Revisiting the Energy-Happiness Paradox: 
A Quasi-Experimental Evidence of Electricity Access in Indonesia

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Abstract
This study revisits the energy-happiness paradox hypothesis using the context of a developing nation. We used Indonesia as a case study, a unique archipelagic country with sparse subnational energy infrastructure, leading to the persistent regional energy access gap. We employed an instrumental variable technique to obviate conventional bias in the happiness regression. The model utilised a newly available national-level household survey on life satisfaction and historical data on digital maps of Indonesia’s electricity infrastructure conditions in 1985. Unlike the phenomena known as the energy-happiness paradox found mainly in the developed countries that suggest the null relationship between having energy access and people’s happiness, our finding reveals a positive effect of electricity access on people’s happiness. We also show that the mechanism in which the effect operates is through individuals’ satisfaction with housing conditions. The heterogeneity analysis shows that the impact of electricity access on happiness is more prominent in the lagging region. It justifies the placed-based policy strategy by the government in developing countries for expanding electricity access in favour of disadvantaged areas.

Keywords Energy access · Electricity · Life satisfaction · Happiness · Indonesia

JEL Classification O18 · Q48

1 Introduction

Energy is an essential element of individuals’ daily activities and is closely related to many development outcomes, including wellbeing. However, equal and reliable access to energy with no exception to electricity, remains a major challenge for many, if not all, developing countries in the world (Sustainable Energy for All, 2020). In this study, we investigate the...
The implication of electricity access on people’s happiness in developing economies with Indonesia as a case study.

Among developing nations, Indonesia is the fourth most populated country in the world and the largest economy in Southeast Asia that tries to increase access to modern energy for the whole nation (Dartanto et al., 2020). Although Indonesia has made a great electrification achievement in most parts of the country, the issue remains most prominent in the Eastern part of the country, among the poorest provinces. Thus, the challenge of universal access to electrification remains a national agenda in developing economies such as Indonesia (Asian Development Bank, 2015).

The government in developing countries such as Indonesia uses public expenditure on electricity subsidies\(^1\) to boost demand accompanied by a monopoly market structure of electricity distribution\(^2\) (Burke & Kurniawati, 2018; Burke & Resosudarmo, 2012; McCawley, 1970; Soesastro & Atje, 2005) to achieve equal access to electricity. The combined policy agenda is believed to achieve the universality of energy access to reach the poor and households living in the lagging regions. Whether such a strategy gains success, among others, could be evaluated from the perspective of revealing the link between electricity access and people’s happiness. Indonesia’s regional inequality in access to electricity due to its unique archipelagic setting provides an opportunity to establish an empirical link between the presence of electricity access and happiness. Consequently, the impact of electricity access on happiness may vary based on time and region.

The literature in the field of subjective wellbeing has investigated multiple factors affecting one’s satisfaction or happiness, including an individual’s characteristics, such as income (Cheung & Lucas, 2015; Frijters et al., 2004; Gori-Maia, 2013; Salinas-Jiménez et al., 2011), gender (della Giusta et al., 2011), marital status (Ngoo et al., 2015) and education (Salinas-Jiménez et al., 2011) as well as a household’s characteristics, such as the number of children (Angeles, 2010; Becchetti et al., 2013), and household income (Appleton & Song, 2008; Yuan, 2016). Other studies have also incorporated macro-level data as the determinants of one’s life satisfaction, such as economic growth and income inequality (Mikucka et al., 2017; Roth et al., 2017), openness and business climate (Bjørnskov et al., 2007), and institutional factors, such as decentralisation (Sujarwoto & Tampubolon, 2015) and good governance (Ngoo et al., 2015). The predominant determinant of life satisfaction or happiness is arguably the income level. An infamous theory of the happiness-income paradox is known as the Easterlin Paradox, stating that income affects subjective wellbeing at a point in time (cross-section), but over the long-run (ten years or more), it does not vary with income (Clark & Shields, 2008; Easterlin et al., 2010).

A comprehensive empirical study on the happiness-energy access relationship is rare, if not absent, in the context of developing countries, including Indonesia. Tasik (2019) is solely a published article that examines the relationship between energy spending and an individual’s happiness using limited experimental data of only 345 individuals living in rural areas of North Sulawesi Province. Not only that the study has limited regional coverage, but the empirical method is also solely based on a cross-sectional analysis without considering any potential biases from possible reverse causality or unobserved individual’s heterogeneity; thus, the causality inference between energy spending and happiness

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1 In 2019, the Government of Indonesia’s (GOI’s) expenditure for electricity subsidy accounted for about 26 percent out of the total expenditure on subsidy (Ministry of Finance, 2019).

2 The sole electricity provider in Indonesia is PT PLN (Perusahaan Listrik Negara), the state-owned electricity enterprise.
remains questionable. This limitation has evoked a challenge to provide better nationally representative evidence using a comprehensive empirical strategy to reveal the happiness-energy causal relation.

Unlike the scarce evidence for the developing countries, studies regarding energy happiness in the developed countries are quite common, although the results are mixed. Okulicz-Kozaryn & Altman (2020) found no relationship between energy use and individuals’ subjective wellbeing at last in the case of developed countries. Nevertheless, this study presents only observational evidence rather than causality between energy use and wellbeing. In contrast to Okulicz-Kozaryn et al. (2020), Welsch & Biermann (2017) revealed that households’ affordability of energy, including electricity, significantly influences the subjective wellbeing in the case of 21 European countries. Other studies in Europe have examined the issue of energy poverty and its impact on wellbeing, proxied by variables such as health status, individual satisfaction, and socioeconomic status (Bollino & Botti, 2017; Druică et al., 2019; Thomson et al., 2017). Liu & Matsushima (2019) showed that the impact of energy quality on life quality differs between the OECD and non-OECD countries, where the importance of energy quality has increased over time in the case of OECD countries.

Similar to Welsch & Biermann (2017), Nie et al. (2021) used the China Family Panel Studies data from wave 2012–2018 to analyse the relationship between energy poverty and depression. Energy poverty is used to see deficiencies in access to basic energy, including electricity and cooking facilities. Meanwhile, the outcome variable of depression is used to measure people’s subjective well-being instead of happiness since it has been widely researched previously. The result shows that the lower the energy poverty, the lower the level of depression will be. The relationship is statistically significant from the ordinary least square, fixed effect, instrument variable, and structural equation modelling methods. Nevertheless, the available empirical studies on electricity access and happiness or subjective well-being in developing countries are still limited. For example, see the recent experimental evidence in Kenya (Lee et al., 2020) or the impact evaluation in Suriname (Corral & Zane, 2020).

Furthermore, the importance of electricity as one form of energy has been documented in many studies. Access to electricity enables individuals, households, and society to have better lighting and utilise other electronic devices, such as television, radio, rice cooker and others, that can improve one’s productivity, quality of work, and other aspects of people’s welfare (Khandker et al., 2013; Niu et al., 2013). Specifically, studies have found that better access to electricity is associated with better education and health (such as lower malnutrition and child mortality), higher income, and higher productivity (Grimm et al., 2015; Kanagawa & Nakata, 2008; Miller et al., 2011; Niu et al., 2013; Sambodo & Novandra, 2019). Moreover, access to electricity also promotes access to other modern energy forms, such as clean cooking, which is more efficient and relatively cheaper than traditional energy. As a result, the overall spending on energy would decrease and people could reallocate their spending on other goods, such as food, health, and education (Niu et al., 2013; Samad et al., 2010). Nevertheless, studies discussing the causal impact of electricity access on the direct measurement of one’s subjective wellbeing or happiness are scarce, if not absent.

