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# Energy poverty in the Lao PDR and its impacts on education and health

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ABSTRACT

The Lao PDR has experienced rapid growth and poverty reduction through its openness to trade, investment, and integration to the regional and world economy. The country has also progressed in providing access to electricity and aims to have a 95% national coverage of electricity by 2020. This paper focuses on assessing the extent of energy poverty, as well as its implications on the well-being of the people, such as in education and health, using the Lao Economic Consumption Survey (LECSs). While access to electricity has dramatically increased, a significant number of households still do not have access to electricity and cannot afford to meet both necessity and energy consumption. Energy-poor households are prevalent among those who have lower income, owning lesser durables, living in rural villages without electricity connection and are far from main roads. This paper also finds that energy poverty negatively impacts households' average school years and health status. The findings would identify the vulnerable groups of people for targeted support. It argues that while ensuring access to electricity should be prioritised, it should be accompanied by policies promoting opportunities to generate income and reduce all forms of energy poverty.

## 1. Introduction

The Lao PDR has experienced rapid growth through its openness to trade, investment, and integration to the regional and world economy. Its gross domestic product (GDP) and per capita income grew more than 7% and 6% per annum, respectively, from 2010 to 2017, making the Lao PDR among the fastest-growing economies in the Association of South East Asian Nations (ASEAN). According to the 8th Five-Year National Socio-economic Development Plan (2016–2020), poverty rates decreased from 27.6% in 2008 to 23.2% in fiscal year 2012–2013.

The Lao PDR is an open economy; the share of total trade to GDP in 2017 was 76% and its nominal growth rate was at 21% in 2010–2017. Trade in services was also important and grew significantly during the same period. The country also attracted significant inflows of foreign direct investment (FDI) with the average share around 6% of GDP in 2017 and its nominal growth rate was at 20% in 2010–2017.

The economy has undergone similar structural change – shifting from agriculture to more steady industry, and a growing services sector. The share of agriculture sharply declined from 31% of GDP in 2010 to 16% in 2017 and the share of industry slightly decreased from 32 to 31% during the same period. The share of services in GDP increased from 36% in 2010 to 41% in 2017. Average real growth of agriculture was 2.8%, while the growth rate of industry and services was 12% and 7%, respectively, in 2010–2017.

However, with a small domestic market, the economy needs to structurally adjust and move to more competitive industries, away from the traditional export sectors such as energy and mining. The country's biggest export in 2017 was electricity, accounting to more than 17% of the country's export. The export of electricity increased from US$189 in 2010 to US$637 in 2017. Other large exports were copper and copper ores, wood products, telecommunication equipment, gold, rubber, and garment products. It is important to diversify the domestic industries and link to global value chains and increase the competitiveness of domestic industries for export market.

Moving forward, there are still major development challenges for the next stage of growth. They include the lack of educated and skilled human to support private sector growth and economic diversification, inefficient and underdeveloped financial sector, inadequate infrastructure, especially transport connectivity between rural and urban areas, low worker productivity due to poor health and nutrition, ineffective public administration and regulatory burdens on private sector, and low innovative and competitiveness of the non-resource sector (OECD, 2014).

The 8th Five-Year National Socio-economic Development Plan (2016–2020) has set out strategies to address these challenges to ensure inclusive and sustainable growth, including effective and efficient utilisation of natural resources. The poverty rate (households live under the national poverty line) is targeted to be reduced from 23.2% in fiscal year 2012–2013 to 10% by 2020. The development plan also aims to move away from a natural-resource-based and extractive-industries-

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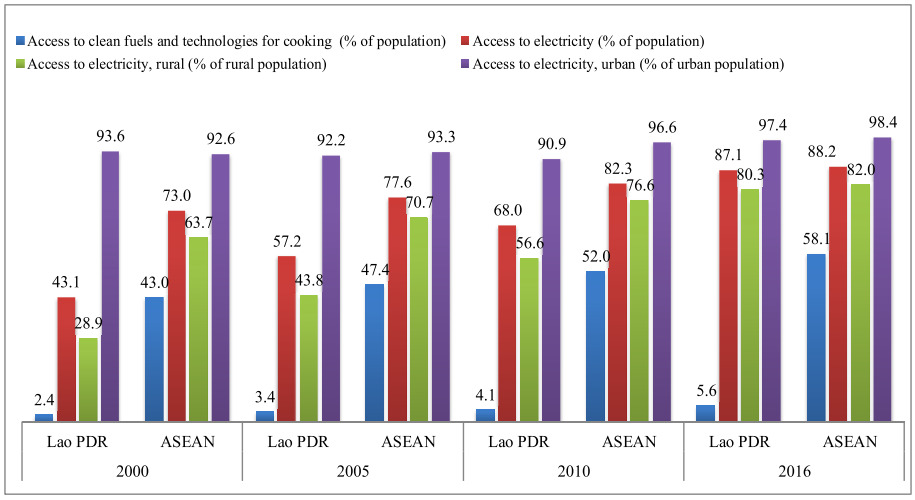


