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Projection of fossil fuels consumption in the Venezuelan electricity generation industry

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ABSTRACT

This study presents a prospective analysis on the impacts of recent efficient energy policies application in Venezuela, integrating both oil production and electricity supply to assess energy resources balance in a quantitative manner. A special focus is given to main fossil fuels used in the electric power industry; natural gas, diesel oil and fuel oil. Four scenarios were proposed, ranging from a low-economy-growth/low-efficiency scenario to an optimist high-economy-growth/high-efficiency scenario. Efficiency effects are more notorious for high-economy-growth case, fuel consumption for electricity generation reduces 38% for natural gas, 12% for diesel and 29% for fuel oil, in the established time period. Deficits in oil and gas Venezuelan production were also determined, deficits are highly affected by economical forecasting, and by fuel smuggling in Venezuelan borders. Results showed the high importance of energy efficiency policies development for Venezuela, in order to reduce fossil fuel domestic consumption to allocate them in a more profitable market.

1. Introduction

Oil exporting economies have to deal frequently with the difficulty of establishing convenient energy policies, which should allow them to produce and exploit their resources while also obtaining the maximum quantity of benefits. This is the case of Venezuela, which energy laws have suffered constant modifications since the beginning of the oil exploitation in its territory. These changes have weakened Venezuelan energy policy frame, as a concrete objective has not been pursued. In the last decade, a set of laws and legislative mechanisms were established, such as the LOH (Hydrocarbons Organic Law) in 2006 [1] and the LOSSE (Electrical Service and System Organic Law) in 2010 [2], which gathered the regulation responsibilities within the same circle, without the supervision of competent and independent organisms. This could be a harmful situation for the energy market balance, as studied by several Latin American energy regulation authors, like Salazar [3], Durbán [4] and Díaz Bautista [5].

This background, together with unfavorable capital availability, affected Venezuelan energetic production in both hydrocarbons and electricity sectors. Delay in productive infrastructure, and lack of investments in this area, have increased main flaws of the national electric sector; Venezuelan electricity grid relies on a hydrothermal power system, which needs a proper balance in order to supply demand correctly. Most important hydraulic power plants are concentrated in the south-eastern side of the country, in the *Caroní* river basin, while thermal power plants feed an important part of the western and central regions. Concentrated energetic resources in eastern and western regions make east-west electric grid and pipeline connections a fundamental infrastructure to effectively supply all energetic demand. Delay in constructions or improvements in those grid connections, and slow down of natural gas production, have caused unavailability of thermal power generation in the western and central sides of the country, causing vulnerability in the operation planning of hydropower plants, which has led to failures in the grid, damages in power plants and unattended demand.

An important attempt to diminish energy consumption, promote renewable energies and enhance energy efficiency in end users was done by enacting the UREE (Rational and Efficient Energy Use Law) in 2011 [6]. This law included programs for replacements of outdated light bulbs, refrigerators and air conditioned systems. There was considered penalties for high consumption users or rewards for electricity savings, and also it encouraged educational programs regarding renewable energies. As stated by Alves [7],

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Abbreviations

API	American Petroleum Institute,
MBPD	Thousand barrel per day
MMCFD	Million cubic feet per day
MMCM	Million cubic meters
CRE	High Economy Growth – Low Efficiency Scenario
EFE	Low Economy Growth – High Efficiency Scenario
BAS	Low Economy Growth – Low Efficiency Scenario
CYE	High Economy Growth – Hihg Efficency Scenario
MENPET	Ministry of Petroleum and Mining
MPPEE	Ministry of Electric Energy
PDVSA	Petróleos de Venezuela Sociedad Anónima

Subscripts

h	Hydropower
pr	Production
def	Deficit

these kinds of actions can positively reduce the demand growth, but efficiency programs should not be linked to situational issues. In this context, UREE law can be considered as an evolution in Venezuelan energy legislation and regulation, however, it would not fix downstream problems regarding insufficient energy generation, disproportionate electricity losses or inadequate electric networks; the system dependency on the hydro resources makes it highly vulnerable to dry seasons, thus, it should be prepared with proper infrastructure and resources availability to withstand that situation. As natural gas pipeline extension projects have been delayed and its extraction has slowed, risks are increased by the fact that hydro resources are geographically concentrated and main electricity networks may become overloaded in cases of peak demands, causing a constant deterioration of the system.

