % percent of households were connected to electricity , which means that 1,78 % were not. According to (General statistical office 2015, 23–25), as of 1 April 2014 the national population of Viet Nam reached 90,493,400 people […] In 2014, the number of households in the entire country reached 24,264,990, an increase of 1,820,668 households since

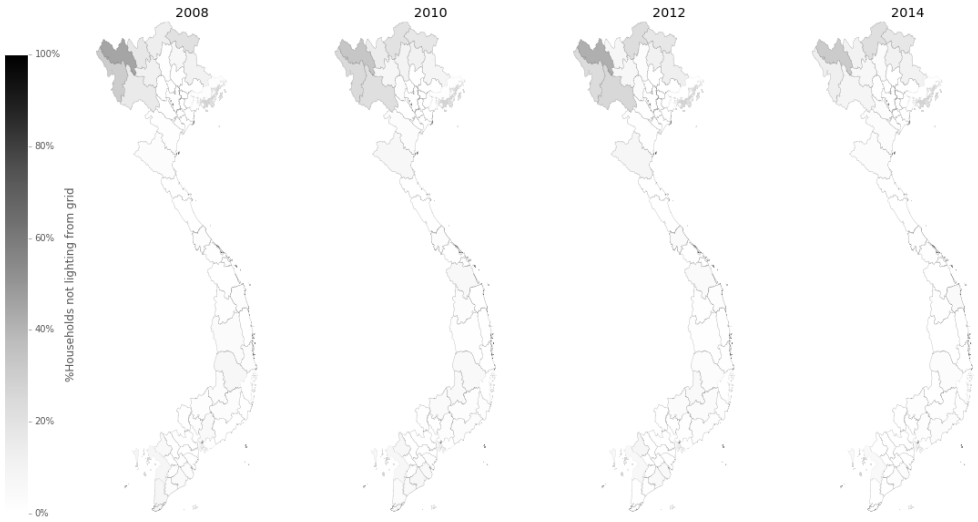


Figure 1: Progress of electrification.
The share of households not relying on the national grid for lightning decreased from 2010 to 2014 in most provinces.

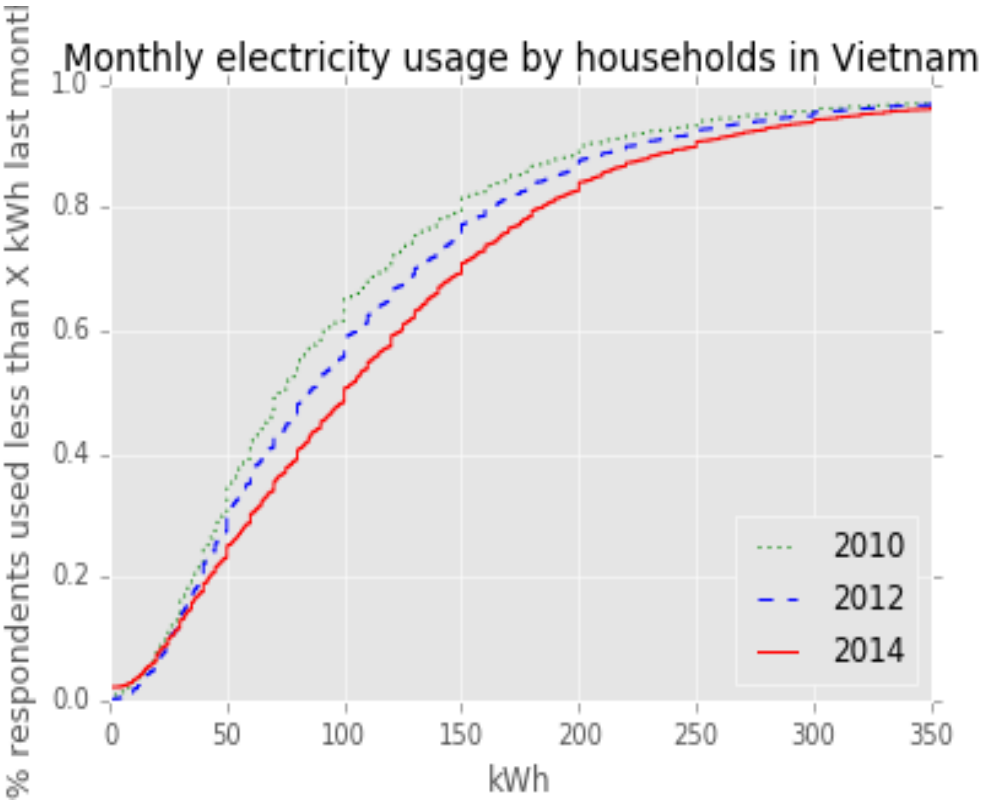


Figure 2: Monthly electricity usage by households in Vietnam.
This is a cumulative distribution. For example, it shows that in 2010, about 80 % of the households used less than 150kWh of electricity in the month.

the 2009 Census. Based on the previous numbers, about 430,000 households were not connected in 2014, and assuming an homogeneous household size that amounts to 1.5 million people.

Figure 2 shows the amount of electricity the households declared using in the last month. Vietnam is a lower middle income economy. In this context, the median amount of electricity usage is 100 kWh per month:

In 2014, out of four Vietnamese households, one used less than 50 kWh per month, and another between 50 kWh and 100 kWh.

Over the 2010-2014 period the distribution shifted to the right, that is towards higher quantities. The median electricity consumption per Vietnamese household in the surveyed month went from 73 kWh to 100 kWh in these four years (+40%), and the mean from 104 kWh to 126 kWh (+21%).