Other evidence on the dynamics between energy use and happiness is as follows. By exploiting information from the IEA World Energy of 1971–2018, Jackson et al. (2022) discovered that happiness improves steeply if the annual mean energy use is between 10 and 75 in 140 countries. Their results suggest that the existing energy supply can fulfil everyone’s necessity, hence the attainment of maximum happiness and
environmental well-being, if the distribution is done evenly. Lee et al. (2020) discovered corresponding results in their analysis, albeit the distinctive measurement and exhausted database. They found a positive life-satisfaction effect in response to the connected electricity grid among Kenyan households from 2013 to 2017, although multiple testing was necessary to acquire such a result. The findings imply that rural electrification does not yield an economically productive impact in the world’s poorest countries, given the high stakes and lack of research surrounding the decision. In contrast to previous literature, Corral & Zane (2020) did not find a significant effect of electrification programs on subjective welfare in their Suriname paper. Nevertheless, it is worth noting that the relationship is consistently positive throughout the literature. The estimates also do not differ by much among households whose head is male or female.

Establishing an empirical relationship between energy access and happiness is challenging yet intriguing. It is challenging as the nature of the happiness domain in one’s life is multifaceted (income, education, health, housing, family and so on), and there has been a rare occasion that the ceteris paribus assumption holds when we relate one domain with the variable of interest, such as electricity access regarding happiness status. Second, many interesting and differing theories have explained the structural mechanism in which each domain’s effect on happiness works. Among others, one popular puzzle is the examination of the happiness-income paradox known as the East–Ervin paradox, as previously explained.

Empirical evidence of the electricity access effect on happiness, thus, is relatively negligible for developing countries due to such an empirical challenge. This study offers a combination of a unique geographical setting and newly available data of nationally representative household survey data on happiness to fill the gap by establishing a causal link between electricity access and happiness. We implement an instrumental variable technique with a mediation framework to reveal two things. The first is whether the presence of electricity access increases a household’s happiness. If yes, through which life domain the effect takes place or to identify among life domains; which one is the most important mediating mechanism of electricity access that improves household happiness in the context of the study.

The present study is expected to contribute to the literature in two ways. It provides additional empirical evidence to assess the electricity effect on the well-being literature (Druică et al., 2019; Okulicz-Kozaryn & Altman, 2020; Thomson et al., 2017; Welsch & Biermann, 2017) in the developing country context. Specifically, we empirically test the presence of the happiness-energy paradox suggested by Okulicz-Kozaryn & Altman (2020) with subnational variation data from a developing country. Moreover, this study is the first to investigate the mechanism by which the effect of electricity access on happiness occurs among potential life domains. In the context of policy perspectives, this study provides evidence of whether infrastructure expansions can achieve the ultimate goal of development, namely human wellbeing and happiness. The organisation of the paper is as follows. Sect. 2 describes the context of the study. Sect. 3 explains the methods. Sect. 4 discusses the results and findings. Sect. 5 concludes.
2 Study Context: Indonesia

2.1 Inequality of Electricity Access

Indonesia is the fourth largest populated nation in the world, distributed unevenly across its 17,000 islands. With such an archipelagic setting, distributing electricity to the nation is a major challenge. Within a decade, we observe a pattern showing improvement in Indonesia’s electricity coverage. The number of households without electricity connections from the country’s solely state-owned enterprise, PLN or *Perusahaan Listrik Negara*, has declined. Comparing the 2017 figures with those in 2007, we could infer that the lowest income group benefited from the GoI (Government of Indonesia) efforts. Over ten years, approximately a 20% increase in households within the lowest income group became subscribers to the PLN provided electricity access. The increase in state-owned electricity subscriptions and a declining pattern of outmoded lighting show that the government mixed policy efforts seem to be successful.

However, the regional variations in the access improvement present a different story. Figure 1 provides dot plots of the electricity access rate by province and income level over 2007 and 2017, measured by the percentage of a household with electricity as a lighting source. While a huge percentage of the electricity access gap has been closed, the access to electricity in some eastern parts of the country is worrisome. Specifically, the province of Papua is seen to be worst compared to other regions, with only approximately 50% coverage. Situations of a large area with landlocked, mountainous and low density are why Papua is the lowest electrification province (Innah et al., 2017). Moreover, it is

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3 We calculate the number of households with access to electricity using the national socio-economic census (Susenas) 2007 and 2017.
noteworthy that the least benefited group from the rapid expansion of electricity access has been households within the first quintile group of expenditures per capita. It indicates that this group and some middle-level quintile groups in specific regions, such as Papua and West Nusa Tenggara, are the ones that are kept ‘left behind’ from the improvement in the electricity access.

In addition to this general pattern, qualitative information suggests that access quality is also diverse in the Indonesian context. Blackout or temporal interruption is of significant concern in Indonesia. Proper and continuous electricity access is important to support night activities and ensure productivity and quality of work during the day. However, in Indonesia, such a standard of expected service might still be far from realized. Sambodo (2016) showed that West Java Province still experiences the rolling blackout. The situation outside Java is more profound; he indicated them as “power crisis” regions. Note that the share of the outside Java population is approximately half of the total Indonesian population. According to Statistics Indonesia, in 2018, Java Island was inhabited by 113 million people (approximately 43%) out of 261 million people.

In addition, the non-standard quality of electricity services is also experienced by a low portion of those with non-PLN electricity. The quality of the service largely depends on its small scale and fluctuations in input, such as fuel originating from outside regions. However, they constitute only approximately 7% of the total share of households with electricity access (Burke & Kurniawati, 2018). Our calculation with Susenas 2017 shows that their share is only approximately 5.5%. Even so, many households still utilise low-quality electricity access.

Why do some subpopulations of Indonesia have a worse status of access to electricity? Remoteness and geographical constraint, in general, make the case. Figure 2 provides a scatter plot portraying the relationship between the percentage of households in the lowest quantile of expenditure and remoteness (measured by the number of islands). Source: BPS-Statistics Indonesia, National Socioeconomic Survey (Susenas), 2007 and 2017 and Indonesian Statistics 2017 (processed by author)
income quintile with electricity connections and the number of islands in each province. Some provinces have a considerable number of islands, so most of the islands are tiny in size and inhabitants. For geographical access, this situation leads to remoteness. Indonesia’s problem in providing full access to the population is its geographical access to small islands. The persistence of the negative relationship of the two variables over the decade suggests the importance of achieving universal electricity access by acknowledging the territorial constraint. The top priority sub-population would be the lowest income group in the remote places, as represented by people living on the small islands.

The unique feature of Indonesia’s geographical constraints above provides the regions and household variation of electricity access, which is essential for policy intervention formulation in achieving the GoI’s national agenda of universal access to electricity. Thus, this paper uses the geographically driven variation of electricity access as the predictor variable of a household’s happiness level. In this regard, we exploit the quasi-random of these variations induced by the probability of experiencing an expansion of electricity access represented by the distance to power plant and substations in 1985 with an instrumental variable technique explained in the next section.

2.2 Recent Policy Changes

Our empirical study period uses the year 2017, in which the recent policy change in the energy sector, including electricity, happened. A notable change is the reorientation of the public budget in the energy sector from a price subsidy to a person-based subsidy. In the past, Indonesia’s energy subsidy policy was in the form of a price support policy, such as a subsidy on per litre of gasoline or per kilowatt hour (kWh) electricity, which aims to provide access to energy commodities through low energy prices for the poor. Unfortunately, such a subsidy system benefited the rich more than the poor (Agustina et al., 2012; Dartanto, 2013; Widodo et al., 2012). Empirical evidence on fuel subsidy policy in Indonesia, for example, found that around 30 percent of the government fuel subsidy was enjoyed by the richest 10 percent of the population, and more than half of the subsidy went to the richest 30 percent (Agustina et al., 2012; Dartanto, 2013). Using a cross-country analysis of developing countries in Africa, Asia, the Middle East, and Latin America, Arze del Granado et al. (2012) showed that the benefit leakage of fuel subsidies is quite substantial, where the top income quintile captures around six times more in subsidies than the bottom quantile.

