AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Income and Modern Energy Use in Rural Households of Mexico in the Context of the Sustainable Development Goal 7

Rafael Perez, Doctoral Student in Economic Development, New Mexico State University, rperez89@nmsu.edu; Eduardo Zepeda, Senior Inter-Regional Adviser, UN DESA, zepeda@un.org

Selected Paper prepared for presentation at the Southern Agricultural Economics Association's 2016 Annual Meeting, San Antonio, Texas, February, 6-9 2016

Copyright 2016 by Rafael Perez and Eduardo Zepeda. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

Abstract:

The United Nations' Sustainable Development Goal 7 (SDG7) consists in ensuring access to affordable, reliable, sustainable and modern energy for all. Before Mexico can achieve this goal, a deeper insight into the prevailing status of rural households' energy access needs to be identified. The primary purpose of this study is to evaluate how does the consumption for different energy carriers vary with income in Mexican rural households. Using household survey data an approach to the income elasticities of different energy carriers (electricity, liquefied petroleum gas (LPG), natural gas, coal, and firewood) is computed. The preliminary results suggest that all variables reported the expected sign except for firewood. When the income of Mexican rural households increases by 1%, their consumption of electricity, LPG, natural gas, and firewood, increases by 0.35%, 0.24%, 0.44%, and 0.12%, respectively. Additionally, when the income varies by 1%, the coal consumption decreases by 0.09%.

Keywords: Modern energy, income elasticity, rural households, Sustainable Development Goals.

JEL: O13, 012, Q01

Introduction

This study focuses on the effect of income as a determinant of modern energy access in the rural households of Mexico. In addition, it proposes a measure to approach the spatial component to modern energy access. Before the country can achieve the Sustainable Development Goal 7 (SDG 7), a deeper insight into the prevailing status of rural households' energy access needs to be identified. In this regard, this document develops an attempt to measure the income-elasticity of modern energy in the rural households of Mexico as of 2014.

The research question directing this study consists in determine how does the consumption for different energy carriers vary with income in Mexican rural households? It is expected that in rural Mexico, the greater the income, the greater the consumption of modern energy. In this sense, this study is informed by the energy ladder approach, which states that households switch to more convenient energy forms as their disposable income increases (Leach 1992, quoted in Ekholm et al. 2010). Income effect will be approached through income elasticities of different energy carriers: electricity, liquefied petroleum gas (LPG), natural gas, coal, and firewood.

The following section of the document describes the sustainable development goals emphasizing Goal 7, the concept of energy access, and its context in Mexico. Then, the data gathered from the 2014 Survey of Household Income and Expenditures (ENIGH) and information on the prices of energy carriers retrieved from government agencies are described. The methodology section specifies the model used to test the hypothesis and includes the suggested measure for the spatial component. The preliminary results are then presented in the next section, and the last section consists of some concluding remarks.

SDG7, Energy Access Concept, and Context in Mexico

This study contributes to the discussion of the achievement of SDGs in Mexico in terms of modern energy. Ekholm et al. (2010) stress the relevance of available clean and affordable energy to poor households as a prerequisite for the fight against poverty. Regarding social impact, this study provides an attempt to measure the income elasticity of modern energy to set the background to assess the effect of a subsidy in alternative energies such as natural gas. The study also contributes to the evaluation of the achievement of modern energy access in the context of rural Mexico for 2014, using an empirical approach.

The UN Open Working Group on Sustainable Development, established in January 2013 by the decision 67/555 of the General Assembly, prepared a proposal submitted in July 2014, which outlined the 17 SDGs and 169 targets to be achieved by 2030 (UN DESA 2013). This study focuses on Goal 7 of the SDGs, which consists in ensuring access to affordable, reliable, sustainable and modern energy for all.