Over that period, the use of electricity by Vietnamese households moved towards a more uniform distribution. The Gini index of Figure 2 ‘s distributions was 45.3 in 2010 , 43.1 in 2012 and 42.6 in 2014.

The main reason why the electricity consumption increased is economic growth, as shown Table 1 . As people become richer, they afford to consume more electricity. To quantify this effect, we regressed within period the quantity of electricity used over the annual income. Results are shown in Supplementary_Figure 3. The relation is stable for all three years, we report only for 2014:

Electricity use in kWh per month = 28.3 + 0.99 * annual income in M VND

In other words, statistically a Vietnamese household used 1 kWh per day as basic needs, plus 1 kWh per month for each million VND of annual income.

That rule of thumb does not apply across periods. We have seen that from 2010 to 2014, the increase in electricity consumption was 27 kWh for the median, and 22 kWh for the mean According to our survey dataset, the household income increase from 2010 to 2014 was about 11 M VND2014 for the mean, 12 M VND2014 for the median, when adjusted for the inflation of the consumer price index.

4. Energy affordability ensured by block tarification and subsidies

Figure 3 shows the evolution of electricity tariffs in Vietnam. The tariff is progressive. In 2010 for example, consumers paid electricity 600 VND/kWh up to the first 50 kWh, then 1004 VND/kWh from the 51st kWh to the 100th, and so on.

Progressive block tariffs for electricity are popular for many developing countries since it has two advantages. Progressive block tariffs mean that the more a household consumes the higher price it has to pay. First, they ensure that poor people can access to electricity at lower price. Second, progressive tariffs stimulate electricity saving behavior, since bigger consumers face higher marginal costs. The first block can be provided at a price lower than production costs, enacting a solidarity between users (see illustration Supplementary_Figure 1).

Vietnamese government has adopted progressive block tariffs for electricity since 1994. The rules have evolved as follows :

- 1994: 3 blocks – the first block is 150kwh

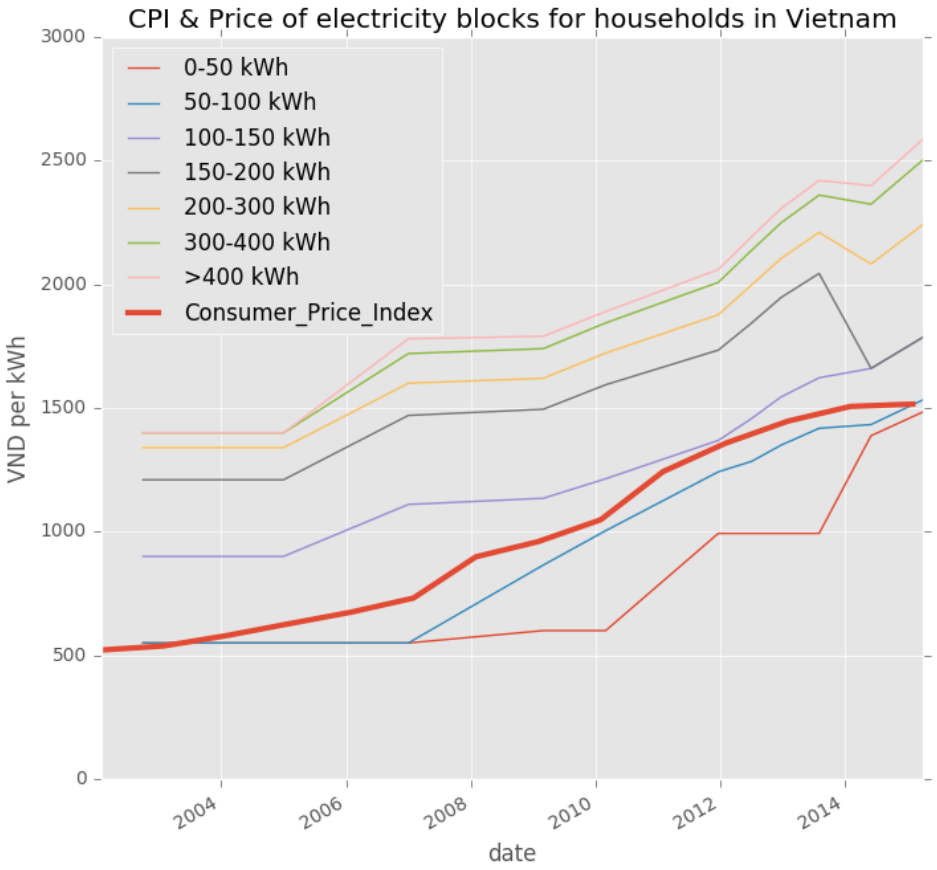


Figure 3: The price of electricity in Vietnam increased slower than other prices. Electricity block tariff for households in Vietnam, and inflation (Consumer Prince Index)

Year	2008	2010	2012	2014
Households not paying anything	0.023 % of household	3.4 % of households	3.2 % of households	2.2 % of households
Households paying more than 10 % of their income for electricity bill	0.5 % of households	0.4 % of households	0.5 % of households	1.1 % of households
Half of the households pay less than	1.7 % of income	1.5 % of income	1.8 % of income	2.1 % of income
95 % of the households pay less than	4,8 % of income	4.6 % of income	5.2 % of income	6.2 % of income

