# Examining and Evaluating the Multidimensional Energy Poverty Index (MEPI) in the Philippine Household Context

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Energy poverty refers to insufficient energy consumption to meet one's basic needs. Measuring energy poverty is a vital calculation for a household assessment concerning accessibility of energy, affordability of energy prices, usage of energy resources, and sufficiency of energy consumption. Previous literature has extensively used the multidimensional energy poverty index (MEPI) to analyze the lack of access to modern energy services, including energy poverty intensity and incidence, and provide a framework for government policymaking. However, there is a variation between countries on how MEPI energy deprivation factors affect household welfare. This study aims to determine more accurate measures of household energy poverty in the Philippines using the 2004 and 2011 Household Energy Consumption Survey (HECS) and illustrate critical factors that affect the energy deprivation scores of the improved MEPI in the Philippine household context. In conclusion, with the improved energy poverty weights and measures that are Philippine-specific, it revealed that households who are multidimensionally energy-poor across all regions have slightly worsened from 2004 to 2011. This calls for more interventions and more appropriate policy implementation of promoting access to modern energy services and aiding to improve the conditions of Philippine households.

## 1. INTRODUCTION

The United Nations (n.d.) described energy poverty as the lack of accessible and renewable modern energy resources, wherein deprivation among energy consumption is prevalent. The immobility and insufficiency of proper energy resources have impeded the ability of various countries to implement sustainability. With the creation of the multidimensional energy poverty index (MEPI) as a basis for measuring energy poverty amongst households, measurements and assessments must be made to gather information from different energy dimensions and to assess households' energy access more accurately.

The main objective of the study is to identify MEPI's relevant energy indicators and to generate more accurate deprivation scores using Philippine-specific MEPI weights. The findings from this study will hopefully contribute to the further understanding of energy poverty and its overall sustainability to ensure energy accessibility and security amongst urban and rural areas in the Philippine regions.

## 2. LITERATURE REVIEW

Energy poverty and its underlying factors are not entirely new concepts, though their functions in the poverty eradication field are embodied in a modern dimensional perspective (Organisation for Economic Co-operation and Development, 2011). Its eradication is always perceived as an economic challenge, and in response, there are legislated government policies that revolve around it to develop the economic and social conditions of individuals, especially the marginalized. Some studies detailed their significance to energy deprivation and economic development within households to further explore other possible indicators.

The analysis of energy poverty and consumption is also directed towards household energy consumption and affordability. Reiche et al. (2000) emphasized that there is a correlation between electricity access and people's welfare. It is seen when they investigated the access of electricity in rural areas and its social impact on individuals using it. Barnes et al. (2010) also discussed how the reduction in energy spending could be affected by access to electricity. It is so because when there is a decrease in the relative price of energy, then the expenditures, other than food expenses, are more likely to be energy-intensive.

## 3. FRAMEWORK

There are various theoretical frameworks that assess energy consumption: energy ladder hypothesis, energy stacking, energy utility function, and energy demand function.

*Energy Ladder Hypothesis*

The energy ladder hypothesis assumes that households imitate a consumer that can maximize their utility, which implies that as households increase their income, they can afford to consume more sophisticated energy carriers and resources (Hosier & Dowd, 1987).

*Energy Stacking*

Erdmann & Haigh (2013) detailed that considering economic growth alone is not enough when it comes to assessing the main driver for households' change in behavior towards energy use. There are also other important drivers to consider such as:

environmental pressure, advancement in technology, availability of resources, choices people make, rate of urbanization, and standards of living.

*Energy Utility Function*

Kidane (1991) expounded how utility, the overall level of satiation, is maximized by the available commodities and set variables that affect consumption. The indirect utility function contains optimal values of energy ($x_E^*$) and non-energy ($x_N^*$) goods given their prices and household income for a maximum utility where:

$$U^* = V(p_E, p_N, m)$$

*Energy Demand Function*

The demand theory notes the relationship between the goods purchased and the prices within the market, assuming that others are held constant. The Marshallian demand function is derived from the utility maximization problem for all goods affected by their prices and income where:

$$x_E^* = x_E(p_E, p_N, m)$$

$$x_N^* = x_N(p_E, p_N, m)$$

*Economic Frameworks*

Traditionally, poverty has always been seen as a multidimensional perspective or problem. However, it is mostly measured with one dimension only: income. In most energy policies and studies, the assumption that is stipulated is how a household's level of income can fairly represent whether people were able to reach a particular minimum threshold in a variety of dimensions — specifically having access to clothing, energy, nutrition, and housing.

