Energy security in Central America: a proposal for a comprehensive estimate

Daynier Escalante Pérez

Abstract

This paper presents a set of indicators for the evaluation of energy security in Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. A study of the energy problems of each country established indicators suitable for producing an energy security index (ESI). These indicators were submitted to experts for validation, with the help of energy sector specialists from the Central American countries. The Delphi method was used to process the results, and all the indicators were approved. SPSS software was used to conduct a principal component analysis with the aim of compacting the number of indicators, losing as little information as possible and obtaining an interpretable solution. The ESI for each country was calculated from the resulting variables. The ESI trend in each country was examined in the light of domestic and international events that may have had an impact on the behaviour of the indicators.

Keywords

Energy resources, petroleum, electricity, energy security, evaluation, energy statistics, statistical methodology, energy policy, Central America

JEL classification

O21, Q48, Q43

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I. Introduction

Since late 2006, when the oil price reached its highest level in more than two decades and weather events on a scale that could not be ignored confirmed the reality of climate change, countries have focused on analysing the relationships between climate change, sustainable development and the undesirability of current fossil fuel use because of its effects on economic, social and political life throughout the world (Lamy, 2006). Taken together, these elements were judged by society to be critical to its progress and to the response required in the face of the potential threats, risks and challenges posed by the global context. As a result, a new term arose: energy security. The policies based on this new concept turned to energy supply security, with a focus on geopolitical concerns and the operational reliability of national energy systems. First and foremost, energy security must mean access to enough affordable energy to meet domestic demand (Blyth and Lefevre-Marton, 2005).

The definition of energy security has changed over time. Following the oil crisis of the 1970s, the concept was related to crude oil supply risk because of possible disruptions originating in the Middle East. Based on studies conducted in the present century, other factors that affect the stability of the fuel supply and increase the price of energy have been added to the definition, such as political conflicts, unexpected natural disasters, concerns about terrorism, and energy-related environmental challenges (Intharak and others, 2007).

Energy policies in the Central American countries address the need for access to affordable energy services. They have shifted the electricity generation matrix towards clean and more efficient energy, establishing goals for including more renewable energy and reducing fossil fuel dependence. However, the energy policy plans consulted barely touch on the concept of energy security, giving it little attention or importance.

This document assesses the energy security of seven Central American countries that are served by the subregional headquarters of the Economic Commission for Latin America and the Caribbean (ECLAC) in Mexico and by the ECLAC subregional headquarters for the Caribbean: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. The databases of the World Bank, the Latin American Energy Organization (OLADE) and ECLAC were consulted. All data were accessed in digital format. In the case of the OLADE database, information is available on a restricted basis for public bodies. In addition to data from the abovementioned organizations, official information from ministries of energy, companies and regulators was used along with data from each country's national press and the official websites of economic and political bodies to analyse the behaviour of the indices by country.

The second section of this article analyses energy security at the global level, considering various definitions and estimation methods. The third section presents the methodology used to estimate the energy security of the countries in the subregion. The fourth section presents the results of the principal component analysis carried out with the Statistical Package for the Social Sciences (SPSS) software and examines the trend of each country's energy security index (ESI) in the light of domestic and international events that may have had an impact on the behaviour of the indicators. Lastly, the fifth section presents the conclusions of the research.

II. Defining and estimating energy security

The World Energy Council (WEC, 2012) highlights the interest of developed and emerging countries alike in energy security, but notes that there is no shared vision among governments, organizations, academia and analysts on what the concept means, which remains a challenge. After reviewing more

than 40 definitions suggested in the literature, Sovacool and Mukherjee (2011) report that the concept is fuzzy and the set of attributes it encompasses depends on the researcher's interests and objectives.

From academic and institutional studies on the subject, it is clear that energy security concepts and the debate around them have changed over time as a result of technological advances, the diversification of energy sources, social concerns, environmental considerations and the influence of society on public decision-making, as well as the proliferation of energy threats and challenges (Herrero, 2016). For most of the twentieth century, energy security policy focused primarily on avoiding oil shortages. Now, however, the focus is on the availability of adequate, affordable and sustainable resources to meet the demand not just for oil, but for energy (Intharak and others, 2007; UNDP, 2000; WEC, 2012).

The International Energy Agency (IEA) defines the concept essentially as the uninterrupted ability to meet demand (IEA, 2022). In line with this perspective, Kleber (2009) stresses the need to keep infrastructure intact in order to avoid energy outages from natural, accidental or intentional events. For other authors, it is the desirable characteristics of the supply that matter; for example, it should be environmentally friendly, properly governed and socially acceptable (Sovacool and Mukherjee, 2011). For their part, Von Hippel and others (2011) identify four energy security challenges: (i) the environment, (ii) technology, (iii) demand management and (iv) social, cultural and political factors. While some authors favour a broad, comprehensive definition applicable to all types of countries (Vivoda, 2010), others argue that a tailored definition is needed to truly help countries improve their energy security (Cherp and Jewell, 2014).

There are various techniques for estimating energy security (Abdalla, 2005; Jansen and Seebregts, 2010; Kemmler and Spreng, 2007; Kruyt and others, 2009; Schipper and Haas, 1997; Sovacool and Brown, 2010; Sovacool and Mukherjee, 2011; Unander, 2005). Most use indicators and indices designed to reflect reliability, adequacy, economy, sustainability and other desirable attributes of the energy supply, depending on the definition used. Indicators allow a vast array of complex data to be concentrated into recognizable patterns. The number and variety of indicators varies considerably in the literature, from a few to hundreds. The gap between indicators in developed and emerging countries is wide because of the asymmetries between them, their different circumstances and the information available.