Table 2 : Electricity bill as a fraction of income.
Source : VHLSS

- 1995: The 1994 first block was separated to 100kwh for new first block and 50kwh for second block
- 1997: adding new blocks but the first two remained the same
- 2009: splitting the first block to 2 blocks. The first 50kwh has the price of 35 – 40% of average electricity price. The second 50kwh has the price equaling to the average production costs.
- 2011: amending the first two blocks
    - The first block is 0 – 50 kWh. The price equals to average production costs. This block and price is only for low income households which consume less than 50kwh per month. These households have to register to EVN for the block. If the electricity consumption of three months exceeds 150 kWh, the seller will apply the price for the second block.
    - The second block is 0 – 100 kWh. The price is set to the average approved price of electricity.
    - A household which has an income poverty certificate would get the subsidy of 30.000 VND/household/month if it consumes less than 50kwh.
- 2014: Adding households that get subsidized price. The household must meet the criteria that Prime Minister define and use less than 50 kWh per month. The subsidized amount equals to the consumption of 30kwh at the price of the first block.

Figure 3 shows that electricity tariffs for the first block was kept under control during the high-inflation years after the global economic crisis of 2008. This contributed to protect the poorer consumers and to mitigate inflation. Tariffs eventually catched up in 2015.

Supplementary_Figure 5 shows how Vietnamese households increased the amount the spend on electricity. Between 2008 and 2014, the amount of money that Vietnamese households devote to electricity almost doubled. This is in real terms, corrected for the inflation of the consumer price index. At the same time, households became richer. To look at the relative weight of electricity in the budget of households, consider Table 2 and Supplementary_Figure 2 . They show the share of income that Vietnamese households devote to electricity, concluding that :

In 2014, 95 % of Vietnamese households devote less than 6.2 % of income to electricity.

This can be regarded as a measure of success that electricity is affordable in Vietnam, as it is far below the 10 % energy poverty limit mentioned above Section 2 (see Supplementary_Figure 4). It does not include any fuel expenses, for transportation or cooking. However the table shows a worrying trend:

Between 2010 and 2014, the share of income that Vietnamese households devote to electricity increased by about one third.

5. Satisfaction : people say their electricity needs are meet

Table 3 summarizes the answers to VHLSS 2010/2012/2014 surveys Q12. *Has consumption of electricity [.…] 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 insufficient to meet their needs. That ratio dropped under 3 % in 2014.

Figure 4 shows geographically this rapid progress in satisfaction between 2010 and 2012. In the 2014 survey wave, only 2.7 % answered that their consumption of electricity did not meet their needs. This may be a surprising result compared to the relatively slower progress of the grid shown Figure 1. During the 2010-2014 time period, what quick and decisive progress towards meeting the UN Sustainable Development Goal 7 could explain this result ? Several reasons can be considered.

We do not think that increase in energy access is the main reason for that result, the grid did not expand that fast. We can also rule out that physiological needs decreased. A systematic survey error may be present, even if according to the survey documentation, the wording of the question was the same in 2010, 2012, 2014. It is conceivable that the 2010 heatwave could have led to exceptionally high cooling needs and low flows to hydropower stations. Energy demand is known to be sensitive to weather. Further research is necessary to assess this effect in Vietnam, and to compare the 2014 heatwave to previous ones.

The expectations and behaviors may have adjusted so that the households were more able to meet their needs with what was provided. However, this effect may rather play in the opposite direction, given that the equipment levels increased. Regarding the demand for electricity by households, (General statistical office 2015, 26) stated that:

> *The percentage of households with fixed and/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 times higher than 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 conjecture that another reason for increased satisfaction levels between 2010 and 2012 is that the reliability of electricity supply increased. However we cannot verify this conjectures here directly, the questionnaires did not ask about the existence of power cutoffs. And while reliability may be measured from an engineering perspective by looking at blackouts statistics, in Vietnam the numbers are not available because of fragmentation in the electricity distribution system.

Who are the households who declared that their electricity usage did not meet their needs ? In 2010 and 2012, we did not find visible differences between them and the rest of the population, from the electricity consumption viewpoint. Results are more contrasted in 2014. Table 4 compares them with the rest of the population. Half of the self-declared electricity poor households used less than 22.0 kWh in the month. That is 306 respondents.

In 2014, half of the households in Vietnam who declared insufficient electricity used less than 22 kWh per month.

The energy quantity 22 kWh divided by 30 days amounts to 733 Wh per day. This is largely enough to charge many telephones, since a phone battery contains about 5 Wh. It is also enough

for lightning, as a modern efficient light bulb about 10W and it is used a few hours per day. A TV and fans can also fit in this energy budget. However, it does not beyond these basic needs into modern comfort appliances. This amount of energy is not enough to run an air conditioning unit, refrigerator, electric cooking or heating.

However, using little energy can be satisfying, if the needs are modest. In the whole sample, 7.8 percent of respondents used less than 22 kWh of electricity. That is 1783 respondents. Those who are unsatisfied are a minority. Among the households using less than 22 kWh last month, for one who declares lacking electricity, five do not.

In 2014, among households using less than 22 kWh per month,
only one out of six declared that their needs were not met.

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 that determine sufficiency. (Jérome Vignon 2014) also found a low correlation between objective and subjective energy poverty indicators. More specifically, in France, only 20% of the households spending more than 10% of their income on energy also declare suffering from cold. More investigation seems needed to better understand these effects, which also depend on the effectiveness of existing subsidies (see Supplementary_Figure 6).