The ‘mistargeted’ problem combined with increasing consumption and price volatility of fossil fuels placed a huge burden on the government fiscal budget, which drove the need for energy subsidy reforms. Since the 1997 Asian Financial Crisis, the GoI has executed several budget cuts for energy subsidies and re-allocated fiscal spares for various social protection and welfare programs (Pradiptyo et al., 2016). In 2015, the subsidy for gasoline was completely abolished while the subsidy on diesel was reduced to only IDR 1000 (around USD 0.074) per litre (Asian Development Bank, 2015; Dartanto, 2013, 2017; Chelminsiki, 2018). In recent years, the revolution of energy subsidy reforms has been directed toward changing the subsidy policy from a commodity-based subsidy system to a person-based (targeted) subsidy system. These reforms have been infamously implemented in the case of

4 USD 1 = IDR 14,000.
reforms to electricity tariffs and the kerosene-to-LPG conversion program (Andadari et al., 2014; Budya & Yasir Arofat, 2011; Thoday et al., 2018).

The key element enabling Indonesia’s subsidy reform into a person-based (targeted) subsidy system is the availability of the Unified Database System (called the Basis Data Terpadu or BDT/Data Terpadu Kesejahteraan Sosial or DTKS), initiated in 2005. The BDT is a micro-level database (by name by address) constructed from the census data (from Statistics Indonesia (BPS)) and contains the social, economic and demographic information of respondents (TNP2K 2018). These data are then used to conduct the proxy means test (PMT) to classify the poorest 40 percent of the population. As of 2015, the last round of updates, about 25.7 million households are in the bottom 40 percent of income (i.e. the poorest 40 percent in the population). The BDT database is not only useful to determine the eligibility of targeted energy subsidies, but it is also utilised to determine the beneficiaries of social assistance programs, such as subsidized rice, conditional cash transfer (called Program Keluarga Harapan or PKH), and educational assistance, such as Indonesia Smart Card (Program Indonesia Pintar or PIP) (Tohari et al., 2019).

Concerning the electricity tariff subsidy reform, the reform started in 2013 with the electricity tariffs for some consumers, such as industrial customers and those with an electricity tariff subscription above 900 VA (Voltage Ampere), were increased. The early electricity subsidy reform system suffered from subsidy leakage despite lessening the fiscal burden. In this case, some consumers with an electricity connection subscription of 900 VA or lower are not in the poorest 40 percent of the population yet are included as the subsidy beneficiaries. Thus, to reduce the inclusion error problem, the electricity subsidy reform is later targeted toward revoking subsidies for consumers with 900 VA and 450 VA connection subscriptions who are non-poor, i.e., not listed in the BDT. It aims to eliminate subsidy leakage and ensure that the subsidy is well-targeted to those in need.

The reform is carried out gradually, starting with the 900 VA subscription consumers. The PLN subscribers’ database is matched with the BDT, and those not listed in the BDT are removed as subsidy beneficiaries. The matching process was executed by visiting households to observe their current situation and validate their eligibility as subsidy beneficiaries. The state-owned enterprise PT PLN was in charge of this process, in which they mobilised their workers to visit the household by household and carried out the validation procedure. By early 2017, this reform reduced the number of electricity subsidy beneficiaries with the 900 VA subscriptions from 22.35 million households in 2016 to only 4.1 million households (Dartanto et al., 2020). The electricity subsidy reform is still ongoing, further validating the consumers in the 450 VA subscription group.

Despite its effectiveness, the person-based targeted subsidy system is not without limitations. One main limitation is the use of BDT as a reference for the database on the poor, which was last updated in 2015. Considering the dynamic nature of poverty, the absence of a more up-to-date database might generate both inclusion and exclusion error problems. Specifically, some eligible poor households might not be included in the existing BDT database or the exclusion error, while others who are part of the current BDT database might be no longer eligible, or there is an inclusion error (Dartanto et al., 2020).

5 However, in response to the current global COVID-19 pandemic situation, the GoI mandated a fiscal stimulus by giving a 100 percent discount of electricity tariffs for consumers with 450VA connection subscription, and a 50 percent discount electricity tariffs for subsidized consumers with 900 VA connection. As of the time of writing this paper, this stimulus policy has been extended until March 2021 (Kontan.co.id, 2021).
3 Methods

3.1 Data and Variables

The main data source for this study comes from the nationally representative household survey of happiness in Indonesia in 2017, known as SPTK (Survey Pengukuran Tingkat Kebahagiaan/Survey of Measuring Happiness Level), consisting of 72,317 individuals or samples. This is the country’s first and most recent available data capturing life satisfaction and happiness. Both outcome variables of interest (happiness and housing satisfaction), key explanatory variables (having electricity access), individual and household covariates (age, gender, education level, income level), rural–urban dummy, and island dummies were extracted from this survey. In addition, we merged the provincial level data of the share of the agricultural sector and Gini the index of the year 2017 from Statistics Indonesia. The instrumental variable was constructed from digital map data of the Electricity Supply Business Plan in 1985 of the Indonesian National Electricity Provider (PLN) and the Ministry of Energy and Natural Resources.

The main outcomes of interest in this study are overall happiness level and housing satisfaction level. Both variables come from the first nationally representative happiness survey in Indonesia of the year 2017, namely SPTK. The data for happiness were collected from the question: “How happy is [NAME] with life as a whole?”. The responses were coded to the numerical values ranging from 0 (very unhappy) to 10 (very happy). Similarly, the data for housing satisfaction were collected from the question: “How satisfied is [NAME] with the house and house facilities?”. The responses were coded similarly to the happiness question in which 0 corresponds to very unsatisfied and 10 corresponds to very satisfied. Thus, both variables have an ordinal ranking in nature.

The main explanatory variable of interest is the household’s electricity access status. The question to assign the treatment variable was the question: “What is the main source of lighting used in [NAME]’s house?”. The responses were coded from one of the three options: (1) PLN electricity, (2) non-PLN electricity, and (3) no electricity. PLN is the state-owned enterprise responsible for distributing the electricity service in the nation and acting as the service’s monopolist. We assign a treatment variable equal to one (having electricity) if the respondent reveals response 1 or 2 and 0 if they respond 3 to the question.

3.2 Empirical Strategy

Inferring happiness differences across an individual with and without electricity access from the observational data might not have a causal interpretation because a fundamental issue of the subject without electricity might not be a perfect counterfactual for those with electricity. Conventional regression of happiness includes demographic factors to isolate individual heterogeneity from the key variable of interest. In addition, the estimate often includes general life domains, such as income, education, or health and interprets the coefficient in the key variable of interest as the net effect apart from the effects through the life domains (Nikolaev, 2016; Nikolaev & Burns, 2014). Electricity

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6 The use of a simpler Likert’s scale that ranges between 1 (very happy) to 4 (very unhappy) as for example in other survey of The Indonesian Family Live Survey/IFLS might make respondent easier in providing their responses. However, the finer scale of SPTK has a merit of larger variations for statistical purpose.
access as part of energy access is only one of several life domains of happiness, such as education and income. To obtain the net effect, we incorporated individual education and household level of income in the estimates. The individual level of education was elicited using categorical variables referring to no-schooling, primary, secondary and tertiary. The household level of income was also elicited with a categorical variable of four income groups (< IDR 1.8 million, IDR 1.8–< 3 million, IDR 3–< 4.8 million, and IDR 4.8–< 7 million). Moreover, the inclusion of these dummy variables is expected not only to isolate the role of these domains in explaining the happiness level. They also act as the control for sorting issue or, technically, the confounding effect from education and income level in examining the correct relationship between electricity access and happiness. It is likely that individuals with better education and income levels are happier and can obtain electricity access better. Thus, this conditioning strategy is expected to correct the upwards bias of the point estimate of the electricity access effect on happiness.

In contrast to the life domain noise and sorting issue, the regression parameter of the happiness estimates is often underestimated by the presence of individual heterogeneity in valuing the impact of the key variable of interest on happiness. There are two common causes: hedonic adaptation and social comparison elements (Clark & Shields, 2008). The theory of hedonic adaptation suggests that as individuals move up to the higher socioeconomic ladder, they adjust their happiness aspirations to a new level, lowering the happiness magnitude. The relevance of the theory with our analysis is that the cross-sectional treatment variable in our study masks heterogeneous intensity of time since they obtain the treatment. Thus, people with a longer time having electricity may report a lower happiness level as they move up socially or economically. Second, people incorporate comparisons with their group of reference in valuing happiness level (Nikolaev, 2016; Nikolaev & Burns, 2014). Identifying the adaptation or comparison nature is not easy as we do not have access to the relevant observable variable in the survey. Nevertheless, the inclusion of these control variables might not completely obviate the bias.