As with the estimation of other ill-defined concepts, estimating energy security entails methodological problems. For example, the more qualities are required of the energy supply, the more indicators will be needed to characterize it, and this dilutes the original and primary concern, which is to avoid supply disruption (Cherp and Jewell, 2014). The qualities demanded of the energy supply are concepts that are often equally vague (sustainability, resilience and robustness, among others), meaning that finding the best and most accurate indicators is also a problem. Another issue is the weight given to each indicator when calculating a synthetic index, i.e., the selection of uncorrelated indicators, weighting factors and standardization criteria. Indicator selection is also critical when conducting analyses comparing different countries with substantially different energy security problems. Tanaka (2011) cautions that the characteristics and needs of each country or region are different, which makes it inappropriate to rely on uniform criteria for assessing energy-related issues.

For years, the Organization of American States (OAS) has been calling for urgent, concerted action to ensure that energy uncertainty does not undermine the prosperity of Latin America and the Caribbean. OAS has also called for progress in energy efficiency and integration and advocates cooperation in this field among all countries that have renewable energy initiatives with the aim of achieving energy sustainability (OAS, 2010 and 2014).

III. Methodology for evaluating energy security in Central America

An economy that can decouple economic growth from energy use through energy efficiency and conservation will have an energy security advantage. Several factors can influence energy supply security, including the availability of fuel reserves, the ability to procure supplies, the level of diversification of energy resources and suppliers, the accessibility of fuel resources in terms of availability of the requisite energy and energy transportation infrastructure, and geopolitical concerns related to resource procurement (Intharak and others, 2007).

The situation of each country's energy sector was analysed in the light of these factors, with a particular focus on difficulties that currently pose a problem for energy security. This analysis yielded a set of national indicators that each country can use to assess its energy security in the light of its own problems. The analysis of the issues in the countries of the subregion resulted in 40 indicators reflecting factors such as the independence, availability, reliability, affordability and quality of the energy supply.

Given the differing characteristics of the energy sector in the countries studied and the availability of experts to carry out the research, it was decided to conduct a Delphi-type survey. The following were considered in selecting the 45 experts who participated: (i) years of experience in the sector, (ii) knowledge of the topic under investigation, (iii) academic background, (iv) availability to participate in the research and (v) the general criterion of analytical capacity. The surveys were carried out in four stages (diagnosis, design, implementation and evaluation). From the third stage onward, the survey was carried out in a single round. It was thus not an iterative process, besides which feedback from each round (statistical information) was limited, but it was agreed that it was important to avoid exhausting the panel and to ensure that the results were not skewed.

Víctor Hugo Ventura Ruiz, who was Chief of the Energy and Natural Resources Unit at the ECLAC subregional headquarters in Mexico at the time, sent out email invitations for the survey. Responses were received in two ways, 8 via links and 27 in the form of email attachments. Of the 35 specialists who responded to the questionnaire, 34 had a high overall average rating (a competence level of 0.81), so the responses can be said to have been of good quality, and 58.8% had worked in the energy sector for more than 20 years. The opinions expressed by the experts were tabulated and statistically processed. The indicators were recognized by the experts as highly suitable (36.6%), clearly suitable (61%) and suitable (2.4%). From all the data validated by the experts, information on 29 indicators was obtained (see table 1). The time series period taken as the baseline was 2000–2017. Data from OLADE (2019), ECLAC (2019) and the World Bank (2019) were used. All data were accessed electronically. In the case of the OLADE database, information is available on a restricted basis for public bodies.

Table 1
Central America: indicators of energy security

✓ Self-sufficient in energy	✓ Diversification of petroleum product suppliers
✓ Dependent on imported energy	✓ Diversification of external supply sources for oil and derivatives
✓ Dependent on imported gasoline	✓ Crude oil storage
✓ Dependent on imported diesel	✓ Gasoline storage
✓ Dependent on imported electricity	✓ Diesel storage
✓ Dependent on petroleum products in the transport sector	✓ Liquefied petroleum gas (LPG) storage
✓ Dependent on firewood in the residential sector	✓ Kerosene storage
✓ Inflows of currency for oil imports	✓ Fuel oil storage
✓ Currency generated by the hydrocarbon subsector	✓ Refineries' share of petroleum products consumed

✓ Energy intensity	✓ Diversification of electricity generation
✓ Processing efficiency	✓ Electricity losses
✓ Diversification of energy production	✓ Rate of electricity coverage
✓ Diversification of energy consumption	✓ Affordability of gasoline
✓ Diversification of fossil fuel consumption	✓ Affordability of diesel
	✓ Affordability of residential electricity

Source: Prepared by the author.

Since the variables had different measurement units and scales, they were standardized unidirectionally (positive) in relation to the ESI, as proposed by Gupta (2008). In other words, the higher the value of the variable, the higher the ESI. The adjustment transformed all selected variables into the 0–1 scale, with 0 being the lowest value of the indicator, representing energy insecurity, and 1 being the highest value for energy security.