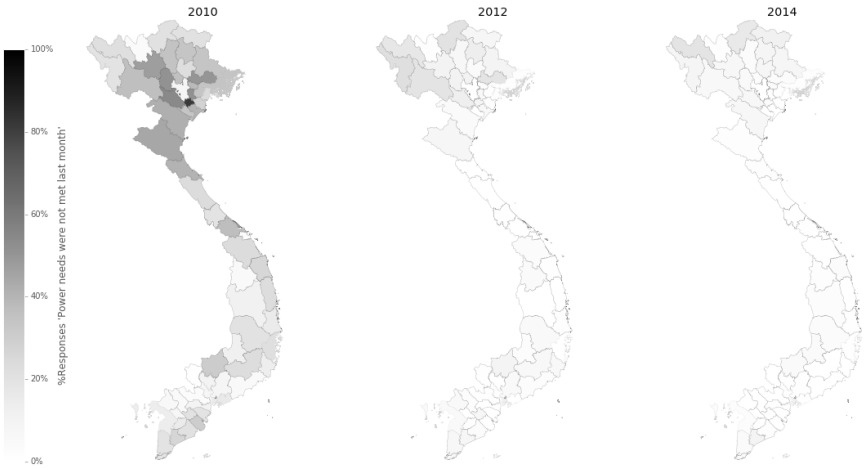


Figure 4: Satisfaction levels progress.
The share of households declaring their electricity consumption was not sufficient to meet their needs in the previous month decreased rapidly between 2010 and 2012.

Survey year	**2010**	**2012**	**2014**
	N = 9 261	*n* = 9 242	*n* = 22 695
Not sufficient	24.4 %	4.8 %	2.7 %
Sufficient	72.6 %	89.6 %	91.7 %
More than sufficient	3.0 %	5.6 %	5.6 %

Table 3 : Satisfaction with the electricity consumption.
Source : Question 'Has your household's consumption of electricity over the last 30 years been sufficient to meet its needs ?' , Vietnam Intercensal Population and Housing Survey (2010, 2012, 2014).

Electricity used in the last month (March 2014)	**All households**	**Households who declared Insufficient electricity use**
	n = 22 695	*n* = 611
Median (half of the households used less than this)	100 kWh	22 kWh
50 % Interquartile range (one quarter of the households used less, one quarter used more)	50 – 166 kWh	0 – 80 kWh
90 % Interquartile range (5 % used less, 5 % used more)	17 – 318 kWh	0 – 214 kWh

Table 4 : Quantity of electric energy used a month.
Source : Vietnam Intercensal Population and Housing Survey (2014)

6. Conclusion : Key Performance Indicators and future challenges

Based on our survey data, Table 5 summarizes key performance indicators to monitor progress towards the sustainable development goal SDG7 related to access to clean, reliable and affordable energy for all. The first row directly refer to the KPI #51 (see section 2). For now the problem of providing access to clean energy for all is largely solved. The fraction of households without access to electricity is one to two percent. This represents in the order of a million people, in areas where extending the grid is technically and economically difficult. The future may involve more decentralized electricity supply in these areas.

The second row is about satisfaction, the share of households stating if their electricity needs were met or not. The perceived sufficiency of supply relates to the 'reliable' dimension of the SDG7. We keep the indicator oriented towards "less is better" because when it comes to survey results, "declaring being not satisfied" and "not declaring being satisfied" should not be confounded.

These two indicators show success on the basic level of the sustainable development goal. Two essential engineering challenges have been solved : access to grid –as apparent from the first row– and generation capacity to satisfy demand –as apparent from the second. In one generation, most Vietnamese families experienced the transition from using decentralized, traditional energy to using modern fossil fuels and electricity grid power from centralized production sources.

The third row is the share of households above an electricity poverty line. This is a classic indicator. The literature offers many diverging approaches about where is the line. In the table we set the electricity poverty line at 30 kWh. There are three reasons to choose this number in Vietnam. First, it is the amount subsidized in official policies. Second, it is close to intercept when we regress the electricity consumption on income. Third, it corresponds to 1 000 Wh per day, which is a round number easy to reason with by stakeholders and researchers alike.

That third row is about the fraction of the population still on the first step of the energy ladder – with less than 1 000 Wh per day, one can hardly use a refrigerator or air conditioning. This fraction is declining, but still over ten percent. This is consistent with the lower middle income status of the economy.

The fourth row is the share of households spending less than 6 % of income on electricity. This is also a classic indicator discussed above, related to affordability. We set the threshold at 6% for several reasons. a) We believe that 10 % threshold discussed in the introduction is unreasonably

Year	**2008**	**2010**	**2012**	**2014**
Share of households using grid electricity for lightning, rural / urban	95.7 % / 99.7 %	95.3 % / 99.7 %	95.6 % / 99.7 %	96.9 % / 99.8 %
Share of households declaring their electricity use within last 30 days did not meet their needs	NA	24.0 %	4.7 %	2.7 %
Share of households declaring less than 30 kWh of electricity use within the last 30 days	NA	16.4 %	14.0 %	13.1 %
Share of households paying less than 6 % of their income for electricity	97.4 %	97.6 %	96.9 %	94.5 %

Table 5 : Evolution of key performance indicators towards access to clean and affordable energy for all in Vietnam.

high. b) Our number is for electricity only, excluding fuels for heating and transportation. c) The low number of answers in Vietnam at 10 % implies that relative measurement error is larger. d) The shape of the tail of the distribution is regular, so the value of the threshold is does not matter to measure the progress over time.