Accordingly, we attempt to tackle this noise using an instrumental variable approach. The quasi-random variation of our instrumental variable—the distance to the nearest substation back in time—is expected to eliminate any remaining systematic bias from adaptation and comparison factors. Hypothetically, the instrumental variable estimate provides upwards correction to the coefficient of interest as the two sources of biases tend to create downwards bias.

The following is the basic estimating equation to identify the effect of having electricity access on happiness.

\[
\Pr(Y_j = i) = \alpha_0 + \alpha_1 E_i + X_i \alpha_2 + R_j \alpha_3 + e_i
\]

where \( Y_j \) is individual \( i \)'s index of happiness in which \( j \in \{0, 1, \ldots 10\} \), \( E_i \) is individual \( i \)'s status of having electricity access, and \( X_i \) is vector individual and household level covariates and it includes age, gender, education level, and income level. \( R_j \) is set of regional level covariates that cover the urban–rural dummy, island dummies, provincial Gini index, and provincial share of the agricultural sector. We implement the maximum likelihood estimator for the ordinal limited dependent variable model of ordered probit to estimate the marginal effects based on the parameter of interest \( \alpha_1 \) in Eq. (1). The basic estimating strategy chosen is to accommodate the fact that the dependent variable is ordinal data in nature. On the other hand, ordinary least square (OLS) provides a handy and straightforward interpretation of the coefficient of interest compared to the ordered probit model. Thus,
we extend the specification in Eq. (1) with the OLS estimator. The following equation is the OLS estimator of Eq. (1).

\[ Y_i = \beta_0 + \beta_1 E_i + X_i \beta_2 + R_j \beta_3 + \epsilon_i \quad (2) \]

Moreover, to address the conventional bias as described in Sect. 3.4, concerning the issue of sorting, we also extend the estimation of Eq. (1) with an instrumental variable approach, instrumenting \( E_i \) with \( Z_j \). We use the distance to the PLN electricity substation in 1985 as the instrumental variable. Our identification relies on the argument that the placement of the PLN substation in 1985 has a quasi-random nature in affecting current socio-economic outcome, and thus happiness, through recent time household’s access to electricity.

We define \( Z_j \) as the average distance of the centroid of a village to the nearest PLN substation electricity at the provincial level in 1985. There are a couple of reasons for using the operational definition of the variable. First, the SPTK data only allow us to identify and merge the observation with the external data at the provincial level. Second, the information on the digital map representing the oldest history that we can obtain is in 1985.

To fulfil the exclusion restriction assumption and to gain a meaningful first-stage existence, we use a historical infrastructure plan of electricity to instrument the endogenous variable \( E_i \). The strategy is recently applied in some empirical estimates, see for example (Kassem, 2018). Information about the historical electricity infrastructure was collected from the state’s own enterprise, the Indonesian National Electricity Provider (PLN) and the Ministry of Energy and Natural Resources’ Electricity Supply Business Plan, known as RUPTL. From the sources, we created a digital maps of Indonesia’s electricity infrastructure conditions for 1985. The digital map is made manually by marking the coordinates of all electricity substations and power plants in Indonesia. The map then allows us to calculate the Euclidian distance of each village to the nearest PLN substation in 1985. We used the Indonesia electricity map, RUPTL, and PLN inventory data as the main sources and Google Maps for the secondary check. The following table presents the summary statistics of the variables used in this study.

The instrumental variable estimating equations are as follows:

**FirstStage**: \( \hat{E}_i = \kappa_0 + \kappa_1 Z_j + X_i k_2 + R_j k_3 + \epsilon_{i1} \)  \quad (3a)

**SecondStage**: \( Y_i = \delta_0 + \delta_1 \hat{E}_i + X_i \delta_2 + R_j \delta_3 + \epsilon_{i2} \)  \quad (3b)

We implement the 2SLS estimator in Eqs. (3a) and (3b). The operational definition of all variables is the same as that used in Eq. (1).
3.3 Mediation Analysis

This study aims to decompose the effect of electricity access on household happiness through a mediating factor. The conceptual framework to establish the link is based on identifying the directed acyclic graph (DAG) depicted in Fig. 3. We argue that the causal link between households’ electricity access \( (E) \) on happiness \( (Y) \) is mediated mainly by the extent to which the individual is satisfied with their housing condition \( (M) \). In other words, the improved satisfaction of housing conditions from having electricity access would alter household happiness more than it did not. The estimation of the mediation factor allows us to decompose the element of direct effect (DE) and indirect effect—through housing satisfaction (IE) of electricity access impact on happiness.

Then, we decompose the mechanism of changes into two effects: the direct and indirect effects. There are two basic mechanisms of the changes. First, the changes in happiness are due to the direct benefit of improved electricity access. Second, the changes in happiness are associated with the improved mediating factor induced by improved electricity access.

In performing the mediation analysis, we adopt the instrumental variable estimation with a mediating factor developed by Dippel et al. (2020), known as the \textit{ivmediate} model. Based on the DAG in Fig. 3, using a single instrument suffices to identify both the causal treatment and mediation effects by the condition that both mediation and the treatment variables have a joint confounding factor. In our case, happiness and life satisfaction of each life domain are both derived from individuals’ utility. Therefore, they share the same origin of states. Hence, the likelihood of having joint unobserved confounding factors is high and we argue that the identification of the \textit{ivmediate} model is suitable. The estimating equations for measuring both the direct and indirect effects of electricity access on happiness are as follows. We have these equations to estimate the effect of electricity access on the mediating variable.

\[
\text{Firststage} : E_i = \gamma_i Z_r + \varepsilon_i \tag{4a}
\]

\[
\text{Secondstage} : M_i = \kappa_i \hat{E}_i + \omega_i \tag{4b}
\]

Subsequently, the final effect of electricity on happiness, the mediating parameter, and the direct effect of the treatment are identified by the following two stages least squares (2SLS).

\[
\text{Firststage} : M_i = \lambda_1 Z_r + \lambda_2 E_i + \zeta_i \tag{5a}
\]

\[
\text{Secondstage} : Y_i = \mu_1 \hat{M}_i + \mu_2 E_i + \eta_i \tag{5b}
\]

Dippel et al. (2020) proved that the identifying assumption yields a new exclusion restriction, allowing for the use of \( Z \) as an instrument for \( M \) conditional on \( T \). Thus, this procedure will yield two first stages in (2a) and (2a), and Eqs. (3a) and (3b) will provide the estimates for mediation. We decompose the total effect into direct effect \( (\mu_2) \) and indirect effect \( (\kappa_1, x \mu_1) \). In the estimation, we include additional covariates including individual characteristics (age, gender, marital status, education), household characteristics (household head gender, household income), geography (urban/rural dummy, density, regional GDP per capita and island dummies). (Table 1)
### Table 1 Summary statistics