With the indicators standardized, principal component analysis was applied to construct the ESI. The SPSS statistical software package was used for this. When the descriptions of the principal component analysis in SPSS are analysed, it can be seen that this method is suitable. In this study, values above 0.7 are taken as a strong correlation (positive or negative). In deriving the principal components, the ESIs for each country and for the subregion as a whole (ESI_k) are calculated as a weighted sum of the components (C_n) within the total change in the ESI (sum of all eigenvalues) (see equation (1)). The weights (λ_n) are the variances of the successive principal components. The components are calculated as a linear average.

$$ESI_k = \frac{\lambda_1 C_1 + \lambda_2 C_2 + \ldots + \lambda_n C_n}{\lambda_1 + \lambda_2 + \ldots + \lambda_n} \quad (1)$$

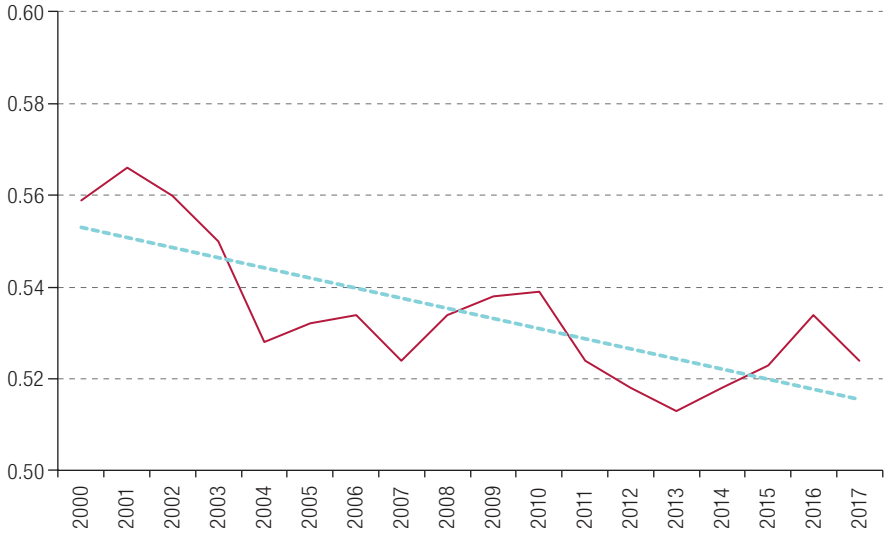
The statistics confirmed the suitability of each of the analyses performed in SPSS.

IV. Analysis and discussion of the ESI evaluation

This chapter presents the ESI results obtained. It does not provide an analysis of the trend projection of the index, but rather a brief description of its behaviour in the period under study and the possible causes of this.

The ESI values for the subregion are confined to a range of 0.53 to 0.57. Figure 1 shows a number of up and down cycles in the ESI, with a declining trend. Dependence on the international oil price influences all countries in the subregion as net importers. For this reason, every fluctuation of the index is associated with the behaviour of oil shocks. The shutdown of refineries in several countries, rising imports (mainly from the United States), the growth of the vehicle fleet, international and national economic crises, increased electricity generation and the introduction of other energy sources for residential consumption are other events affecting the behaviour of the ESI in Central America that will be observed when each country is examined.

Figure 1
Central America: energy security index



Source: Prepared by the author.

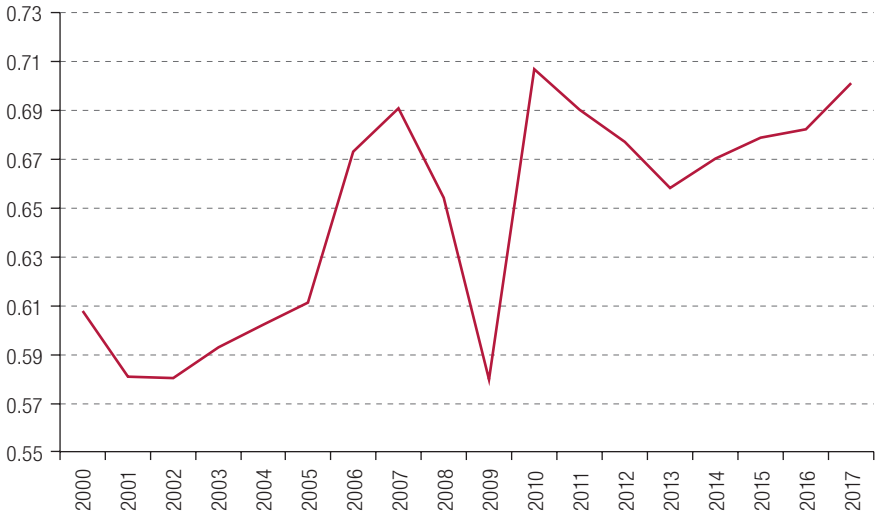
1. Belize

The objectives of the national sustainable energy strategy launched by the Government of Belize include improving energy security by developing renewables and adopting more efficient energy transformation technologies. Given that Belize has no refineries and has to import all the petroleum products it needs, international oil market volatility is recognized as a vulnerability, which motivates the government's efforts to focus sectoral planning on increasing energy independence. In this context, the decline of oilfields and the possible suspension of offshore oil activities to avoid environmental damage that could affect tourism, one of the country's main sources of income, are of concern. Efforts to achieve self-sufficiency notwithstanding, regional integration is seen as a vital strategy to ensure the availability and reliability of the energy supply (MESTPU, 2012).

Although Belize's index value was the lowest of any country in the subregion in the early 2000s, it was the fastest-growing during the period, with marked up and down cycles (see figure 2). The index remained low from 2000 to 2005, precisely because of the country's heavy dependence on energy imports, which affects all indicators. Oil was found in 2005 by Belize Natural Energy together with European companies (SICA, 2005), and oil production increased in the following years. Energy production rose and imports fell as a result. Oil exports began in 2006, and a portion of output was allocated to power plants. Rising international oil prices and exports in those years caused the oil balance to shrink and turn positive in 2008.