Pachauri et al. (2012) state that modern energy access generally refers to three forms of energy: less polluting households' energy for cooking and heating, electricity for powering appliances and lights in households and public facilities, and mechanical power from electricity or other energy. Additionally, Jones (2010) discusses the access to modern energy services in terms of households' access to electricity and facilities such as clean cooking fuels and stoves, advanced biomass cook stoves and biogas systems.

Balachandra (2011) defines energy access as the extent of poor people's access to the energy end-use services delivered by the modern energy carriers like electricity, petroleum products, and modern bioenergy as well as the extent of poor people's reliance on traditional solid fuels. Examples of traditional energies are firewood, crop-waste cattle dung for cooking or heating, and kerosene, vegetable oils and candles for lighting.

The National Council of Social Development Policy Evaluation (CONEVAL) establishes the guidelines and criteria to define, identify, and measure poverty for rural and urban population. CONEVAL takes into account the energy access component through reporting the access to the basic housing services. In particular, this institution points out whether electricity is obtained from the public service, from a solar panel, or another source. Concerning fuel for cooking, this institution considers whether the person uses LPG or natural gas, electricity, firewood or coal (CONEVAL 2007). Similarly, SENER and AIE (2012) state that the energy basket consumed in Mexican households includes LPG, firewood, electricity, natural gas,

solar energy, and kerosene. However, information on the sources of firewood (purchased or freely collected) is not available.

The National Strategy of Energy (NSE) by the Ministry of Energy (SENER) established the objectives to be achieved in the energetic sector in Mexico within the period ranging from 2013 to 2027. NSE set as general objectives to boost the growth of GDP, and to achieve social inclusion. The NSE proposes indicators to measure the progress in these objectives. As for the second objective, there are 9 indicators: per capita consumption; gap between regions in terms of per capita consumption in the residential sector; share of households without electricity access; electricity price-cost ratio; electric energy service coverage; electric energy equipment of households; growth in energy supply through distributed generation; agreements with the communities to facilitate the development of grid lines; and participation of social sector in projects related to energy.

The lack of energy access can be due to the lack of physical access, physical availability, accessibility, affordability, and adequacy (Balachandra 2011). In the case of low income and very low-income households in rural Mexico, the possible causes of the lack of energy access can be attributed to the lack of physical availability and affordability, more specifically to income poverty, and the distance of the poor rural household to the grid. If the distance between the grid and the household proves to be significant explaining the lack of energy access, alternative options should be offered such as extending the grid coverage or providing small-scale renewable energy. Sovacool and Drupady (2013) developed a study analysing energy access through hydroelectric grid and solar household systems (SHSs) in rural areas. Their study focused on the choice between grid expansion and off-grid electrification using renewable energy in areas that lacked economic and technical resources, calculating the marginal cost of bringing in grid electricity to a household.

ENIGH, NEB and Energy Carriers Prices

The present research is mainly based on the 2014 National Survey of Household Income and Expenditure (ENIGH), carried out by the National Institute of Statistics and Geography (INEGI). Additionally, other sources such as the National Energy Balance (NEB) from SENER and data from previous studies were also consulted. ENIGH 2014 was carried out from August to November 2014. Information in the 2014 ENIGH was presented in different tables referring to the personal expenditure, the concentrated expenditure by household, the physical characteristics of households, and the characteristic of the household member (INEGI 2015).

Data used in this research was gathered from the tables of Household Expenditure, and Personal Expenditure. The variables gathered from the retrieved Household Expense table were the expenditure in services of conservation and fuels, in particular LPG (G009), coal (G012), firewood (G013), electric energy (R001), and natural gas (R003). The current income of rural households was retrieved from the household expenditure table as well. Due to the lack of data regarding the household's expenditure on kerosene and solar energy, these energy carriers were excluded from the analysis.

The NEB provides information on the final consumption of fuels by sectors. Information on the consumption is disaggregated by sector: agricultural, transport, industrial, residential, commercial, and public. The residential category of the last group refers to the consumption of fuels for cooking, water heating, heating, lighting, refrigeration and ironing in the rural and urban population (SENER 2013). Since the information is aggregated for the national level, data from NEB is only used as reference.