| Variables               | Total                  | Electricity = 1          | Electricity = 0          |
|-------------------------|------------------------|--------------------------|--------------------------|
|                         | Mean       | SD    | Min    | Max    | Mean       | SD    | Min    | Max    | Mean       | SD    | Min    | Max    |
| Happiness               | 7.78       | 1.44  | 0.00   | 10.00  | 7.81       | 1.43  | 0.00   | 10.00  | 7.45       | 1.50  | 0.00   | 10.00  |
| Housing satisfaction    | 6.87       | 1.95  | 13.00  | 98.00  | 6.95       | 1.92  | 0.00   | 10.00  | 6.14       | 2.05  | 0.00   | 10.00  |
| Age                     | 46.38      | 13.58 | 13.00  | 98.00  | 46.68      | 13.59 | 13.00  | 98.00  | 43.61      | 13.12 | 15.00  | 98.00  |
| Male = 1                | 0.49       | 0.50  | 0.00   | 1.00   | 0.47       | 0.50  | 0.00   | 1.00   | 0.63       | 0.48  | 0.00   | 1.00   |
| Urban = 1               | 0.42       | 0.49  | 0.00   | 1.00   | 0.46       | 0.50  | 0.00   | 1.00   | 0.05       | 0.23  | 0.00   | 1.00   |
| Gini index              | 0.36       | 0.03  | 0.28   | 0.43   | 0.36       | 0.03  | 0.28   | 0.43   | 0.36       | 0.03  | 0.28   | 0.43   |
| Share of agri. Sector   | 18.59      | 8.07  | 0.09   | 41.52  | 18.39      | 8.04  | 0.09   | 41.52  | 20.45      | 8.14  | 0.09   | 41.52  |
| Educ. = Primary         | 0.43       | 0.50  | 0.00   | 1.00   | 0.43       | 0.50  | 0.00   | 1.00   | 0.45       | 0.50  | 0.00   | 1.00   |
| Educ. = Secondary       | 0.24       | 0.43  | 0.00   | 1.00   | 0.25       | 0.43  | 0.00   | 1.00   | 0.14       | 0.35  | 0.00   | 1.00   |
| Educ. = Tertiary        | 0.11       | 0.31  | 0.00   | 1.00   | 0.11       | 0.32  | 0.00   | 1.00   | 0.06       | 0.23  | 0.00   | 1.00   |
| Income (IDR 1.8–< 3 million) | 0.29   | 0.45  | 0.00   | 1.00   | 0.29       | 0.45  | 0.00   | 1.00   | 0.28       | 0.45  | 0.00   | 1.00   |
| Income (IDR 3–< 4.8 million) | 0.19   | 0.39  | 0.00   | 1.00   | 0.19       | 0.39  | 0.00   | 1.00   | 0.14       | 0.35  | 0.00   | 1.00   |
| Income (IDR 4.8–< 7 million) | 0.11   | 0.31  | 0.00   | 1.00   | 0.11       | 0.32  | 0.00   | 1.00   | 0.06       | 0.24  | 0.00   | 1.00   |
| Income (> IDR 7 million) | 0.09   | 0.29  | 0.00   | 1.00   | 0.09       | 0.29  | 0.00   | 1.00   | 0.04       | 0.20  | 0.00   | 1.00   |
| Island = Java           | 0.32       | 0.47  | 0.00   | 1.00   | 0.36       | 0.48  | 0.00   | 1.00   | 0.03       | 0.16  | 0.00   | 1.00   |
| Island = Nusa Tenggara  | 0.08       | 0.27  | 0.00   | 1.00   | 0.07       | 0.25  | 0.00   | 1.00   | 0.15       | 0.36  | 0.00   | 1.00   |
| Island = Kalimantan     | 0.10       | 0.30  | 0.00   | 1.00   | 0.09       | 0.29  | 0.00   | 1.00   | 0.14       | 0.35  | 0.00   | 1.00   |
| Island = Sulawesi       | 0.13       | 0.34  | 0.00   | 1.00   | 0.13       | 0.34  | 0.00   | 1.00   | 0.12       | 0.33  | 0.00   | 1.00   |
| Island = Maluku         | 0.03       | 0.17  | 0.00   | 1.00   | 0.03       | 0.16  | 0.00   | 1.00   | 0.07       | 0.25  | 0.00   | 1.00   |
| Island = Papua          | 0.05       | 0.21  | 0.00   | 1.00   | 0.02       | 0.15  | 0.00   | 1.00   | 0.30       | 0.46  | 0.00   | 1.00   |
| Observations            | 72,317     |       | 65,391 |       | 6,926      |       |       |       |

Revisiting the Energy-Happiness Paradox: A Quasi-Experimental...
Table 2  Basic results (Ordered Probit)

| Panel A-Estimate Coefficients | (1)         | (2)         | (3)         |
|-------------------------------|-------------|-------------|-------------|
| Dependent variable: Happiness (0–10) |             |             |             |
| Electricity = 1, 0 Otherwise  | 0.2832***   | 0.1675***   | 0.1757***   |
|                               | (0.013)     | (0.014)     | (0.015)     |
| Age                           | -0.0083***  | -0.0055***  | -0.0055***  |
|                               | (0.000)     | (0.000)     | (0.000)     |
| Male = 1                      | -0.0530***  | -0.1001***  | -0.0905***  |
|                               | (0.008)     | (0.008)     | (0.008)     |
| Education (No schooling is omitted category) |             |             |             |
| Primary                       | 0.0737***   | 0.0675***   |             |
|                               | (0.011)     | (0.011)     |             |
| Secondary                     | 0.1369***   | 0.1142***   |             |
|                               | (0.013)     | (0.013)     |             |
| Tertiary                      | 0.2214***   | 0.1930***   |             |
|                               | (0.016)     | (0.016)     |             |
| Income (IDR < 1.8 million is omitted category) |             |             |             |
| IDR 1.8–<3 million            | 0.2087***   | 0.2059***   |             |
|                               | (0.010)     | (0.010)     |             |
| IDR 3–<4.8 million            | 0.3732***   | 0.3657***   |             |
|                               | (0.012)     | (0.012)     |             |
| IDR 4.8–<7 million            | 0.5458***   | 0.5332***   |             |
|                               | (0.014)     | (0.014)     |             |
| > IDR 7 million               | 0.6545***   | 0.6351***   |             |
|                               | (0.016)     | (0.016)     |             |
| Urban dummy                   |             |             | 0.0966***   |
|                               |             |             | (0.009)     |
| Island dummies (Sumatra is omitted category) |             |             |             |
| Java                          | -0.0971***  |             |             |
|                               | (0.018)     |             |             |
| Nusa Tenggara                | -0.1427***  |             |             |
|                               | (0.018)     |             |             |
| Kalimantan                    | 0.2173***   |             |             |
|                               | (0.016)     |             |             |
| Sulawesi                      | 0.1226***   |             |             |
|                               | (0.021)     |             |             |
| Maluku                        | 0.3431***   |             |             |
|                               | (0.026)     |             |             |
| Papua                         | -0.0455*    |             |             |
|                               | (0.026)     |             |             |
| Gini index                    | 1.4641***   |             |             |
|                               | (0.241)     |             |             |
| Share of agri. Sector         | 0.0057***   |             |             |
|                               | (0.001)     |             |             |
| cut1                          | -3.5183***  | -3.2832***  | -2.6099***  |
|                               | (0.054)     | (0.056)     | (0.104)     |
Table 2 (continued)

Panel A-Estimate Coefficients

|        | (1)         | (2)         | (3)         |
|--------|-------------|-------------|-------------|
|        | (0–10)      | (0–10)      | (0–10)      |
| cut2   | −3.1424***  | −2.8991***  | −2.2277***  |
|        | (0.035)     | (0.037)     | (0.096)     |
| cut3   | −2.7742***  | −2.5221***  | −1.8518***  |
|        | (0.026)     | (0.028)     | (0.092)     |
| cut4   | −2.4003***  | −2.1392***  | −1.4693***  |
|        | (0.022)     | (0.025)     | (0.091)     |
| cut5   | −2.0898***  | −1.8194***  | −1.1494***  |
|        | (0.020)     | (0.023)     | (0.091)     |
| cut6   | −1.6891***  | −1.4049***  | −0.7346***  |
|        | (0.019)     | (0.022)     | (0.091)     |
| cut7   | −1.2252***  | −0.9227***  | −0.2511***  |
|        | (0.018)     | (0.022)     | (0.091)     |
| cut8   | −0.5070***  | −0.1740***  | 0.5025***   |
|        | (0.018)     | (0.022)     | (0.091)     |
| cut9   | 0.3843***   | 0.7481***   | 1.4334***   |
|        | (0.018)     | (0.022)     | (0.091)     |
| cut10  | 1.1124***   | 1.4875***   | 2.1816***   |
|        | (0.018)     | (0.022)     | (0.091)     |
| Observations | 72,317 | 72,317 | 72,317 |