In 2007, Belize's economy was affected by Hurricane Dean. Coupled with the global economic recession in 2008 and a drop in domestic tourism, this sent that year's recovery into reverse. The economy stagnated in 2009 and recovered in 2010 (The Commonwealth, n.d.). The crisis was also reflected in energy security, as oil consumption increased in a number of sectors. This situation led to an increase in imports, which, coupled with high oil prices on the world market, resulted in a very small negative oil balance in 2009. As the country recovered from economic stagnation in 2010, oil exports grew by 71% to US$ 103.1 million owing to higher prices. There was also a sharp increase in electricity generation, especially from hydroelectric power plants (ECLAC, 2011). The oil production curve peaked in 2011 (González García, 2013), and as domestic crude output began to decline, fuel exports were also limited and imports increased.

Figure 2
Belize: energy security index



Source: Prepared by the author.

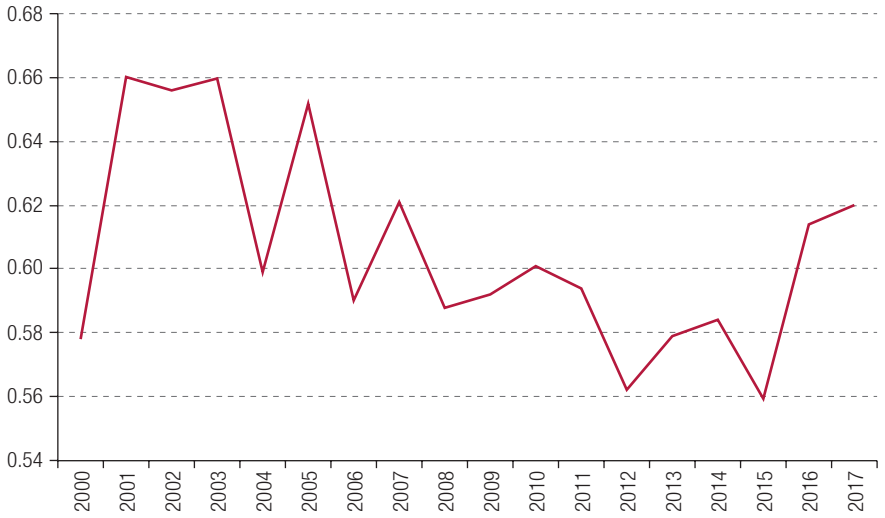
The ESI rose from 2013 to 2017. Electricity imports from Mexico decreased from 38.7% of total consumption to 26.6% in those years owing to increased production from renewable sources. Energy intensity increased as a result of measures implemented by the government to improve energy efficiency (ECPA, 2017). The electricity price decreased in 2017, as did average consumption per consumer (Rojas Navarrete, 2018). Electricity consumption increased owing to the progress of electrification in the country, especially in rural areas (ECPA, 2017). In addition, LPG consumption increased because of low prices (BBN, 2019), which meant a reduction in residential firewood consumption.

2. Costa Rica

Although Costa Rica has seen a slight recovery in this area in recent years, the country's energy security has declined (see figure 3). This deterioration, mainly from 2004 to 2015, was associated with the volatility of oil prices on the international market, the reduction in storage capacity due to the shutdown of several storage facilities (ECLAC, 2013) and the gradual decline in refined oil production, which was discontinued altogether in 2011 with the permanent closure of the Costa Rican Oil Refinery (RECOPE). This resulted in a higher oil bill, a reduced diversity of fuel suppliers and increased dependence on oil products from the United States (Salazar, 2016).

The ESI has been gradually increasing since 2016, mainly owing to a decline in domestic gasoline and diesel prices. The likely cause of this decline has been the collapse of international prices, coupled with an increase in the minimum wage (ECLAC, 2019). Furthermore, in the residential sector, biomass (firewood) for cooking has been gradually replaced by other fuels, mainly electricity, whose share increased from 42% to 63% from 1990 to 2015, while that of firewood decreased from 49% to 25% (ECLAC, 2018b). The rise in the ESI is linked to the fulfilment of energy strategies aimed at harnessing natural resources and increasing energy efficiency. The national energy system has been strengthened by clean electricity generation, mainly by hydropower plants, which poses energy security challenges because of the risk posed by droughts. The remarkable progress with electricity points up the difficulties encountered in reducing oil consumption, whose share of the energy mix remains high, at 63% in 2015 (Zárate Montero and Ramírez García, 2016).

Figure 3
Costa Rica: energy security index

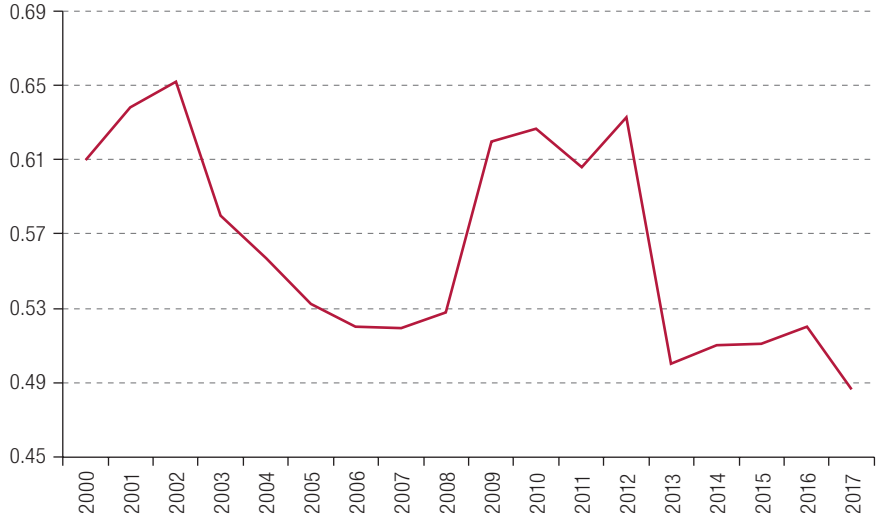


Source: Prepared by the author.