Since the ENIGH 2014 only provides information about the expenditure of households in energy, an approximation of their consumption is calculated as the product of this expenditure and the price for the specific energy carrier. The prices of the different energy carriers analysed in this study are retrieved from official data from SENER, the Ministry of Electricity (CFE), and information from previous studies.

The electricity price in Mexico, which is set by the Ministry of Finance and Public Credit (SHCP), SENER, and the Ministry of Electricity (CFE), is differentiated by sector and by final user. To obtain the consumption from the ENIGH 2014, this study considers the average prices of electric energy for the residential sector provided by the statistic section of the Energetic Information System (SIE). Since the ENIGH 2014 was retrieved from August 2014 to November 2014, to compute the consumption of electricity, the average price for this

period was used (SENER 2015). The resulting price of averaging the residential price for the period and converting the KwH units to MJ[1] was 0.316 $/MJ. This price was multiplied by the expenditure on electricity by household to generate the consumption of electric energy.

The price of LPG was also obtained from SIE (SENER 2015a). First, the national average was measured, then the average from August to November was computed. The applied conversion factor from Kg/$ to MJ/$ was 1kg=49MJ (ELGAS 2013). The resulting price used for the study is 13.96 $/Kg, which after converted to MJ resulted in 0.28 $/MJ.

For the natural gas price, the information was retrieved from the Energy Regulatory Commission (CRE), which provides information on the prices of natural gas for the different regions in Mexico according to the private enterprises providing the natural gas services in the country (CRE 2015). This institution provided information on a monthly basis periodicity, and it has information from the previous three years regarding the price of residential, industrial, and commercial users. Similarly to the other carriers' prices in this study, the national average price was obtained considering the regions for each month from August 2014 to November 2014, and then the average price from this period was computed. Accordingly, the price obtained, which was used to compute the household consumption of natural gas for 2014, is 1.7 $/MJ.

The price of coal was approached using the average value of the production of that mineral at the national level in Mexico. The information was retrieved from the Geological Mexican Service (SGM). This institution provides monthly information on the production and the value of coal from 2013 to 2015. The average value of coal from August 2014 to November 2014 was 502 $/ton, that value was applied to the computation of the consumption of this type of energy in Mexican households (SGM 2015). To convert the ton of coal into MJ, each ton of coal has $2.9x10^4$ MJ (http://www.iae.org.ar/equivalencias.pdf). As such, it was assumed that the price of coal was $0.00001834/MJ. It is important to stress that this value does not represent the price of coal but is used as a proxy due to the lack of data. For this reason, the resulting consumption of coal might be overestimated.

Firewood prices were obtained from an evaluation of firewood used as energy in Mexico carried out by FAO. The utilized price was 250$/$m^3$, which after assuming a conversion factor of $1m^3$ [lv]=2.35 GJ as suggested by Kofman (2010), resulted in 0.10$/MJ. After gathering price information of the different energy carriers in Mexico, the consumption of energy by household was computed.

[1] The conversion factor applied for this calculation was 1Kwh=3.6MJ

Methodology

Previous studies have analysed the determinants of the lack of energy access in developing countries. In the case of India, Balachandra (2011) developed an analysis of the policy effectiveness in achieving energy access in rural areas within a temporal, income, and regional frame considering the household's monthly per capita expenditure (MPCE). The study used the classes adopted by the National Sample Survey Organization (NSSO) to group households as a proxy for income classes. The classification considered by the author was low income, middle income, and high income. Ekholm et al. (2010) split NSSO survey data into 10 consumer groups to analyse the energy consumption patterns by consumer groups in terms of households' expenditure level and nature of surroundings – whether urban or rural.