Panel B-Marginal Effects

| Electricity = 1, 0 Otherwise | (1)         | (2)         | (3)         |
|--------------------------------|-------------|-------------|-------------|
| Happiness = 0 (Very unhappy)  | −0.0004***  | −0.0002***  | −0.0003***  |
|                               | (0.000)     | (0.000)     | (0.000)     |
| Happiness = 1                 | −0.0010***  | −0.0005***  | −0.0006***  |
|                               | (0.000)     | (0.000)     | (0.000)     |
| Happiness = 2                 | −0.0025***  | −0.0014***  | −0.0015***  |
|                               | (0.000)     | (0.000)     | (0.000)     |
| Happiness = 3                 | −0.0056***  | −0.0031***  | −0.0033***  |
|                               | (0.000)     | (0.000)     | (0.000)     |
| Happiness = 4                 | −0.0084***  | −0.0048***  | −0.0050***  |
|                               | (0.000)     | (0.000)     | (0.000)     |
| Happiness = 5                 | −0.0175***  | −0.0100***  | −0.0104***  |
|                               | (0.001)     | (0.001)     | (0.001)     |
| Happiness = 6                 | −0.0285***  | −0.0165***  | −0.0171***  |
|                               | (0.001)     | (0.001)     | (0.001)     |
| Happiness = 7                 | −0.0414***  | −0.0240***  | −0.0249***  |
|                               | (0.002)     | (0.002)     | (0.002)     |
| Happiness = 8                 | 0.0084***   | 0.0052***   | 0.0054***   |
|                               | (0.001)     | (0.000)     | (0.001)     |
| Happiness = 9                 | 0.0461***   | 0.0261***   | 0.0272***   |
|                               | (0.002)     | (0.002)     | (0.002)     |
4 Results and Discussion

4.1 Baseline Estimates

The primary result of the association between energy access and happiness is presented in Table 2-Panel A and its corresponding marginal effect is presented in Table 2-Panel B. In general, we found a positive effect of electricity on happiness. The ordered probit model suggests relatively modest positive differences in happiness between individuals with and without electricity access. The naive estimate (column 1 Table 2-Panel A and Table 2-Panel B) shows that the percentage of individuals with electricity that reveals “very happy” is 5 points higher than those without electricity. On the other extreme of the happiness scale, the percentage of individuals with electricity that reveals “very unhappy” is less by 0.04 points. We only include basic demographic covariates of age and gender in this specification. The point estimates become more conservative when we include education and income as well as regional level covariates. The corresponding figures decrease toward 3 points and 0.03 points, respectively. The decrease in magnitude is as expected and it suggests the changes in the gross effect and net effect of electricity access on happiness once the education and income domains are controlled.

The baseline estimates using OLS with full conditioning variables reveal a marginal effect of 0.22 units between status having electricity and not. This effect is approximately 3% of the control group’s mean (7.45). This size is comparable with the magnitude observed from the ordinal model earlier. This conservative magnitude is lower than the estimate that only includes age and gender (approximately 5%).

Even though the OLS estimate with full control is less biased than without control, we strongly believe that the conventional bias in the form of sorting associated with the scale norming/hedonic adaptation and relative deprivation could understate the true effect of electricity access on happiness. We now turn into the estimates that better capture causal interpretation of electricity access impact on happiness once these unobserved factors are controlled.

4.2 IV Estimates

The first-stage existence of the IV estimate suggests a moderate effect of the instrument on the endogenous variable. Every 1,000 km increase in the provincial distance to the nearest substation reduces individuals’ probability having electricity access by 0.03%. The
reported excluded-F test reveals a high value of 909 for the model with the full control variables. The visualisation of the monotonicity strength of the instrumental variable on the endogenous variable is provided in Fig. 4.

Our IV estimate in column 6 of Table 3-Panel A confirms the results of the OLS and multinomial model. The point estimate is approximately 0.5, translating into an effect of 6.7% of the control mean. The estimate confirms the presence of the positive effect of electricity access on happiness found in OLS and multinomial estimates. Our finding of a positive modest effect is similar to the finding of electricity access effect on happiness in Kenya (Lee et al., 2020) but in contrast to findings in Suriname (Corral & Zane, 2020). Nevertheless, we are cautious that happiness or subjective well-being is a very subjective measure, so the relationship captured with these estimates might still be inclusive of subjectivity and could alter the magnitude of our point estimates. However, we are confident about the direction of the effect given the consistency of the results from the three models examined.

The positive relationship between electricity access and happiness contrasts with the energy-happiness paradox hypothesis that Okulicz-Kozaryn & Altman (2020) suggested. The possibility that the estimates of the energy-happiness relationship vary is not surprising. In a more general context, the impact of energy access on human development depends on the region. Acheampong et al. (2021), for example, concluded that access to energy does not equally benefit every party involved in their energy-related activities. Their study from aggregate data from 79 energy-poor countries across regions in the world with the period of observation starting from 1990 to 2018 found a significant effect of access to electricity and clean energy on human development. However, its effect is different across regions. In Caribbean-Latin America and sub-Saharan Africa, access to energy increases human development, while in South Asia, it is found to be the opposite.
### Table 3  OLS and IV results

|                         | Panel A-Main Estimates | OLS                  | IV                  |
|-------------------------|------------------------|----------------------|---------------------|
|                         | (1)                    | (2)  (3)             | (4)  (5)            | (6)  |
| Electricity = 1, 0      | 0.3850***              | 0.2104***            | 0.2248***           | 0.1792*** | 0.0393 | 0.4946*** |
| Otherwise               | (0.019)                | (0.019)              | (0.021)             | (0.038) | (0.038) | (0.134) |
| Age                    | −0.0111***             | −0.0066***           | −0.0064***          | −0.0107*** | −0.0061*** | −0.0069*** |
|                         | (0.000)                | (0.000)              | (0.000)             | (0.000) | (0.000) | (0.000) |
| Male = 1                | −0.0575***             | −0.1217***           | −0.1101***          | −0.0703*** | −0.1340*** | −0.1008*** |
|                         | (0.011)                | (0.011)              | (0.011)             | (0.011) | (0.011) | (0.011) |
| Education (No schooling is omitted category) | | | | |
| Primary                 | 0.1142***              | 0.1068***            | 0.1275***           | 0.0959*** |
|                         | (0.016)                | (0.016)              | (0.016)             | (0.017) |
| Secondary               | 0.2099***              | 0.1817***            | 0.2313***           | 0.1636*** |
|                         | (0.018)                | (0.018)              | (0.018)             | (0.020) |
| Tertiary                | 0.3237***              | 0.2877***            | 0.3435***           | 0.2699*** |
|                         | (0.020)                | (0.020)              | (0.020)             | (0.022) |
| Income (IDR < 1.8 million is omitted category) | | | | |
| IDR 1.8–< 3 million     | 0.3120***              | 0.3067***            | 0.3190***           | 0.2986*** |
|                         | (0.014)                | (0.014)              | (0.014)             | (0.015) |
| IDR 3–< 4.8 million     | 0.5280***              | 0.5151***            | 0.5367***           | 0.5052*** |
|                         | (0.016)                | (0.016)              | (0.016)             | (0.016) |
| IDR 4.8–< 7 million     | 0.7372***              | 0.7167***            | 0.7465***           | 0.7081*** |
|                         | (0.018)                | (0.018)              | (0.018)             | (0.018) |
| > IDR 7 million         | 0.8623***              | 0.8319***            | 0.8724***           | 0.8220*** |
|                         | (0.019)                | (0.020)              | (0.019)             | (0.020) |
| Urban dummy             | 0.1174***              | 0.020                | 0.0955***           | (0.016) |
|                         | (0.012)                | (0.012)              | (0.016)             | |
| Island dummies (Sumatra is omitted category) | | | | |
| Java                    | −0.1368***             | −0.1262***           | (0.024)             | (0.025) |
|                         | (0.024)                | (0.024)              | (0.025)             | (0.030) |
| Nusa Tenggara           | −0.1864***             | −0.1471***           | (0.025)             | (0.030) |
| Kalimantan              | 0.2591***              | 0.2846***            | (0.021)             | (0.024) |
| Sulawesi                | 0.1192***              | 0.1345***            | (0.028)             | (0.029) |
| Maluku                  | 0.4082***              | 0.4467***            | (0.033)             | (0.039) |
| Papua                   | −0.0477                | 0.1060               | (0.034)             | (0.084) |
| Gini index              | 2.1800***              | 1.9904***            | (0.319)             | (0.330) |
| Share of agri. sector   | 0.0071***              | 0.0078***            | (0.001)             | (0.001) |
| Constant                | 7.9726***              | 7.4724***            | 6.5014***           | 7.5901*** |
|                         | (0.025)                | (0.029)              | (0.120)             | (0.037) |
|                         |                       |                      |                     | (0.037) |
|                         |                       |                      |                     | (0.146) |
### Table 3 (continued)