3. El Salvador

El Salvador shows a marked downward trend in energy security, which began to decline in 2002 (see figure 4), mainly because of rising imports of petroleum products and electricity, low momentum in efforts to harness local energy sources and high consumption of firewood by the residential sector. From 2008 to 2012, the ESI rose because fuel supply operations were launched by Puma Energy and Grupo Terra, which, together with other domestic companies, contributed to a greater diversification of suppliers (ECLAC, 2019). Storage capacity for gasoline and fuel oil has increased and it remains high for diesel, possibly because the Acajutla oil refinery began operating as a storage terminal when it was shut down. According to Puma Energy, it is more economically efficient to import fuels than to import crude oil and process it (Cabrera, 2015).

Figure 4
El Salvador: energy security index



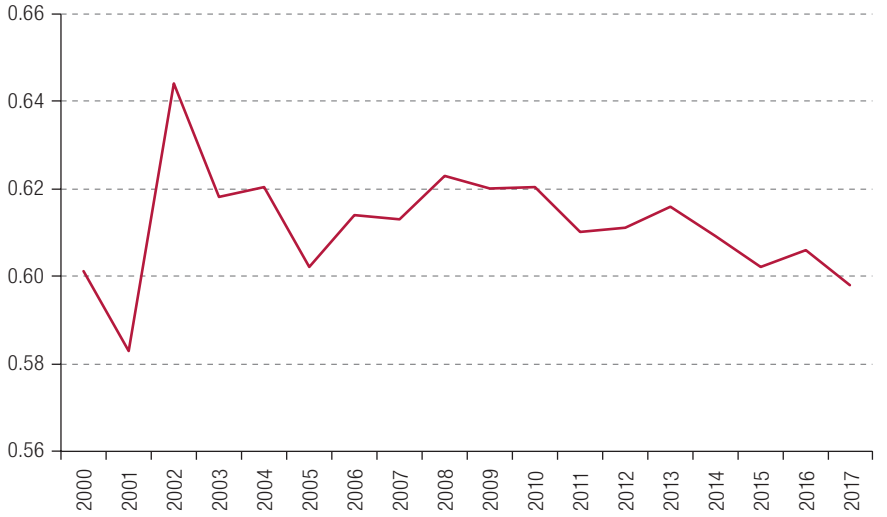
Source: Prepared by the author.

The shutdown of the refinery in 2012 drove up purchases of refined products and the oil bill, which accordingly weighed on the trade balance. Since 2013, imports have accounted for 70% of the total energy supply. The majority of petroleum products are supplied by the United States, and final consumer fuel prices are aligned with international market trends (ECLAC, 2019; CNE, 2013). There is neither a high level of hydrocarbon storage nor a diversity of storage sites. Other causes contributing to the low index value in 2017 were: (i) the growth of the vehicle fleet, leading to higher consumption in the transport sector (Peñate, 2018) and (ii) higher imports of electricity, which is purchased in the Regional Electricity Market (MER), as this is cheaper and means that consumers can be charged less for the service (Linares, 2019).

4. Guatemala

Figure 5 shows Guatemala's ESI, one of the highest in the subregion. Among the main factors contributing to its stability has been the performance of the electricity subsector, whose electricity exports make the country the main supplier to the Electricity Interconnection System for the Countries of Central America (SIEPAC). Another positive aspect is the price of electricity for the residential sector, which has made Guatemalan rates the lowest in the Central American isthmus since 2017. The fuel storage and distribution infrastructure, which is internationally classified as adequate and reliable, is another noteworthy feature (ECLAC, 2019).

Figure 5
Guatemala: energy security index



Source: Prepared by the author.

The decline in the ESI since 2002 is essentially due to falling crude oil production and increased imports of refined products. Most oil production (90%) goes to the international market. The rest is used to generate electricity and to surface streets and roads (Espinasa and others, 2013a). Closure of the Escuintla refinery in 2002 led to the cessation of crude oil imports and an increase in purchases of finished products. Dependence on imports of oil and petroleum products from the United States has been rising, reaching 80% in 2017 (ECLAC, 2019). Increased theft and a booming black market in fuels are also undermining energy security.