**Fig. 1.** Access to electricity in the Lao PDR and ASEAN
Source: Computed from World Development Indicator (2018).

dependent economy to high value-added manufacturing and services (Ministry of Planning and Investment, 2016).

Even though Lao PDR is an energy-exporting economy, specifically electricity, it has yet to achieve full electricity coverage nationwide (Fig. 1). Access to clean fuel and technologies for cooking is still very slow. However, people's access to electricity had significantly increased from 43% in 2000 to 87% in 2016. Access to electricity by the rural population increased from 29% to 80%, and from 94% to 97% by the urban population during the same period. The development plan also aims to achieve a 95% national coverage of electricity by 2020.

To support the government in its implementation of the energy policy to meet its development target, it is important to get proper understanding of the accessibility and affordability of electricity across demographic and geographic profiles.

There are some studies on the energy issues of the Lao PDR such as those of the Asian Development Bank (2010, 2013), Tuominen et al. (2013), Pillai (2014), and Kouphokham (2016). While these studies address the supply, investment, and some policies in the energy sector, as well as consumption of energy by status of households, there is no research on the extent and potential impacts of energy poverty on Lao people's welfare. Since energy poverty is a new concept at least in the Asian context, there is a dearth of research and publications on this area.

This is what this paper can contribute to the literature. The paper focuses on assessing the extent of energy poverty in the Lao PDR and implications on the well-being of the people. The paper provides empirical evidence of energy poverty using different definitions, identifies who are energy poor, and what their characteristics are. It then investigates how energy poverty and its impact on the welfare of the people, such as education and health.

The rest of the paper is organised as follows: Section 2 briefly reviews the energy sector; Section 3 provides the literature, methodology, and data; Section 4 presents empirical findings; and Sector 5 summarises the findings and conclusion.

## 2. Energy sector review for Lao PDR

The Lao PDR is rich in energy resources with vast hydropower potential for both big and small scales, high coal reserve, and also high potential in biomass, solar, and wind power that could make it to be a "battery" for energy-deficit neighbouring countries, Asian Development Bank (ADB) (2013). The hydropower alone could produce up to 8100 MW of its 20,000 MW potential capacity by 2020.

The latest results from a joint survey by the Lao PDR's Ministry of Energy and Mines (MEM) and the Economic Research Institute for ASEAN and East Asia (ERIA) show that the total primary energy supply in Lao PDR grew on an average at 7.5% per year from 2000 to 2015, driven by the supply of coal energy increased at an average rate of 42.2%, followed by hydro at 9.8% per year. Petroleum imported supply for transport sector also increased rapidly at an average of 8.5% a year. The electricity supply increased fourfold during the same period, while that of biomass has declined significantly. As a result, the share of biomass in total supply dropped from 78% in 2000 to 34% in 2015, while that of petroleum increased from 15% to 20%, hydro from 5% to 9%, and coal from 0.5% to 33% during the same period.

On the demand side, the total final energy consumption increased at an average annual growth rate of 5% from 2000 to 2015, whereas the demand of coal energy grew by 28.4% per year, followed by electricity at 13.4%, petroleum products consumption at 8.5%, and biomass consumption at 1.4% per year during the same period, Ministry of Energy and Mines and Lao PDR and the Economic Research Institute for ASEAN and East Asia (2018). Similar to the supply side, the share of biomass in the total supply decreased from 78% in 2000 to 46% in 2015, while the share of coal and electricity increased from a low base to 13% and 12%, respectively in 2015. The share of demand for petroleum products increased from about 20% to 30 during the same period.