| Panel A-Main Estimates | OLS  | IV  |
|------------------------|------|-----|
|                        | (1)  | (2) | (3) |
| N                      | 72,317 | 72,317 | 72,317 |
| Excluded–F             | 7,212 | 7,249 | 909 |

| Panel B-First-stage regression of IV estimates | (1) | (2) | (3) |
|------------------------------------------------|-----|-----|-----|
| Electricity = 1, 0 Otherwise                  |     |     |     |
| Distance to nearest substation in 1985        | -0.0004*** | -0.0004*** | -0.0003*** |
| (0.000)                                        |     |     |     |
| Age                                            | 0.0006*** | 0.0016*** | 0.0014*** |
| (0.000)                                        |     |     |     |
| Male = 1                                       | -0.0286*** | -0.0377*** | -0.0309*** |
| (0.002)                                        |     |     |     |

**Education (No schooling is omitted category)**

|                      | OLS  | IV  |
|----------------------|------|-----|
| Primary              | 0.0463*** | 0.0384*** |
| (0.003)              |     |     |
| Secondary            | 0.0898*** | 0.0642*** |
| (0.003)              |     |     |
| Tertiary             | 0.0870*** | 0.0629*** |
| (0.004)              |     |     |

**Income (IDR < 1.8 million is omitted category)**

|                      | OLS  | IV  |
|----------------------|------|-----|
| IDR 1.8–< 3 million  | 0.0344*** | 0.0278*** |
| (0.003)              |     |     |
| IDR 3–< 4.8 million  | 0.0463*** | 0.0342*** |
| (0.003)              |     |     |
| IDR 4.8–< 7 million  | 0.0487*** | 0.0312*** |
| (0.003)              |     |     |
| > IDR 7 million      | 0.0566*** | 0.0363*** |
| (0.004)              |     |     |

**Urban dummy**

|                      | OLS  | IV  |
|----------------------|------|-----|
| Urban dummy          | 0.0801*** |     |
| (0.002)              |     |     |

**Island dummies (Sumatra is omitted category)**

|                      | OLS  | IV  |
|----------------------|------|-----|
| Java                 | -0.0458*** |     |
| (0.004)              |     |     |
| Nusa Tenggara        | -0.0691*** |     |
| (0.006)              |     |     |
| Kalimantan           | -0.0311*** |     |
| (0.005)              |     |     |
| Sulawesi             | -0.0225*** |     |
| (0.005)              |     |     |
| Maluku               | -0.0117 |     |
| (0.010)              |     |     |
| Papua                | -0.1513*** |     |
| (0.016)              |     |     |
4.3 Heterogeneity Analysis

Indonesia’s diverse archipelago divides the nations into two diametral conditions of non-lagging and lagging regions, corresponding to the levels of happiness and electrification. To what extent this inequality translates into our estimation of the electricity effect on happiness is presented in Table 4. The heterogeneity estimate suggests that the magnitude effect of electricity access on happiness is larger in lagging regions than in non-lagging regions. The interaction variable suggests that the difference between the impact in the lagging and non-lagging regions is approximately 0.15 units, translating into 2% of the control group’s mean. This positive impact confirms our earlier hypothesis about impact heterogeneity in the presence of hedonic adaptation; the impact in the advanced regions should be lower than in the lagging regions. This is due to the presumption that the share of individuals with higher aspirations for happiness is larger in the non-lagging region.

4.4 Mediation Analysis

To better understand how the happiness effect of electricity access on happiness works, we decompose the total effect obtained from Eqs. (3a) and (3b) into two components: the direct and the indirect effects. Before estimating the intermediate model of Eqs. 5a and 5b, we precede the analysis by testing the association of happiness and various life satisfaction indexes presented in Table 5. The estimate is also expected to serve as a reliability check to determine whether the happiness measure is well behaved and is associated with its core elements: life satisfaction, affection, and eudaimonia (Deci & Ryan, 2008). As we can see from the OLS estimate of Table 5, happiness is positively associated with people’s satisfaction on housing, education, life activity, income, health, family matters, leisure, and so on.
| Panel A-Subsamples | (1) Male | (2) Female | (3) High income | (4) Low income | (5) Java Island | (6) Outside Java | (7) Non-lagging | (8) Lagging regions |
|-------------------|----------|------------|-----------------|----------------|-----------------|-----------------|---------------|-------------------|
| Electricity = 1, 0 Otherwise | 0.7301*** | 0.0948 | 1.9840** | 0.7628*** | -1.5524 | 0.4651*** | -0.6481 | 1.0313*** |
| N | 35,167 | 37,150 | 6,467 | 23,539 | 23,463 | 48,854 | 62,516 | 9,801 |
| Excluded−F | 488 | 358 | 22 | 237 | 0 | 731 | 127 | 188 |
| Individual covariates | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Region covariates | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

| Panel B-Interaction forms | (1) Happiness | (2) Happiness | (3) Happiness |
|--------------------------|--------------|--------------|--------------|
| Electricity = 1, 0 Otherwise = 1 | 0.2496*** | 0.1394*** | 0.1647*** |
| Lagging region = 1 | -0.2014*** | -0.1261*** | -0.1120*** |
| Electricity = 1, 0 Otherwise = 1 # Lagging region = 1 | 0.2776*** | 0.1949*** | 0.1466*** |
| Age | -0.0066*** | -0.0066*** | -0.0066*** |
| Male = 1 | -0.1216*** | -0.1216*** | -0.1183*** |
| Primary | 0.1129*** | 0.1129*** | 0.1166*** |
| Secondary | 0.2081*** | 0.2081*** | 0.2116*** |
Panel A: Robust standard errors are reported in parentheses. Individual covariates include age, gender, education, and income level. Region covariates include urban dummy, island dummies, Gini index and share of agricultural sector.

**Table 4** (continued)

|                           | (1)                      | (2)                      | (3)                      |
|---------------------------|--------------------------|--------------------------|--------------------------|
| Happiness                 |                          |                          |                          |
| Tertiary                  | 0.3221***                | 0.3167***                |                          |
|                           | (0.020)                  | (0.020)                  |                          |
| IDR 1.8–<3 million        | 0.3120***                | 0.3213***                |                          |
|                           | (0.014)                  | (0.014)                  |                          |
| IDR 3–<4.8 million        | 0.5274***                | 0.5444***                |                          |
|                           | (0.016)                  | (0.016)                  |                          |
| IDR 4.8–<7 million        | 0.7368***                | 0.7576***                |                          |
|                           | (0.018)                  | (0.018)                  |                          |
| > IDR 7 million           | 0.8607***                | 0.8807***                |                          |
|                           | (0.019)                  | (0.019)                  |                          |
| Gini index                |                          |                          | 0.9647***                |
|                           |                          |                          | (0.173)                  |
| Share of agri. Sector     | 0.0095***                |                          |                          |
|                           | (0.001)                  |                          |                          |
| Constant                  | 7.5563***                | 7.5382***                | 6.9772***                |
|                           | (0.027)                  | (0.036)                  | (0.078)                  |
| Observations              | 72,317                   | 72,317                   | 72,317                   |

Panel A: Robust standard errors are reported in parentheses. Individual covariates include age, gender, education, and income level. Region covariates include urban dummy, island dummies, Gini index and share of agricultural sector.

*Significance at p < .1
**Significance at p < .05
***Significance at p < .01
social, environment, security satisfaction and affections. All coefficients are statistically significant.