That fourth row shows that electricity is affordable for most households in Vietnam. The increase between 2008 and 2010 coincide with a period where the electricity tariff increased slower than the inflation. The decrease after 2010 show that electricity expenses have increased faster than income. One part of this is a price effect, the first block catching up with the general level of prices, and another part is a quantity effect, with demand for electricity increasing.

A word about the challenges ahead to conclude. As apparent in Table 1 , the population growth rate is about one percent per year, and the economic growth rate six percent, the urbanization gains 0.7 percentage point per year. The average size of household is also decreasing, as the traditional family model with three generations under one roof is loosing ground. These factors imply a continued growth in the demand for electricity services. This growth has to be met by increase in energy efficiency and increase in energy generation, transmission and delivery capacity. This is challenging as the public debt is getting near its limit and the domestic production of coal has peaked and is too low to feed all power plants. Raising further the price of electricity would be necessary to pay the price of imported coal, to finance investments in solar and wind power plants, to reinforce the grid and to make it smarter. Further research on tariffs and subsidies is needed to know how to spread the burden among the different segments of the electricity market.

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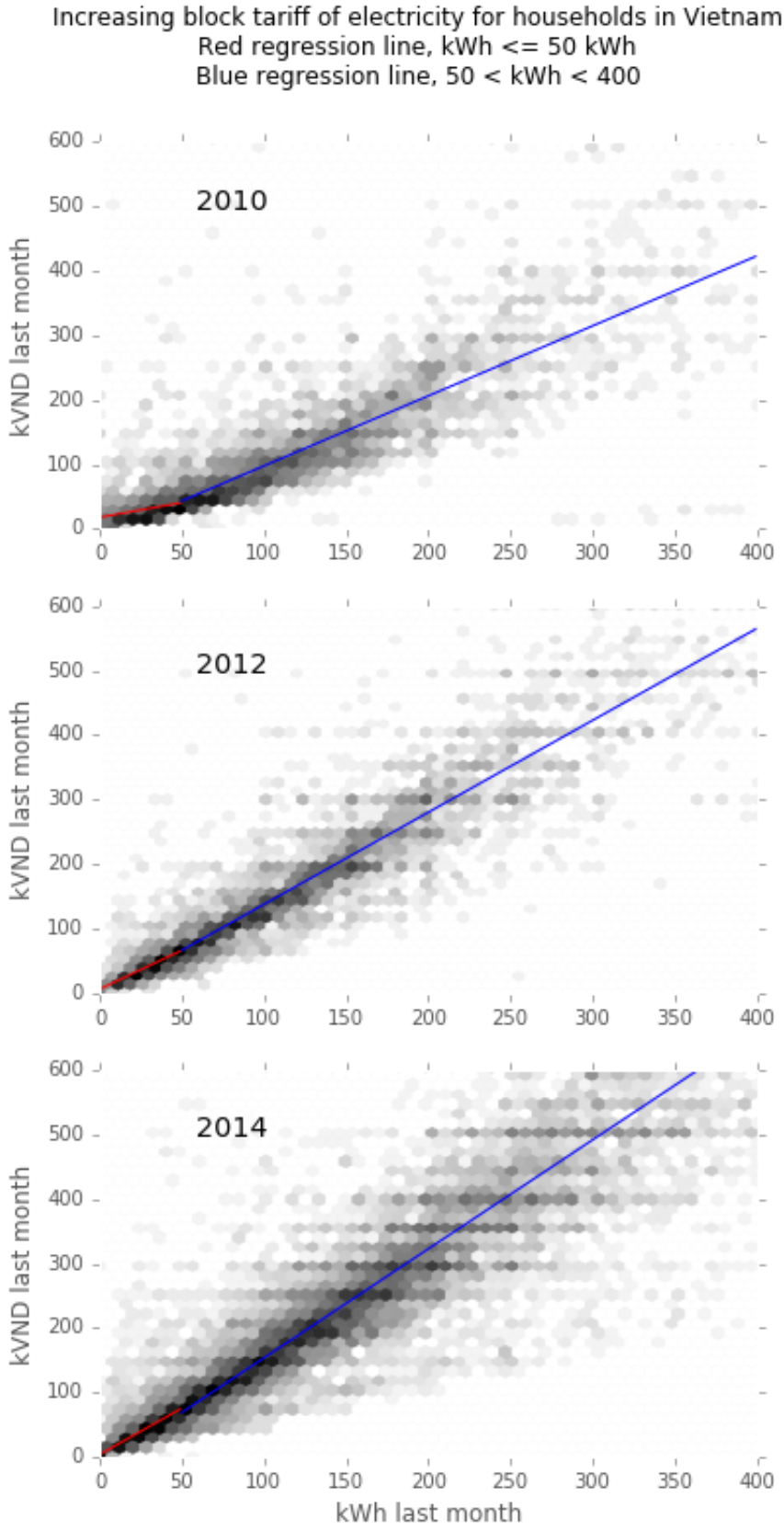
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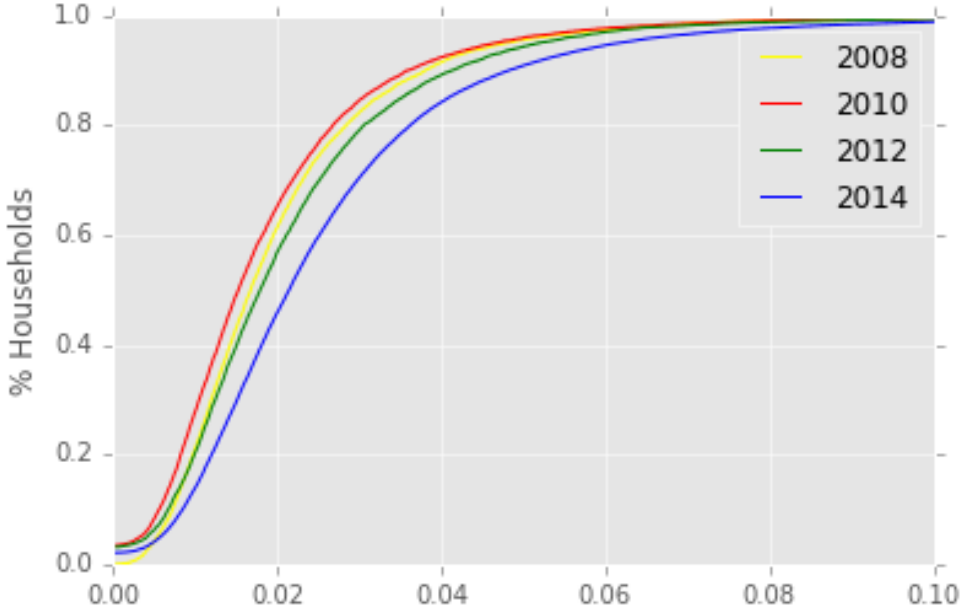
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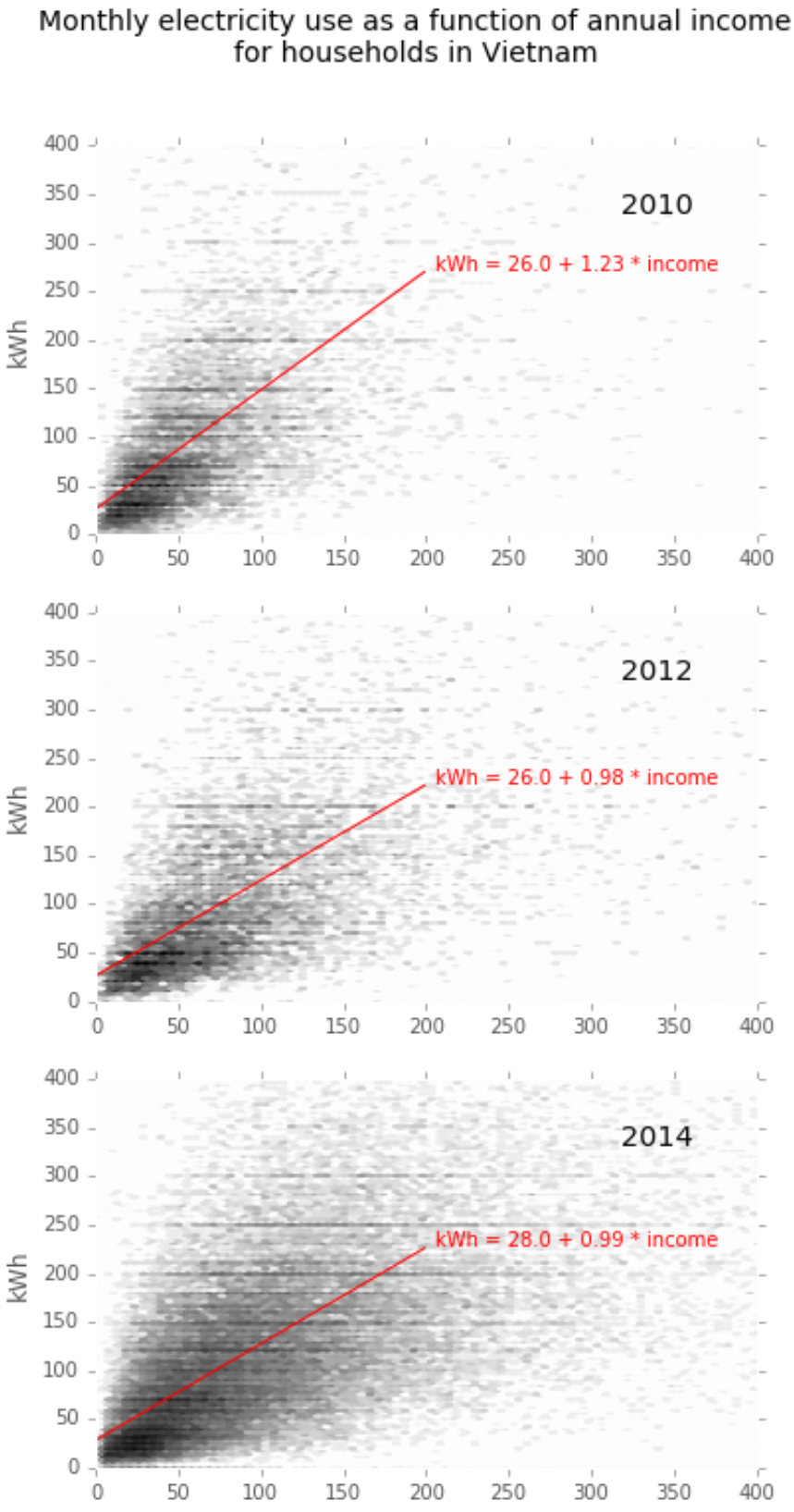
8. Supplementary material