The increase in supply and demand of electricity led to a higher rate of people's access to electricity, from 43% in 2000 to 87% nationwide in 2016. If this trend continues, it is very likely that the government can reach the target of a 95% national coverage of electricity by 2020.

## 3. Literature review and methodology

### 3.1. Literature review

#### 3.1.1. Definition of energy poverty

The research on energy poverty has been conceptualised around the 'fuel poverty' concept as discussed by Moore (2012) and Nierop (2014).

Sovacool and Drupady (2012) provide more comprehensive surveys of the literature and concepts of energy poverty. They refer to various definitions by international organisations, such as the United Nations Development Programme, which defines energy poverty as the 'inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset'. The Asian Development Bank defines energy poverty as 'the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe, and environmentally benign

energy services to support economic and human development'.

Laldjebaev et al. (2016) define energy poverty as 'lack of access to electricity networks; or dependence on burning solid biomass, such as wood, straw, and dung, in inefficient and polluting stoves to meet household energy needs.

#### 3.1.2. Measurement of energy poverty

The International Energy Agency's Energy Development Index uses four indicators to capture a specific aspect of potential energy poverty (Sovacool and Drupady, 2012). These are (i) per capita commercial energy consumption, which serves as an indicator of the overall economic development of a country; (ii) per capita electricity consumption in the residential sector, which serves as an indicator of the reliability of, and consumer's ability to pay for, electricity services; (iii) share of modern fuels in total energy use in the residential sector, which serves as an indicator of the level of access to clean cooking facilities; and (iv) share of population with access to electricity.

Sovacool and Drupady (2012) also discussed measurements of energy poverty. One method is to track the minimum amount of physical or animate energy needed for basic needs, such as cooking and lighting, or to look at the poorest people in a country and then detail the types and amounts of energy they use. Another is measuring how much income is spent on energy services. Typically, a family that spends more than 10%–15% of their earnings on energy services per month or year is considered 'energy poor' or classified under 'fuel poverty'.

Moore (2012) also discussed the 10% threshold share of income spent on energy and alternative definitions. The threshold and different definitions would affect the scale, distribution of the target populations, the relative importance of the main causal factors, and the consequent policy implications on reducing energy poverty and income distribution.

#### 3.1.3. Impacts of energy poverty on household welfare

Practical Action (2010) and United Nations Conference on Trade and Development Statistics (2018) suggest that lack of access to energy services is a poverty as it restricts human capabilities to meet their needs and realize their full potential. It is also an outcome of poverty because low-income individuals are limited in their financial abilities to afford goods and services that their better-off fellow citizens enjoy. Moreover, it can be a cause of poverty because it reinforces constraints in income generation potential as energy can be used as inputs for productive activities.

Trace (2016) also amplifies that energy access is not only necessary for lighting, cooking, and heating the home but also for people to earn a living, thus promoting economic development and poverty reduction. Energy access is used to pump clean groundwater for drinking and irrigation to increase agricultural productivity. It facilitates effective information and communication (Internet, telephony, radio, and television); transport; commerce; agro-processing; small-scale manufacturing; and industry. Energy access also preserves refrigerated vaccines and improves emergency and intensive healthcare, education, and cultural opportunities.

On the impact of energy poverty, Gonzalez (2016) argues that energy poverty could hamper human health, as relying on biomass for cooking and heating results in premature deaths from respiratory, cardiovascular, and other ailments caused by exposure to indoor air pollution, especially for women and children.

The extent and the impacts of energy poverty also depend on geographical terrain, population size, and climatic variations (Sovacool and Drupady, 2012).

### 3.2. Empirical models and data

#### 3.2.1. Empirical models

This paper follows the standard definition discussed in the literature. A household is energy poor if (i) it is not connected to an electricity grid or (ii) its consumption on energy exceeds 10% of total income or expenditure.

As Trace (2016) discusses, counting those with a grid connection to electricity as having energy, irrespective of affordability or reliability of the supply, could be an underestimation of energy poverty as connection does not mean access to minimum levels of evening lighting, cooling, space heating, or productive uses. It could also be overestimated as people could have a reasonable level of energy services (lighting, information and communication technology, a fan for cooling) supplied from other sources such as solar and have good quality biomass cookstoves.