The values of some indicators have fluctuated since 2008, causing the index to rise and fall. Some of the reasons for these results are: (i) imports of oil, its derivatives and coal have increased since 2009

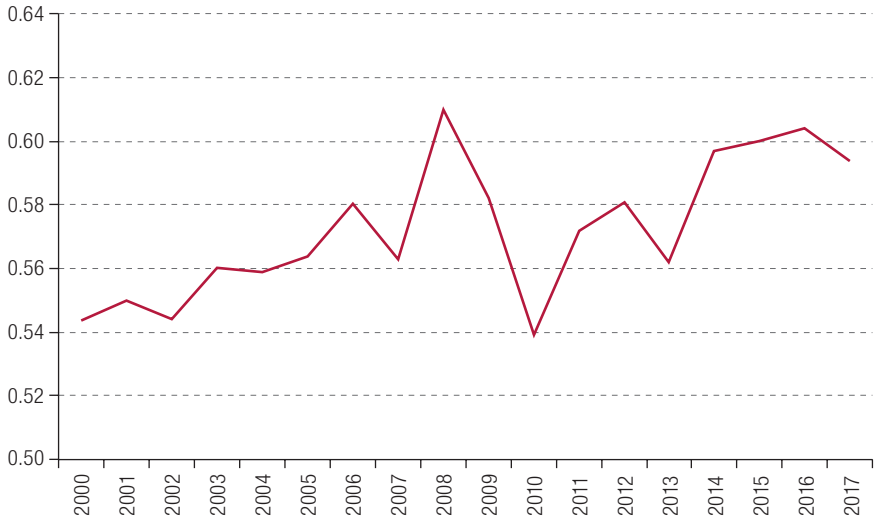
(OLADE, 2019), owing largely to the growing demand from the San José thermoelectric plant (Espinasa and others, 2013a); (ii) the vehicle fleet has expanded, with a consequent increase in fuel consumption (Bolaños, 2016; Marroquin, 2018); (iii) high oil prices in the international market have affected the oil balance (Carcar, 2012), domestic fuel prices and the affordability of derivatives (Anaya, 2018); and (iv) residential firewood consumption is high owing to the absence or inaccessibility of modern energy services, which forces much of the Guatemalan population to resort to this fuel to meet their needs (INAB, 2015).

In the face of external dependence, there has been no lack of interest in harnessing local energy resources within a framework of sustainability (ENEE, 2016; Koberle, 2012; MEM, 2019; Ortiz, 2014). The objective of the National Energy Plan 2017–2032 is to enhance energy security by increasing the reliability of electricity grids and keeping rates stable (MEM, 2017, p. 96). However, it does not place as much emphasis on the issue of imported hydrocarbons and petroleum products, perhaps because of the limited scope for action to reduce this dependence. So far, the main efforts and achievements have centred on the diversification of electricity generation (MEM, 2018), although the importance of investing to increase efficiency, rationalize consumption and expand coverage, especially in rural areas, is also recognized (MEM, 2017). This last objective is fundamental to achieving universal access to modern energy, as firewood continues to be the most heavily consumed energy product in the residential sector, and replacement by LPG is not a sustainable option (INAB, 2015).

5. Honduras

Energy security in Honduras has improved steadily since the turn of the millennium (see figure 6). The ESI fell from 2006 to 2007, a development associated with increased imports from the United States, a shortage of fuel storage infrastructure (Domínguez Amador, 2014) and a 15.4% increase in the vehicle fleet (Benegas, Barahona and others, 2012). This caused the transport sector to increase its consumption by 14.1% from one year to the next. The ESI rose between 2007 and 2008 as fuel consumption in the transport sector fell (ECLAC, 2018a). Fuel imports from the United States also declined, while the share of imports from other countries, such as the Bolivarian Republic of Venezuela and Ecuador, increased. In addition, storage levels increased from one year to the next (OLADE, 2019), and electricity rates increased because of the rise in the international oil price (*Proceso*, 2011).

Figure 6
Honduras: energy security index



Source: Prepared by the author.

The ESI fell considerably from 2008 to 2010, owing to the global economic slowdown resulting from the financial crisis and to the economic, trade and non-economic sanctions imposed because of the political situation in the country after the coup d'état in June 2009. Some of the measures that affected the energy sector were: (i) the suspension of oil subsidies by PetroCaribe, (ii) the imposition of economic sanctions by the United States, and (iii) the suspension of all loans from the World Bank, the International Monetary Fund and the Inter-American Development Bank. These crises caused domestic production, consumption and imports to contract and affected supplier countries and companies, among others (*La Prensa*, 2011).

As the political crisis of 2009 was progressively overcome, the country began growing once again and economic and energy security indicators improved. With no oil fields or refineries, Honduras must import the petroleum products it consumes. In 2013, the oil bill accounted for 18% of total imports. Three companies (Texaco, Unopetrol and Puma Energy) dominate imports and supply. Fuel consumption has been subject to the volatility of international market prices since the abolition of oil subsidies in 2009. By 2017, 87.69% of the rural population in the country had begun increasing their firewood consumption, mainly as an energy source (Secretariat of Energy, 2018).