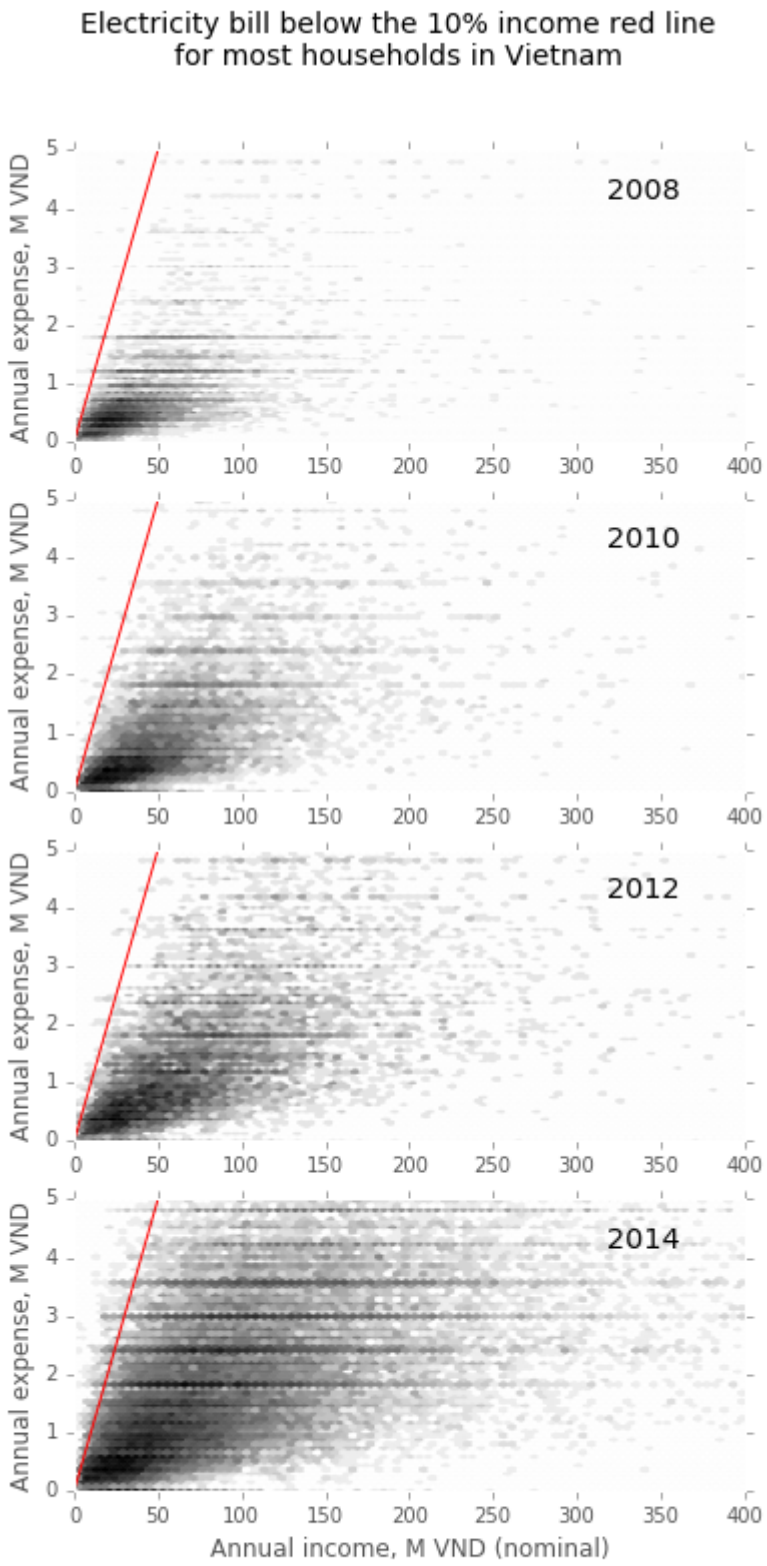
Supplementary_Figure 1: Electricity bills of Vietnamese households