Balachandra (2011) identified unaffordability due to poverty and inaccessibility due to inadequate infrastructure as factors affecting the modern energy access in poor countries. In addition, Ekholm et al. (2010) concluded that the most statistically significant factors explaining the lack of energy access are income and location. This study measures the income effect of different energy carriers and set the background for a measure of the inaccessibility factor. The current income of household obtained from ENIGH 2014 is used to evaluate the unaffordability factor.

To measure the impact of changes in income in the consumption of different energy carriers this study considers the following log-log equation:

$$lnQ_i = \beta_0 + \beta_1 lnY + ui$$

Where Q_i represents the household consumption of energy carrier *i* in MJ. Hence, there is one estimated equation for each of the following energy carriers: electricity (e), LPG (lpg), natural gas (ng), coal (co), and firewood (fw). Y represents the household's income. The equation is estimated applying OLS.

The energy ladder approach states that households switch to more convenient energy forms as their disposable income increases (Leach 1992, quoted in Ekholm et al. 2010). If that proves to be the case in Mexico's rural households, it is expected that coal and firewood energy carriers present negative income elasticities. The income elasticities for electricity, natural gas, and GLP are expected to be positive.

The inaccessibility factor is proposed to be measured through the distance from the rural household to the closest energy grid. ENIGH 2014 provides information on the households' geographic location. Geographic information of electric grids can be obtained from INEGI[2]. Once the location of households and grids are identified the distance between the two can be generated using a GIS software. If the distance between the grid and the household proves to be significant explaining the lack of energy access, alternative options should be offered such as extending the grid coverage or providing small-scale renewable energy as Sovacool and Drupady (2013) suggested.

Results

Five equations were estimated, one for each energy carrier, by OLS using the econometric software Gretl. Table 1 includes the income elasticities for the different energy carriers.

Table 1. Income elasticity of different energy carriers in Mexico's rural households, 2014

Energy carrier	Income elasticity	t-value
Electricity	0.353	12.933
LPG	0.245	10.982
Natural gas	0.443	5.9904
Firewood	0.124	0.772
Coal	−0.091	-0.639

Source: Author's own calculations with data from ENIGH 2014

All variables reported the expected sign except for the income elasticity of firewood. When the income of a Mexican rural household increases by 1%, its consumption of electricity, LPG, natural gas, and firewood, increases by 0.35%, 0.24%, 0.44%, and 0.12%, respectively. Additionally, when the income varies by 1%, the coal consumption decreases by 0.09%.

The signs of the income elasticity for electricity, natural gas, and GLP are as expected. However, income elasticity of firewood was positive. This result indicates that the energy ladder approach does not hold for this energy carrier. Rural households are not switching to more convenient energy forms as their income increases (Leach 1992, quoted in Ekholm et al 2010). SENER and AIE (2009) mention that, even when households have access to modern energy in Mexico, there is an increasing mixed use of LPG and firewood simultaneously, for economic and cultural reasons.

[2] http://www.inegi.org.mx/geo/contenidos/topografia/topografia_1m.aspx

Concluding Remarks

This study presented an attempt to measure the income component as determinant of modern energy access in rural households of Mexico; in addition, it proposed a measure for the inaccessibility factor of modern energy access. Income elasticities for electricity, GLP, natural gas, coal, and firewood were computed. The aim of this study was to describe the situation of rural households in Mexico as of 2014. In so doing, this study was intended to contribute to the discussion of the Sustainable Development Goal 7 (SDG 7), providing a deeper insight into the prevailing status of rural households' energy access.

The preliminary results suggest that the greater the income, the greater the consumption for modern energy in rural Mexico. Nonetheless, the consumption of traditional energy presented a positive income effect in the case of firewood. This situation can be due to cultural practices as suggested by SENER and AIE (2009). Therefore, the energy ladder approach, which states that households switch to more convenient energy forms as their disposable income increases, was not rejected except for firewood.