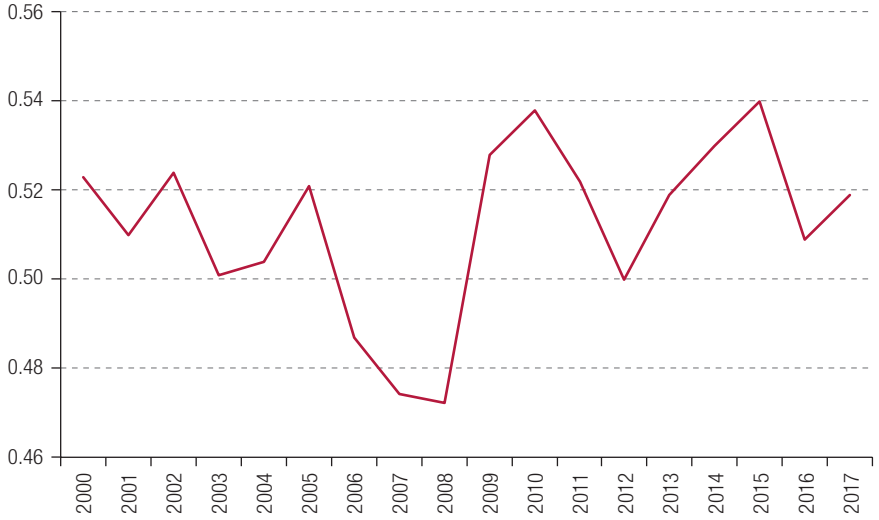
In recent years, dependence on petroleum products has dropped as the resources consumed to generate electricity have decreased because of progress with renewables and a rise in electricity imports. Honduras is the only country in the subregion with three regional electricity interconnections. Growth in electricity generation from clean energy sources has been steady. The country is home to the largest solar photovoltaic park in Latin America and the Caribbean. New hydropower plants and wind farms are also expected to come on stream (Twenergy, 2017). Unfortunately, the improvement on the generating side has not been reflected in increased affordability. Electricity coverage remains the lowest in the subregion, and electricity consumption has not increased despite population growth. Electricity rates are high and unstable owing to the still-large share of thermal power plants in the generating mix.

Despite this unevenness, the electricity subsector is leading growth in the energy sector. Some of the factors contributing to this are the availability of abundant renewable resources for electricity generation, a legal framework for the electricity subsector that makes it open to domestic and foreign investment, the removal of barriers to regional trade, and the strengthening of regional institutions and regulations, as well as domestic and regional infrastructure (PROHONDURAS, 2016). In addition, development policy and energy policy reflect the Sustainable Development Goals. However, energy security is subsumed in other objectives and has not emerged as an explicit goal matched by strategies to achieve it (ENEE, 2016; ECLAC, 2018a; PROHONDURAS, 2016).

6. Nicaragua

Energy security in Nicaragua declined until 2008 (see figure 7) and, although it recovered the following year, its behaviour has been erratic. This trajectory reflects economic difficulties and an unfavourable international environment. Between 2003 and 2008, the country experienced an energy crisis with constant electricity rationing (Ortega Hegg, 2007). Obsolescent equipment, lack of maintenance and heavy dependence on oil derivatives for power generation led to power cuts and high electricity prices. Once the shortages had been dealt with, recovery was undermined by a decline in output of refined products, increased imports of both petroleum products and electricity, and higher electricity rates (ECLAC, 2013). Inadequate infrastructure and weak competition in supply markets make Nicaragua the Central American country with the highest pre-tax fuel prices. Although storage capacity has increased, there is still not enough to take advantage of economies of scale in fuel imports (Álvarez Hidalgo, 2016).

Figure 7
Nicaragua: energy security index



Source: Prepared by the author.

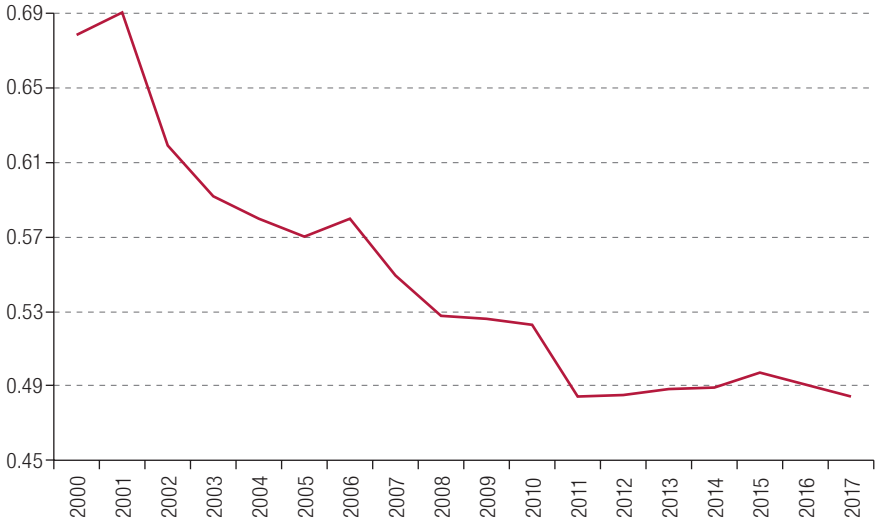
Electricity coverage and the use of renewable energy sources in electricity generation have increased in recent years (CONICYT, 2017). Nicaragua joined SIEPAC and regional electricity market operations in 2016. Residential consumption of firewood has been decreasing as modern energy sources have gained ground, although it has not been replaced by electricity but instead by LPG, an imported product (Alexander von Humboldt Centre, 2018). The objective of energy policy is to harness the potential of renewable sources in order to improve the sustainability of the energy mix, in particular by eliminating electricity generation with petroleum derivatives (Espinosa, 2016). However, energy security is not an explicit priority; rather, the focus is on the efficiency, coverage and quality of the electricity sector (ENATREL, 2016; PRONicaragua, 2019). A transition towards a national energy efficiency policy that contributes to national energy security is envisaged, but the concept is not defined (ECLAC, 2015).

The geopolitical risks of external dependence have emerged starkly in recent years. Because the United States displaced the Bolivarian Republic of Venezuela as the main fuel supplier, Nicaragua was hit hard by the economic sanctions imposed by the Trump administration. The Nicaraguan government's response was to create public companies and nationalize existing firms to ensure continuity of supply.