Setting the 10% threshold in the second definition in this paper is arbitrary as there is no research on the minimum energy cost requirement to achieve either a minimum comfort, plus adequate lighting and cooking use in Asia, not to mention in the Lao PDR. The rationale for 10% threshold was based on the suggestion by Moore (2012) that was what the poorest 30% of households spent on fuel, at twice the median expenditure. The level above the threshold was considered 'disproportionate'.

To identify the characteristics of the energy-poor household, this paper follows findings from Moore (2012) and Nierop (2014). They argue that factors causing energy poverty can be inadequate supply and infrastructure (grid system), low household income, energy prices, energy efficiency, energy needs and preferences, and available resources including geographical location. Income and prices (cost) can directly cause energy poverty through both accessibility and affordability as households with lower incomes tend to spend a higher share of their disposable income on energy services or decide not to connect to grid networks. Energy-inefficient housing and out-of-date household equipment would cause households to spend more money for the same level of energy services.

After identifying the energy-poor households and their characteristics, we then attempt to estimate potential impacts (correlations) of energy poverty on households' health status (i.e. those whose members have temporary or permanent diseases) and education (i.e. average mean years of a household's schooling).

Using the Lao Economic Consumption Survey (LECSs) in 2008/2009 (LECS4) and 2012/2013 (LECS5), we estimate the energy poverty headcount and their characteristics. We further test whether energy poverty affects the education and health status of the household by applying the following statistical model in its general form:

$$EP_i = \alpha_0 + \beta_i X_i + \varepsilon_i \quad (1)$$

$$Edu/Health_i = \gamma_0 + \theta_i EP_i + \delta_i Z_i + \varepsilon_i \quad (2)$$

Where equation (1) is the Probit Model and (2) is the Ordinary Least Square Model (OLS) and Two-Stage Least Square Model (2SLS) where $EP_i$ is the probability of a household's energy poverty status (fitted value) and $Edu/Health_i$ is a household's education or health status; $i$ represents household $i$; and $X_i$ and $Z_i$ are set of independent variables that capture household characteristics and other control variables; $\varepsilon_i$ and $\varepsilon_i$ are error terms.

#### 3.2.2. Sources of data

Our sources of data are the Lao Economic Consumption Surveys (LECSs) in 2008/2009 (LECS4) and 2012/2013 (LECS5).

The Lao Expenditure and Consumption Survey (LECS) covers the whole of Lao PDR. The statistical unit is the households and the surveys cover economic transactions of households to estimate household income, consumption and production and a number of social indicators. The sample size of LECS4 conducted for a period of 12 months starting from April 1, 2007 to March 31, 2008, covered 8304 household from 518 villages. In every village 16 households were selected in the sample. The LECS5 comprises of the survey sample 8226 households, selecting from 515 villages. Eight of these households were randomly selected from those households that had been included in the LECS 4

**Table 1**
National poverty headcount and energy poverty (%).

| | LECS4 – 2008 | LECS5 – 2013 | Changes |
|---|---|---|---|
| Poverty headcount | 27.30 | 23.2 | −4.1 |
| Energy poverty (1) | 40.68 | 23.0 | −17.7 |
| Energy poverty (2) | 39.15 | 24.7 | −14.5 |
| Per capita income (kip/month) | 347,534.70 | 537,058.4 | 54.5 |
| Villages with electricity connection | 66.30 | 76.8 | 10.4 |

Source: Author's Estimation from LECS4 and LECS5.

survey while the other half were randomly selected from the list of all households in the village (World Bank, 2014).

## 4. Empirical results

### 4.1. Energy poverty

The estimates of energy poverty headcount and energy poverty based on the two definitions are reported in Table 1. Energy poverty (1) is for those households that are not connected to an electricity grid. Energy poverty (2) is for those households whose consumption per capita on energy exceeds 10% of their total per capita expenditure. Poverty headcount is estimated based on the national definition of poor people whose per capita expenditure is below the national poverty line.

The poverty headcount in 2008 was about 27% and decreased to 23% in 2013, or 4 percentage points lower than the rate in 2008. The estimated rates of energy poverty by both definitions are quite similar. In 2008, energy poverty (1) was 41% and energy poverty (2) was 39% but these were reduced to 23% and 25%, respectively, in 2013. The rate of energy poverty (1) decreased by 18 percentage points from 2008 to 2013 and while that of energy poverty (2) was 14 percentage points down during the same period.

Key factors for the significant reduction in the poverty rate and energy poverty are the 54% increase in the mean of per capita income and the 10 percentage points increase in the coverage of villages with electricity connections from 2008 to 2013.