*Multidimensional Energy Poverty Index*

In assessing the structures of energy within households, the MEPI is used. It consists of five dimensions, namely: cooking resources, lighting work, household appliances, entertainment and educational supplements, and communication outlets (Nussbaumer et al., 2011). It is composed of energy deprivations, compared to the indirect relation of derived information through presumed correlated variables. It also serves as a headcount ratio product, which focuses on the share of people that are identified as "energy poor" and "energy non-poor," including the average intensity of their deprivation.

## 4. METHODOLOGY

In assessing Philippine energy deprivation due to issues on occasional brownouts, high energy costs, and the lack of sustainable energy resources, data from the Household Energy Consumption Survey (HECS) by the Philippine Statistics Authority (PSA) and National Statistics Office (NSO), from the years 2004 and 2011, are collected. The HECS contains household characteristics and energy practices from the sixteen Philippine regions. To generate the necessary energy deprivation weights, the principal component analysis (PCA) methodology was used, from the energy dimensions proposed by Nussbaumer et al. (2011).

According to Jolliffe and Cadima (2016), the PCA statistical method is centered on transforming correlated variables into a set of uncorrelated variables. It is done by normalizing the variables through a 0 to 1 scale. It then uses the correlation matrix technique to estimate the indicators. After the estimation, generated weights are collected and converted into a standardized value, considering the score's mean value subtracted from the actual value—all divided by the standard deviation of score.

Before proceeding with the MEPI, an energy deprivation cut-off $k$, as defined by Nussbaumer et aL. (2011), is set at $k$ = 0.30. Following the determined cut-offs, the MEPI framework by Nussbaumer et al. (2011) is used to identify essential variables that test the incidence and intensity of energy poverty where:

$$MEPI = H * A, \text{where } H = \frac{q}{n} \ \& \ A = \sum_{i=1}^{n} \frac{c_i(k)}{q}$$

For H, it is the incidence that considers the headcount ratio amongst energy-deprived households. Meanwhile, A indicates the intensity of energy deprivation from a summation of the poverty magnitude amongst households. In further computations, the energy dimensions are major contributors, namely "cooking, lighting, services provided by means of household services, entertainment/education, and communications," in determining energy poverty (Nussbaumer et al., 2011, p. 234).

Given the energy deprivations scores, their relationship with household attributes is tested through an ordinary least squares (OLS) regression model. The household characteristics include the total number of household members, average household income, and household area residence, and energy practices such as the reduction of energy consumption.

## 5. RESULTS AND DISCUSSION

Given the moderate variances amongst the HECS 2004 and 2011 datasets, they indicate that there is more information that can be captured from the components within a percentage total of 1 for the specified weights of each dimension. Amongst the dimensions, the *Cooking* dimension has the greatest share compared to other weights, to be followed by the *Refrigeration* dimension. The *Communication* dimension followed suit in contributing towards household energy consumption. Meanwhile, the *Lighting* dimension's weight was quite lower than Mendoza et al. (2019)'s 0.20 *Lighting* weight, which indicates that there were overestimations towards the effect and significance of the given energy dimensions.

**Table 1**
*PCA Weights at the National Level (2004, 2011, 2011 w/o Communication - WC) vs. Mendoza et al. (2019)'s Study*

| | 2004 | 2011 | 2011 WC | Mendoza et al. |
|---|---|---|---|---|
| **Variance (%)** | **40.77** | **34.65** | **34.58** | **-** |
| Cooking | 0.2413 | 0.2219 | 0.2850 | 0.20 |
| Indoor Pollution | 0.1413 | 0.0807 | 0.1209 | 0.20 |
| Lighting | 0.1166 | 0.001 | 0.0018 | 0.20 |
| Refrigeration | 0.2200 | 0.2304 | 0.2769 | 0.10 |

| | | | | |
|---|---|---|---|---|
| Entertainment/ Education (TV/radio) | 0.2113 | 0.101 | 0.1536 | 0.10 |
| Space Cooling | 0.0694 | 0.1648 | 0.1619 | 0.10 |
| Communication (Computer Activity) | - | 0.2002 | - | 0.10 |
| Cooking | 0.2413 | 0.2219 | 0.285 | - |

In the overall intensity and incidence of energy deprivation, the Philippines has higher levels of energy poverty when compared to Mendoza et al. (2019)'s study, wherein its data is taken from HECS 2011. The rise of deprivation between 2004 and 2011 indicates the worsening of energy consumption and accessibility. At the regional level, Region II has worsened in energy deprivation, alongside ARMM. Meanwhile, NCR and Region IV-A remain the least deprived. The inclusion of the communication dimension has an impact on ARMM, where the absence of the dimension indicates a lower MEPI level, whereas its opposite states otherwise.