7. Panama

Energy security in Panama declined dramatically between 2001 and 2011 (see figure 8). Contributing factors included the transformation of the local refinery into a fuel import centre (Sánchez, Valdés and Castrellón, 2002) and the increase in the oil bill caused by burgeoning imports of refined products, which are more expensive than crude oil. The electricity bill was also affected, as more than 40% of generation in the period was with fossil fuels. Energy security has been on a more or less stable trend since 2011, but at lower levels than at the turn of the millennium. This stability has been achieved despite oil price volatility in the international market (SNE, 2016), which is reflected in domestic fuel prices and electricity rates (Espinasa and others, 2013b; Sánchez González, 2018). Firewood consumption has been decreasing since 2014 because of the penetration of subsidized LPG for the lower-income population (IDB, 2016). This replacement offers some advantages, but postpones the switch to electricity, which is the best option in terms of energy security and sustainability.

Figure 8
Panama: energy security index



Source: Prepared by the author.

Thanks to the abundant potential of its renewable energy resources, the country has the opportunity to profitably meet its long-term energy needs and support its transition to a sustainable energy future. Panama's energy policy focuses on securing fuel and electricity supplies, diversifying the energy mix, reducing the carbon footprint and using energy rationally and efficiently. Panama also seeks to foster integration with the countries of the subregion in order to boost competitiveness and efficiency, thereby contributing to sustainable economic growth in the subregion and strengthening energy security in Central America (ETESA, 2017; SNE, 2016). The National Energy Plan 2015–2050, the energy sector diversification plan, reflects the ambition to achieve greater energy security in Panama, but although the concept is mentioned, neither its meaning nor the concrete measures required to achieve it are spelled out. The reliability and quality of supply in the electricity system are not high, despite the restructuring of the interconnection system in recent years. Nevertheless, there are projects in the subsector to generate 77% of electricity from renewable sources by 2050 (SNE, 2016).

V. Conclusions

The purpose of this research was to analyse the behaviour of energy security in the countries of Central America so far this century, with the help of a number of indicators validated by experts from the different countries that make up the subregion, in order to reflect on the design and fulfilment of energy policy strategies in each of these countries. The conclusions drawn from this work are set out below.

Local circumstances and sensitivity to energy security vary from country to country. As a result, the actions taken and the results achieved are bound to be different in each. None of the countries has had serious energy security problems, with the exception of Nicaragua, which had to take emergency measures as a result of economic sanctions imposed by the United States government.

Although Belize has been the best performer in terms of energy security, it has achieved this with oil. This is useful in the short and medium term, but not in the long term, because the energy transition to a lower-carbon economy is already under way throughout the world. Costa Rica, on the other hand, is pursuing energy security together with sustainability by accelerating the use of renewable energy sources.

All countries have placed more emphasis on continuity and economy in electricity supply than in fuel supply. Perhaps this is because of the greater scope for government action, as State-owned enterprises have long operated in the electricity subsector. In contrast, oil supply has traditionally been dominated by international companies, over which authorities have no control beyond regulation.

Not all energy imports have been inimical to energy security. Integration through SIEPAC has contributed significantly to improving energy security where electricity is concerned. The countries of the subregion see regional integration as an ideal mechanism for improving the availability and reliability of the energy supply. This is due to the size of their economies and the economies of scale that can be achieved through interconnection, coordination and harmonized regulation.

The price of fuels makes them unaffordable for the population, given low minimum wages and the extent of poverty and marginalization. Some countries subsidize LPG to improve access to modern energy sources, mitigate the price impact on the household economy, and encourage the replacement of firewood, whose (still very widespread) consumption affects the health of families and leads to deforestation. The disadvantage of the subsidy lies in the pressure it places on public finances and in the fact that it encourages the consumption of an imported fossil fuel. The alternative is to replace firewood with electricity, a sustainable and lasting solution that Costa Rica has been pursuing.

Despite efforts to increase the use of renewable sources, oil is still the mainstay of the energy supply. Owing to their high dependence on this fuel, the economies of the countries in the subregion are very sensitive to the cost of importing it. Oil price volatility is a permanent source of instability for energy security. The countries have sought to reduce this dependence through the use of local energy sources, mainly hydropower and, more recently, wind and solar energy. Efforts are also being made to rationalize consumption and make it more efficient.

Domestic hydrocarbon production contributes to energy security because it reduces the commercial and geopolitical risks of imports. Similarly, having a refinery, whether public or private, is considered to contribute to energy security. Moreover, refining domestically means that fuel can be sold below international market prices, and it is cheaper to import crude oil than finished products. It is paradoxical that the subregion's oil refineries have closed: by the end of 2017, only Guatemala and Nicaragua still had refineries. Oil companies have withdrawn from this business in favour of importing refined products, especially from the United States, whose competitiveness has increased as a result of the boom in unconventional hydrocarbons there.

Converting oil companies in this way for reasons of efficiency and business strategy has macroeconomic repercussions, since the oil bill rises and the economy needs to find dollars to pay it. Given these conditions, the concern has now shifted to storage capacity, which in some countries is meagre. Diversification of supply sources and suppliers should also be pursued in order to reduce the excessive dependence on refined products from the United States, which in some countries is as high as 100%.

The challenge going forward is to raise levels of energy security and sustainability. This is particularly important now that the countries are consuming more energy in an effort to close the huge industrial and social divides that separate them from countries with a higher level of development.

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