### 4.2. Characteristics of energy-poor households

Table 2 summarises key characteristics of the households in 2008 and 2013. The reported household characteristics are chosen based on the literature and close relationships with energy consumption and poverty, such as household income which is key for overall household consumption, including energy. Villages with or without connection to electricity grids directly affect access and consumption of electricity.

Access and consumption of energy are also dependent on geographical locations such as urban–rural, border areas, road access, and distance to the main roads, etc.

A household's living conditions, such as appliances, machinery and equipment, motors and vehicles, and living space, also affect energy consumption. Other household characteristics such as age, gender, literacy of household head, and household size can affect households' preferences or are used as controlled variables.

For both 2008 and 2013, there were differences in the characteristics of energy-poor and non-poor households by the two definitions.

On average, compared to the non-poor, energy-poor households by the first definition appear to have lower incomes; live in rural villages without electricity connection, are located inland and far from the border; and have poor access to roads. They also own lesser durables, live in a smaller living area, and have a higher rate of illiteracy than the non-energy-poor households.

To statistically confirm the characteristic differences between the energy poverty status in 2008 and 2013, we applied the Probit regression model and the empirical results are reported in Table 3.

Controlling for other household characteristics, the results show that households in energy poverty (1) are those with lower income, living in rural villages without electricity connection, and owning lesser durables than the non-energy-poor, all statistically significant at the 1% level, except for the coefficient of the urban variable in the 2008 sample which is significant at the 10% level. The 1% level of statistical significance for distance from main road variable in the 2013 energy poverty (1) but not in 2008 suggests that the prevalence of energy poverty is still severe for households living farther from the main road, compared to those in 2008. The higher significance level and coefficient of the urban variable in 2013 also reinforces this result.

For energy poverty (2), the sign of coefficients for income and village variables are different from energy poverty (1). The household income variable in 2008 is not significant, suggesting that the number of households having more than 10% share of energy consumption are not much varied by income level, while the village connection to grids is still very significant.

Source: Author's estimation from LECS4 and LECS5.

The change of sign and significance of the urban variable suggests that households of energy poverty (2) can be those from low-income urban areas (the urban poor), even with road access (significant at 10% level).

For the 2013 sample, the coefficient of household income variable is still significant at the 1% level while that of village and durables is at the 10% level. The positive sign at the 5% level of significance of access to road variables may suggest that poverty is persistent even in areas with better road infrastructure and where opportunity to generate

**Table 2**
Summary of household characteristics by energy poverty.

| | Household Characteristics | LECS4 – 2008 | | | | LECS5 – 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Energy Poverty (1) | | Energy Poverty (2) | | Energy Poverty (1) | | Energy Poverty (2) | |
| | | Non-poor | Poor | Non-poor | Poor | Non-poor | Poor | Non-poor | Poor |
| 1 | Logarithm of household income | 13.92 | 12.92 | 13.74 | 13.72 | 12.58 | 11.32 | 12.48 | 11.95 |
| 2 | Village with electricity connection (1 yes, 0 no) | 0.99 | 0.18 | 0.67 | 0.65 | 0.90 | 0.31 | 0.77 | 0.73 |
| 3 | Urban (1 yes, 0 no) | 0.50 | 0.02 | 0.31 | 0.19 | 0.37 | 0.02 | 0.29 | 0.20 |
| 4 | Border district (1 yes, 0 no) | 0.53 | 0.49 | 0.49 | 0.55 | 0.53 | 0.47 | 0.49 | 0.49 |
| 5 | Access to road year-round (1 yes, 0 no) | 0.94 | 0.54 | 0.78 | 0.77 | 0.84 | 0.36 | 0.73 | 0.65 |
| 6 | Logarithm of distance from main road (km) | 0.04 | 0.51 | 0.19 | 0.30 | 0.08 | 0.25 | 0.13 | 0.15 |
| 7 | Logarithm of number of owned durables | 1.85 | 0.81 | 1.49 | 1.42 | 2.02 | 1.00 | 1.84 | 1.61 |
| 8 | Logarithm of living area ($m^2$) | 4.19 | 3.73 | 4.02 | 3.98 | 4.15 | 3.66 | 4.05 | 3.92 |
| 9 | Logarithm of age of household head | 3.86 | 3.75 | 3.82 | 3.80 | 3.87 | 3.74 | 3.85 | 3.80 |
| 10 | Gender of household head (1 male, 0 female) | 0.92 | 0.98 | 0.95 | 0.94 | 0.93 | 0.98 | 0.94 | 0.94 |
| 11 | Literacy of household head (1 illiterate, 0 otherwise) | 0.07 | 0.22 | 0.11 | 0.16 | 0.08 | 0.25 | 0.11 | 0.15 |
| 12 | Logarithm of household size | 1.75 | 1.90 | 1.83 | 1.78 | 1.68 | 1.85 | 1.73 | 1.75 |