**Table 2**
*National and Regional MEPIs (2004, 2011, 2011 w/o Communication - WC) vs. Mendoza et al. (2019)'s Study*

| | 2004 | 2011 | 2011 WC | Mendoza et al. |
|---|---|---|---|---|
| **Philippines** | **0.3544** | **0.441** | **0.3922** | **0.3710** |
| Region I | 0.3398 | 0.5608 | 0.4520 | 0.2400 |
| Region II | 0.4089 | 0.6047 | 0.5233 | 0.2960 |
| Region III | 0.3535 | 0.3815 | 0.2817 | 0.2260 |
| Region IV-A | 0.3103 | 0.2502 | 0.1727 | 0.1660 |
| Region IV-B | 0.4638 | 0.6023 | 0.6017 | 0.4470 |
| Region V | 0.4708 | 0.5600 | 0.5605 | 0.3900 |
| Region VI | 0.4648 | 0.5038 | 0.4484 | 0.4170 |
| Region VII | 0.4190 | 0.4874 | 0.4701 | 0.3920 |
| Region VIII | 0.4418 | 0.5961 | 0.5531 | 0.3660 |
| Region IX | 0.4474 | 0.5273 | 0.5411 | 0.5280 |
| Region X | 0.4178 | 0.5614 | 0.4852 | 0.4220 |
| Region XI | 0.4237 | 0.5045 | 0.4897 | 0.4660 |
| Region XII | 0.4351 | 0.5319 | 0.5275 | 0.4850 |
| NCR | 0.2026 | 0.2543 | 0.1732 | 0.0720 |
| CAR | 0.3520 | 0.4132 | 0.3423 | 0.3050 |
| ARMM | 0.5297 | 0.4458 | 0.5403 | 0.6540 |
| Caraga | 0.4202 | 0.5665 | 0.4958 | 0.4480 |

The relationship between energy deprivation scores and household attributes has proven to be statistically significant based on the p-values. If all explanatory variables are at zero, a unit change creates an increase in deprivation. As for the patterns of the household attributes, a unit increase in the number of household members and living in a rural household residence increases the level of energy deprivation, while holding all other variables constant. Meanwhile, a unit increase in the average household income and practicing the reduction of energy consumption decreases the level of energy deprivation, while holding all other variables constant.

**Table 3**
*Regression Equations (2004, 2011, 2011 w/o Communication)*

| Variables | 2004 | 2011 | 2011 w/o Comm |
|---|---|---|---|
| No. of Household Members | 0.004*** | 0.004*** | 0.005*** |
| Reduction of Energy Consumption | -0.035*** | -0.110*** | -0.105*** |
| Rural Household Residence | 0.097*** | 0.076*** | 0.074*** |
| Average Household Income | -0.166*** | -0.183*** | -0.175*** |
| Constant | 0.631*** | 0.828*** | 0.803*** |

*** $p<0.01$, ** $p<0.05$, * $p<0.10$

## 6. CONCLUSION AND RECOMMENDATIONS

This study mainly proposes a more superior methodology than the estimations of Mendoza et al. (2019)'s study because the weights used to compute MEPI are more specific to the Philippine setting. From the results discussed in this paper, it can be seen how most of the MEPI scores amongst the Philippine regions are still increasing at an alarming rate, instead of observing an improvement in those said scores, as estimated by Mendoza et al. (2019).

The study recommends that the accuracy in measuring the national and regional weights on energy deprivation shall be accounted for to avoid overestimation. In addition to this, the study recommends other methodologies, like the PCA and MEPI, to assess the limitations amongst energy dimensions. Future studies should venture into multidimensional energy development through varied nations, regions, cities, and provinces for more relevant and effective policies.

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