Lack of planning for the national power system has also caused an increase of liquid fossil fuels consumption in power generation industry. Although growth of the thermal energy contribution in the grid was already planned, there is a large energy efficiency drop in power transmission systems and outdated technology power plants. As Venezuela is an oil-exporter country, misusing oil-products also stands for economic losses, due to placing these fossil fuels to burn in power plants, instead of directing them to the exports market or its utilization by more productive industry sectors.

Even though Venezuelan oil sector has been broadly studied, other energetic sectors, such as electricity supply, have few isolated research being produced. Important Venezuelan energy matrix analysis were carried out by Córdova [8] and Fontaine [9]. Kirschstein [10] points different current aspects of the Venezuelan energetic difficulties. Coing [11] makes a detailed qualitative timeline analysis of Venezuelan power industry. Refs. [12–18], concentrate in the technical and economical viability for renewable energies. In this context, there was a need to gather current important aspects of the energetic situation and to analyze the energetic system as a whole, in order to evaluate most critical points and understand its possible consequences in a medium term of 10–15 years.

This study emerges as a proposal for the analysis and projection of these recent events, integrating both oil production and electric power supply, in order to evaluate resources availability in a quantitative manner. It emphasizes in the consumption of main fossil fuels used in the power generation industry: diesel oil, fuel oil and natural gas. Energy planning software LEAP was used in order to carry out projections in four proposed baseline scenarios, which characteristics range from a business-as-usual behavior, to a more efficient and high economic growth conditions.

A characterization of Venezuelan energetic supply chain is proposed, going from the extraction and exploration of primary resources, to diverse final energetic or non-energetic uses. The deficit of these resources in any part of the energetic chain could represent pitfalls for Venezuelan economy, resulting in unexpected importations or unattended demands. Other additional important aspects included were: influence of current pilot wind power projects in the energy matrix and carbon dioxide emissions in each scenario.

In Section 2 authors present a summarized description of Venezuelan power generation industry, for better understanding of the following grid and system projections. Section 3 describes the methodology used to outline the scenario analysis, Section 4 presents the obtained results, that are discussed in Section 5 and final remarks are presented in Section 6.

2. Main characteristics of the Venezuelan power generation industry

Hydro power plants in Venezuela were promoted during the 60's and 70's decades, with the exploitation of the *Caroní* River Basin. From this period onwards, Venezuelan energy resources use and consumption behavior have not substantially changed, since there has not been a definite promotion of other energy sources and energy prices subsidies have been maintained. Tables 1–3 summarize main indicators of Venezuelan power generation industry. Deeper analysis is developed further in this paper, in order to

Table 1
Venezuelan energy consumption indicators for electricity generation [19, 20].

Indicators	2000	2012
Primary Energy Production (ktoe)	230747	192260
Total Primary Energy Supply (ktoe)	51273	72682
Energy for power generation (ktoe)	11217	19423
Hydro	48%	36%
Natural Gas	35%	28%
Diesel	6%	24%
Fuel Oil	10%	12%

Table 2
Power generation capacity shares and peak demands [20].

Installed Capacity	2000	2012
Total Instaled Capacity (MW)	20059	27496
Caroní River Basin	63%	51%
Total Hydro	66%	53%
Thermal	34%	47%
Demand	2000	2012
Peak Demand	11938	18357
Share of installed capacity	60%	67%

Table 3
Electricity Generation shares [20].

Generation (TWh)	2012
Total Generation	127.80
Caroni River Basin	62%
Total Hydro	64%
Thermal	36%
System Overall Losses	33%