Source: Author's estimation from LECS4 and LECS5.

**Table 3**
Regressions on energy poverty by household characteristics.

| | Household Characteristics | LECS 4–2008 | | LECS 5–2013 | |
|---|---|---|---|---|---|
| | | [a]. Energy Poverty (1) | [b]. Energy Poverty (2) | [c]. Energy Poverty (1) | [d]. Energy Poverty (2) |
| 1 | Logarithm of household income | −0.162*** | −0.0436 | −0.124*** | −0.100*** |
| | | (0.0462) | (0.0316) | (0.0351) | (0.0237) |
| 2 | Village with electricity connection (1 yes, 0 no) | −3.007*** | −0.348*** | −1.357*** | −0.190* |
| | | (0.172) | (0.128) | (0.112) | (0.102) |
| 3 | Urban (1 yes, 0 no) | −0.236* | 0.548*** | −1.102*** | −0.0419 |
| | | (0.128) | (0.105) | (0.229) | (0.0674) |
| 4 | Border district (1 yes, 0 no) | 0.0449 | 0.0178 | −0.0256 | −0.0513 |
| | | (0.116) | (0.0810) | (0.0878) | (0.0601) |
| 5 | Access to road year-round (1 yes, 0 no) | −0.256 | −0.234* | −0.109 | 0.254** |
| | | (0.171) | (0.141) | (0.118) | (0.101) |
| 6 | Logarithm of distance from main road (km) | 0.0997 | −0.00478 | 0.285*** | 0.00524 |
| | | (0.0918) | (0.0793) | (0.0877) | (0.109) |
| 7 | Logarithm of number of owned durables | −0.620*** | −0.0389 | −0.978*** | −0.109* |
| | | (0.0944) | (0.0669) | (0.0703) | (0.0563) |
| 8 | Logarithm of living area ($m^2$) | −0.222 | −0.0838 | −0.114 | −0.0171 |
| | | (0.150) | (0.0642) | (0.0782) | (0.0532) |
| 9 | Logarithm of age of household head | −0.0944 | −0.0297 | −0.654*** | 0.00641 |
| | | (0.266) | (0.178) | (0.166) | (0.128) |
| 10 | Gender of household head (1 male, 0 female) | 0.294 | −0.0744 | 0.629** | −0.134 |
| | | (0.323) | (0.147) | (0.275) | (0.116) |
| 11 | Literacy of household head (1 illiterate, 0 otherwise) | −0.263 | 0.0200 | 0.184 | −0.149 |
| | | (0.201) | (0.158) | (0.153) | (0.124) |
| 12 | Logarithm of household size | 0.359** | −0.0341 | 0.625*** | 0.0120 |
| | | (0.159) | (0.0956) | (0.117) | (0.0794) |
| | Constant | 5.2291*** | 0.18867 | 4.240*** | 0.7011 |
| | | (1.2078) | (0.7935) | (0.8423) | (0.5827) |

[a] Probit regression: Number of obs = 1814; LR chi2(12) = 475.73; Prob > chi2 = 0.0000; Log likelihood = −276.92; Pseudo R2 = 0.7158.
[b] Probit regression: Number of obs = 1814; LR chi2(12) = 36.88; Prob > chi2 = 0.0002; Log likelihood = −612.82; Pseudo R2 = 0.0330.
[c] Probit regression: Number of obs = 3397; LR chi2(12) = 548.94; Prob > chi2 = 0.0000; Log likelihood = −525.899; Pseudo R2 = 0.5222.
[d] Probit regression: Number of obs = 2466; LR chi2(12) = 46.17; Prob > chi2 = 0.0000; Log likelihood = −1152.31; Pseudo R2 = 0.0203.

income is low.