For Indonesian people, the first three important satisfaction indexes associated with happiness are the affection index measuring how cheerful the respondent is, the family

Table 5 Association between happiness and various life domain indexes

| Life domain index | Dependent Variable: happiness | All | Lagging region | Non-lagging region |
|-------------------|--------------------------------|-----|----------------|-------------------|
|                   |                               | (1) | (2)            | (3)              | (4)              |
|                   |                               | (5) | (6)            |                   |                   |
| Housing index     | 0.082***                      | 0.082*** | 0.085*** | 0.085*** | 0.082*** | 0.082*** |
|                   | (0.0035)                      | (0.0035) | (0.0095) | (0.0095) | (0.0038) | (0.0038) |
| Education index   | 0.009***                      | 0.009*** | 0.017** | 0.017** | 0.008*** | 0.008*** |
|                   | (0.0025)                      | (0.0025) | (0.0073) | (0.0073) | (0.0027) | (0.0027) |
| Activity index    | 0.035***                      | 0.035*** | 0.055*** | 0.055*** | 0.032*** | 0.032*** |
|                   | (0.0035)                      | (0.0035) | (0.0105) | (0.0105) | (0.0037) | (0.0037) |
| Income index      | 0.061***                      | 0.060*** | 0.066** | 0.066** | 0.060*** | 0.059*** |
|                   | (0.0033)                      | (0.0033) | (0.0104) | (0.0104) | (0.0035) | (0.0035) |
| Health index      | 0.045***                      | 0.045*** | 0.050*** | 0.050*** | 0.044*** | 0.043*** |
|                   | (0.0034)                      | (0.0034) | (0.0099) | (0.0099) | (0.0036) | (0.0036) |
| Family index      | 0.168***                      | 0.168*** | 0.095*** | 0.095*** | 0.179*** | 0.179*** |
|                   | (0.0047)                      | (0.0047) | (0.0133) | (0.0133) | (0.0051) | (0.0051) |
| Leisure index     | 0.027***                      | 0.027*** | 0.042*** | 0.042*** | 0.025*** | 0.025*** |
|                   | (0.0037)                      | (0.0037) | (0.0115) | (0.0115) | (0.0039) | (0.0039) |
| Social index      | 0.057***                      | 0.057*** | 0.075*** | 0.075*** | 0.054*** | 0.054*** |
|                   | (0.0046)                      | (0.0046) | (0.0138) | (0.0138) | (0.0049) | (0.0049) |
| Environment index | 0.001                         | 0.001 | −0.004 | −0.004 | 0.002   | 0.002   |
|                   | (0.0039)                      | (0.0039) | (0.0117) | (0.0117) | (0.0041) | (0.0041) |
| Security index    | −0.002                        | −0.003 | −0.005 | −0.005 | −0.001 | −0.002   |
|                   | (0.0035)                      | (0.0035) | (0.0101) | (0.0101) | (0.0038) | (0.0038) |
| Afection index 1  | 0.350***                      | 0.349*** | 0.321*** | 0.321*** | 0.354*** | 0.353*** |
|                   | (0.0053)                      | (0.0053) | (0.0142) | (0.0142) | (0.0057) | (0.0057) |
| Afection index 2  | 0.011***                      | 0.011*** | 0.002 | 0.002 | 0.013*** | 0.013*** |
|                   | (0.0025)                      | (0.0025) | (0.0077) | (0.0077) | (0.0026) | (0.0026) |
| Afection index 3  | −0.001                        | −0.001 | −0.003 | −0.003 | −0.000 | −0.000   |
|                   | (0.0021)                      | (0.0021) | (0.0067) | (0.0067) | (0.0022) | (0.0022) |
| Constant          | 1.621***                      | 1.565*** | 1.861*** | 1.866*** | 1.559*** | 1.490*** |
|                   | (0.0418)                      | (0.0443) | (0.1153) | (0.1217) | (0.0446) | (0.0473) |
| Observations      | 72,317                        | 72,317 | 9,801 | 9,801 | 62,516 | 62,516   |
| Island FE         | Yes                           | Yes | Yes      | Yes      | Yes | Yes     |
| Adjusted R-squared| 0.433                         | 0.433 | 0.412   | 0.412   | 0.437 | 0.438   |

Robust standard errors are reported in parentheses

*Significance at p < .1
**Significance at p < .05
***Significance at p < .01
The estimates of the *mediate* model in Table 6 suggest that the total positive effect is dominated by individuals’ satisfaction with their housing condition from having electricity. There is an indication of a negative direct effect of electricity access on happiness, as suggested by prior empirical analysis in the energy access-happiness paradox. The magnitude of the negative direct effect, however, is smaller than the indirect effect operating through housing satisfaction, making the total effect positive. The interpretation of this result is that the happiness effect of electricity access operates mainly from the increased satisfaction with housing conditions and facilities. The magnitude effect is positive and is larger than the negative direct effect. The mediation analysis result indicates the presence of the energy access-happiness paradox hypothesis; having electricity access has a negative direct effect on the individuals’ happiness. However, the total effect remains positive due to a large and positive indirect effect operating through individuals’ satisfaction with their housing condition from having access to electricity. We tentatively interpret the negative direct effect as the dissatisfaction of consuming energy originating from the negative externality in the form of resource depletion or pollution, as, for example, argued in Okulicz-Kozaryn & Altman (2020). The magnitude of this effect is, however, negligible and statistically insignificant.

| Dependent variable: Happiness, mediator: Housing satisfaction | (1)       | (2)       | (3)       |
|-------------------------------------------------------------|-----------|-----------|-----------|
| Total effect                                                | 0.1792*** | 0.0393    | 0.4946*** |
|                                                           | (0.041)   | (0.041)   | (0.131)   |
| Direct effect                                               | −0.4264** | −0.4417*  | −0.0185   |
|                                                           | (0.192)   | (0.242)   | (0.115)   |
| Indirect effect                                             | 0.6056*** | 0.4809**  | 0.5131**  |
|                                                           | (0.153)   | (0.192)   | (0.258)   |
| Individual covariates                                        | No        | Yes       | Yes       |
| Regional covariates                                         | No        | No        | Yes       |
| Observations                                                | 72,317    | 72,317    | 72,317    |

Robust standard errors are reported in parentheses. Individual covariates include age, gender, education, and income level. Region covariates include urban dummy, island dummies, Gini index and share of agricultural sector.

*Significance at $p < .1$

**Significance at $p < .05$

***Significance at $p < .01$
5 Conclusion

This study investigates whether the energy access effect on happiness in the developing nation shows a paradoxical relationship as evidence shows for the developed countries. Concerning electricity access, the study found that, in the context of Indonesia, in contrast to the null effect reported in the previous studies, electricity access improves individuals’ happiness. We found a positive and modest impact of electricity access on happiness. We also show that the effect operates through individuals’ satisfaction with housing conditions. In a simple term, having electricity access increases individuals’ life satisfaction with housing conditions, increasing happiness. Nevertheless, the external validity of our findings only applies to developing countries that share a similar context with our country of a case study. It is relevant for archipelagic settings but might not for a country with a continental setting such as China or India that has different constraints for expanding electricity access and how people’s happiness varies. The heterogeneity impact analysis suggests that the magnitude impact is more significant in the economically lagging regions than in the non-lagging regions. It implies a justification of a policy to further expand electricity access on the grounds of well-being in the lagging areas of developing countries. Finally, examining the presence of the energy-happiness paradox in different contexts of developing countries would be a noteworthy future research agenda to build up a more comprehensive picture of the energy-happiness nexus.

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Declarations

Conflict of interest All authors of this article declare they have no financial and non-financial interests that could affect the outcome of the study.

Ethical Approval The data used in this study is a product of official micro on well-being survey (SNPK) in Indonesia data conducted by the Statistics Indonesia (Badan Pusat Statistik). The ethics of the data collection and informed consent (in Bahasa) are available at the following website: https://sirusa.bps.go.id/webadmin/pedoman/2017_2926_ped_Panduan%20Pelaksanaan%20Survei%20Pengukuran%20Tingkat%20Kebahagiaan%20(SPTK)%202017.pdf

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