For future references, the location factor suggested in this study will be developed and included in the model. Furthermore, a temporal and regional study might provide a better understanding of Mexico's rural households' energy access situation. Also, as future recommendations, it is suggested to expand the time frame of the study using ENIGH from previous years and apply a panel data analysis. Other components can be included in the analysis as well, such as the temporal and regional variation in the price of the energy carriers in the country.

Source

Balachandra, P. "Dynamics of rural energy access in India: An assessment." Energy 36, no. 9 (2011): 5556-5567.

Consejo Nacional de Evacuación de la Política de desarrollo Social, CONEVAL, “Medición de la pobreza” (2007): http://www.coneval.gob.mx/Medicion/Paginas/Medici%C3%B3n/Indicadores-de-carencia-social.aspx.

Ekholm, Tommi, Volker Krey, Shonali Pachauri, and Keywan Riahi. "Determinants of household energy consumption in India." Energy Policy 38, no. 10 (2010): 5696-5707.

ELGAS NEW ZELAND, LPG Conversions, (2013): https://www.elgas.co.nz/resources/elgas-blog/138-nz-lpg-conversion-values-kg-litres-mj-a-kwh

Energy Regulatory Commission (CRE), Statistics, Natural Gas Prices to Final Users (2015): http://www.cre.gob.mx/articulo.aspx?id=169

Food and Agricultural Organisation, FAO, TCP/MEX/4553 (DENDROENERGIA PARA EL DESARROLLO RURAL), Evaluacion de la situacion el uso de madera para energia en Mexico, (n.d.): http://www.fao.org/docrep/w8423e/w8423e04.htm

Geological Mexican Service (SGM), Monthly production of coal, Value and production of Coal (2015): http://portalweb.sgm.gob.mx/economia/es/produccion-minera/carbon/382-tablas-carbon.html

INEGI, Encuesta Nacional de Ingreso y Gasto de los Hogares 2014, (2015): http://www.inegi.org.mx/est/contenidos/proyectos/encuestas/hogares/regulares/enigh/enigh2014/tradicional/default.aspx

Institutor Argentino de la Energia (IAE), (n.d.): http://www.iae.org.ar/equivalencias.pdf.

Jones, Richard H. "Energy Poverty: How to make modern energy access universal?." Special early excerpt of the World Energy Outlook (2010).

Kofman Pieter, Units, conversion factors and formulae for wood for energy, (2010): http://www.coford.ie/media/coford/content/publications/projectreports/cofordconnects/ht21.pdf

Ministry of Energy (SENER) and International Energy Agency (AIE), Indicadores de Eficiencia Energetica en Mexico: 5 sectores, 5 retos, (2011): http://www.energia.gob.mx/taller/res/1858/IEE_Mexico.pdf.

Ministry of Energy (SENER), Sistema de Informacion Energetica (SIE), Ministry of Energy, Prices of LPG to final user applied from January 2014. (2015a): http://sie.energia.gob.mx/bdiController.do?action=cuadro&subAction=applyOptions

Ministry of Energy, SENER, Balance Nacional de Energia 2013 (NEB), (2014): http://www.sener.gob.mx/res/PE_y_DT/pub/2013/Balance_2013.pdf

Ministry of Energy, SENER, Sistema de Informacion Energetica (SIE), Ministry of Enery, Average Prices of electric energy by sector. (2015): http://sie.energia.gob.mx/bdiController.do?action=cuadro&subAction=applyOptions

Pachauri, S., N. Rao, Y. Nagai, and K. Riahi. "Access to modern energy: Assessment and Outlook for Developing and Emerging Regions." Laxenburg: IIASA (2012).

Sovacool Benjamin and Ira Martina Drupady. Energy access, poverty, and development: the governance of small-scale renewable energy in developing Asia. Ashgate Publishing, Ltd., 2012.

UN DESA, Open Working Group proposal for Sustainable Development Goals, Sustainable Development Goals, (2013): https://sustainabledevelopment.un.org/sdgsproposal.html