### 4.3. Impact of energy poverty on education

According to the World Bank (2008), access to electricity or electrification may affect education outcomes due to the improvement in the quality of schools, either through the provision of electricity-dependent equipment, or increasing teacher quantity and quality; and increased study time because of better lighting.

The impact of energy poverty on education includes absenteeism from school as well as incidence of illness. Moreover, there is a strong correlation between the time children spent collecting fuel and reduced school attendance (Sovacool and Drupady, 2012).

To check the impacts, we regressed the mean of household's school years in 2013 on energy poverty status of 2008, assuming it takes some time for energy poverty to affect household's education outcomes. Using the lagged independent variable allows us to control for endogeneity problems. In addition to geographical and household characteristics, we included the number of schools in the village to control for the impacts. The regression results are presented in Table 4.

As expected, energy poverty negatively impacts average school years of a household at the 1% level of significance for both models.

Households with an access to roads, lived in urban areas, and led by female, older but literate household heads tend to have higher average years of schooling.

**Table 4**
Impact of energy poverty on household education.

| | | [a]. OLS with Robust Standard Error | [b]. 2SLS with Robust Standard Error |
|---|---|---|---|
| 1 | Energy Poor (1) in 2008 | −0.228*** | −0.215*** |
| | | (0.0161) | (0.0438) |
| 2 | Logarithm of number of school in the village | 0.109*** | 0.0490 |
| | | (0.0202) | (0.0331) |
| 3 | Access to road year-round (1 yes, 0 no) | 0.110*** | 0.0369 |
| | | (0.0160) | (0.0378) |
| 4 | Urban (1 yes, 0 no) | 0.256*** | 0.280*** |
| | | (0.0166) | (0.0314) |
| 5 | Border district (1 yes, 0 no) | −0.0183 | −0.0266 |
| | | (0.0134) | (0.0273) |
| 6 | Logarithm of age of household head | 0.201*** | 0.179** |
| | | (0.0298) | (0.0760) |
| 7 | Gender of household head (1 male, 0 female) | −0.0943*** | −0.0443 |
| | | (0.0297) | (0.0507) |
| 8 | Literacy of household head (1 illiterate, 0 otherwise) | −0.312*** | −0.0985 |
| | | (0.0291) | (0.124) |
| 9 | Logarithm of household size | −0.000139 | −0.00620 |
| | | (0.00314) | (0.00663) |
| | Constant | 0.9648*** | 1.232*** |
| | | (0.12189) | (0.30051) |

Source: Author's estimation from LECS4 and LECS5.
[a] Linear regression: Number of obs = 3658; F (14, 3648) = 184.41; Prob > F = 0.0000; R-squared = 0.3317; Root MSE = 0.39838.
[b] 2 Stage Linear regression: Number of obs = 842; Wald chi2(9) = 27.76; Prob > chi2 = 0.0000; R-squared = 0.2204; Root MSE = 0.39147.

### 4.4. Impact of energy poverty on health

The survey of literature by Sovacool and Drupady (2012) report a strong connection between the effects of in-door air pollution and acute respiratory infections in children in many countries. Dherani et al. (2008) reach the same conclusion that risk of pneumonia in young children is increased by exposure to unprocessed solid fuels. Po et al. (2011) also find a strong association between biomass exposure and specific respiratory diseases in rural populations.

We assessed the impact of energy poverty on households. The dependent variable is the household's report of the number of members having temporary health problems. Energy poverty (1) is chosen as the

**Table 5**
Impact of energy poverty on household health.

| | | [c]. OLS with Robust Standard Error | [d]. 2SLS with Robust Standard Error |
|---|---|---|---|
| 1 | Energy poverty (1) | 0.0398** | 0.162*** |
| | | (0.0178) | (0.0521) |
| 2 | Household with in-house kitchen (1 yes, 0 no) | 0.0513*** | 0.0390 |
| | | (0.0150) | (0.0306) |
| 3 | Household with modern latrine (1 yes, 0 no) | −0.0917** | −0.152*** |
| | | (0.0368) | (0.0547) |
| 4 | Access to road year-round (1 yes, 0 no) | 0.00846 | 0.00196 |
| | | (0.0175) | (0.0439) |
| 5 | Urban (1 yes, 0 no) | 0.00320 | 0.0521 |
| | | (0.0189) | (0.0342) |
| 6 | Border district (1 yes, 0 no) | −0.0486*** | −0.0616** |
| | | (0.0146) | (0.0301) |
| 7 | Logarithm of age of household head | 0.135*** | 0.292*** |
| | | (0.0308) | (0.0726) |
| 8 | Gender of household head (1 male, 0 female) | −0.00554 | −0.0666 |
| | | (0.0299) | (0.0569) |
| 9 | Literacy of household head (1 illiterate, 0 otherwise) | −0.0987*** | −0.146* |
| | | (0.0227) | (0.0827) |
| 10 | Logarithm of household size | 0.0372*** | 0.0393*** |
| | | (0.00389) | (0.00858) |
| | Constant | −0.3861*** | −0.9838*** |
| | | (0.12809) | (0.29431) |