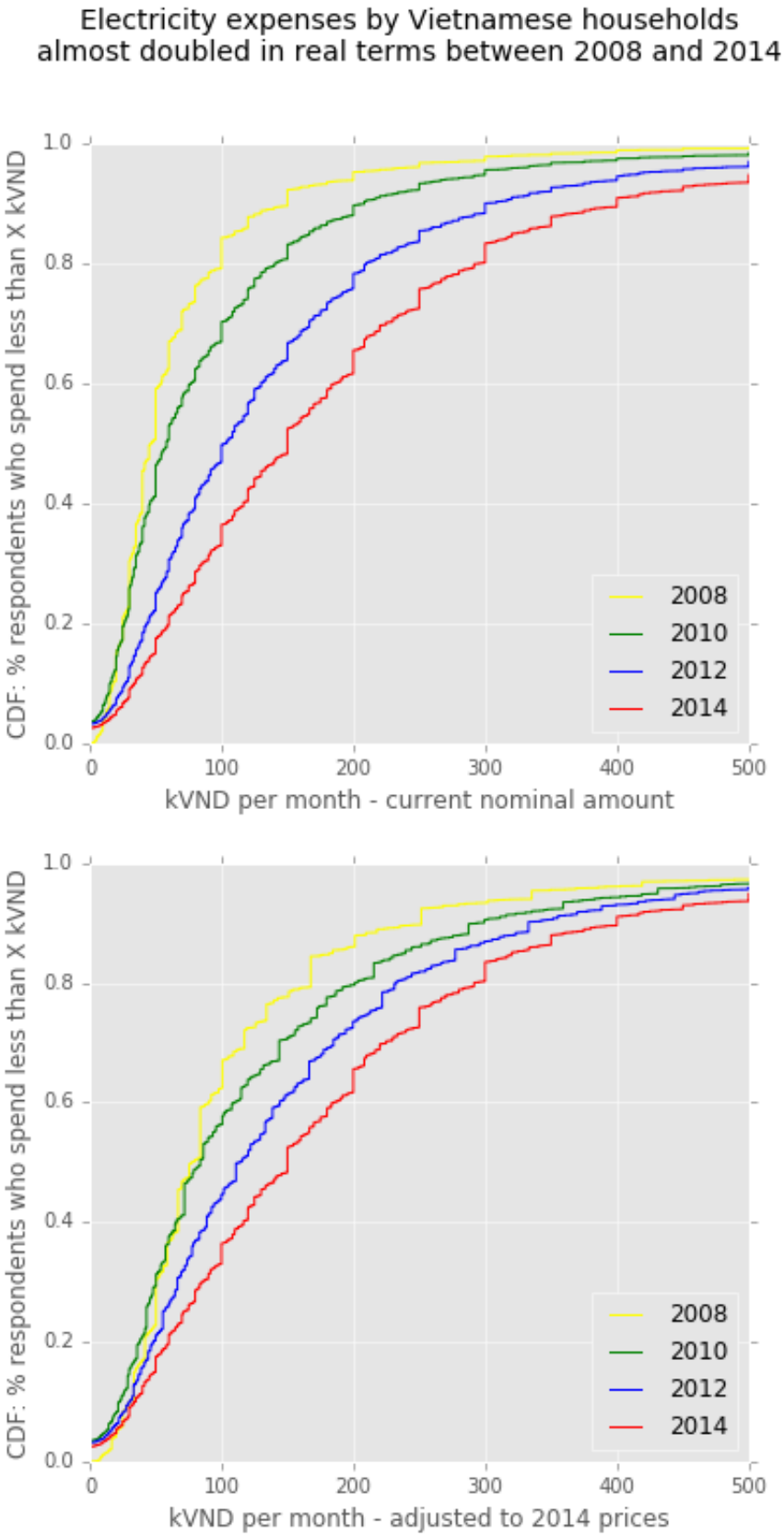
Supplementary_Figure 2: Fraction of income spend on electricity



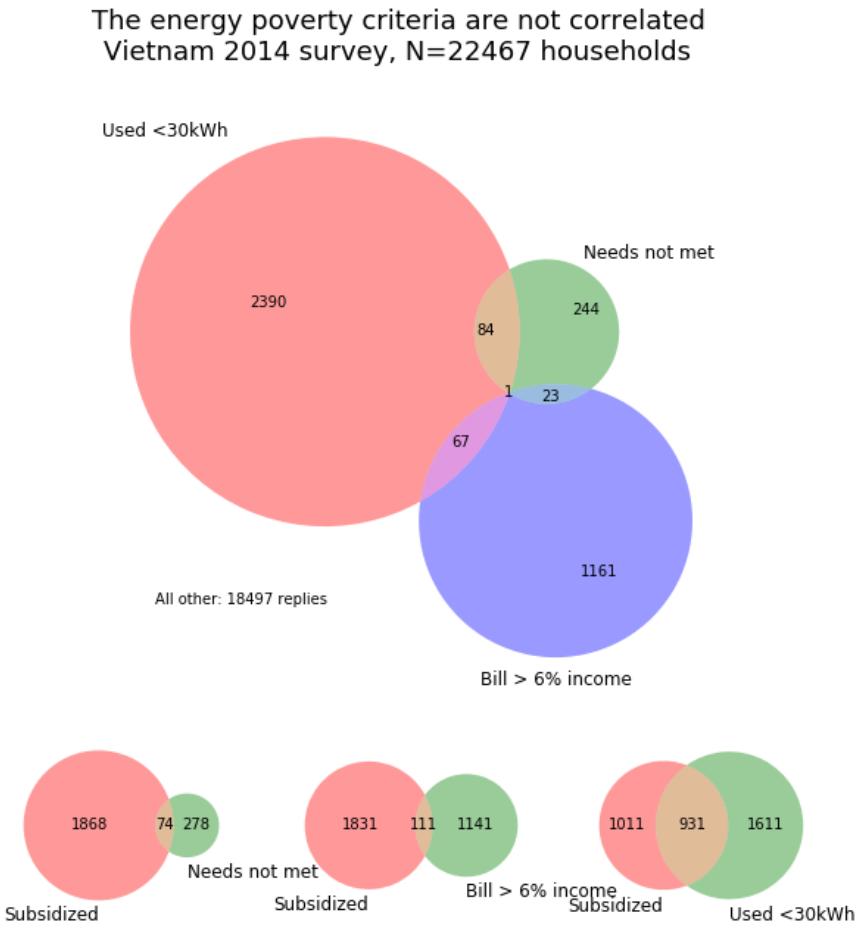
Supplementary_Figure 3: Monthly electricity use as a function of annual income



Supplementary_Figure 4: The electricity budget of vietnamese households is below 10%



Supplementary_Figure 5: Distribution of electricity expense by Vietnamese



Supplementary_Figure 6: Different energy poverty criteria are not correlated