Source: Author's estimation from LECS4 and LECS5.
[c] Linear regression: Number of obs = 4056; F (10, 4045) = 15.86; Prob > F = 0.0000; R-squared = 0.0466; Root MSE = 0.45973.
[d] 2-Stage Linear regression: Number of obs = 916; Wald chi2(9) = 64.17; Prob > chi2 = 0.0000; R-squared = 0.0743; Root MSE = 0.45052.

key explanatory variable because, by definition, it covers only those households without access to electricity for cooking and lighting. Energy poverty (2) is not used as it significantly excludes those have access to electricity and consume less energy, and therefore are less exposed to health risks.

Other health-affecting variables are included such as in-house kitchens, modern latrines, size of living area, and controlled for other household characteristics.

The empirical results from the models shown in Table 5 suggest that energy poverty has negative impacts on health status, with 5% level of significance for Ordinary Least Square model and 1% level for Two-stage Linear regression model. Cooking in an in-house kitchen is significant at the 1% level for the Ordinary Least Square model but not for the Two-stage Linear regression model. Lack of modern latrines are also significant at the 5% level for the Ordinary Least Square model and 1% level for the Two-stage Linear regression model. Higher health risks for households with illiterate and/or older head, and more household members.

## 5. Summary and policy implications

The Lao PDR has made significant progress in poverty reduction and increased access to electricity of its population. From 2008 to 2013, the proportion of energy-poor households without access to electricity decreased by 18% percentage points from 41% to 23%, and those who spent more than 10% of their expenditure on energy, from 39% to 25%. Key factors for the significant reduction in the poverty rate and energy poverty are the 54% increase in the mean of per capita income and the increase in the coverage of villages with electricity connections from 66% to 77% during the same period.

A significant number of households do not have access to electricity and cannot afford to meet both necessity and energy consumption. Energy-poor households are prevalent among those who have lower incomes, own lesser durables, live in rural villages without electricity connection and are far from main roads.

In spite of an improvement in the accessibility to electricity and infrastructure, households can be trapped in energy poverty for those from low-income urban areas (the urban poor), even with road access and where opportunity to generate income is low.

The paper also finds that energy poverty negatively impacts average school years of households. The impact on households becomes more severe when they lack access to electricity. This is in addition to their living in rural areas without access to roads and/or are far from school and being led by older and illiterate household heads.

The empirical results suggest negative impacts of energy poverty on health status due to indoor air pollution, compounded by households' living conditions, such as small space with in-house kitchen and the lack of modern latrines.

Findings from this paper will provide empirical evidence in identifying the vulnerable groups and targeted support. While ensuring access to electricity should be prioritised, it should be accompanied by inclusive development policies to promote rural economy and narrow development gaps. This is because without sufficient income, access to electricity may put pressure on poor households' income and expenditure when they switch from unsafe and less costly energy sources to cleaner energy.

In summary, key to achieve 95% target of national electrification is to increase the access to electricity by the rural population from 80% in 2016 to about 90%, because 97% of the urban population has already had access to electricity in 2016.

Therefore, the government should give priority to rural electricity distribution networks, strengthen energy-related agencies' capacity to plan and manage electrification projects, and provide investment opportunities and incentives to potential private investors for rural electrification by developing appropriate policies, legal framework and regulations such as standard and fiscal incentives (tax exemptions and accelerated depreciation through premium feed-in tariff). It is also necessary to support pilot sustainable financing strategies and build capacity of local stakeholders to manage and operate small electricity concessions, and introduce the distributed energy system (DES) as discussed by Han et al. (2018) and Ellingsen (2010).

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