



## Assessing the obstacles to the participation of renewable energy sources in the electricity market of Colombia



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### ABSTRACT

This paper presents an assessment of the obstacles to the development of non-conventional renewable energy sources in Colombia. In the study, eleven barriers were included in three clusters: technical, social and economic. These barriers obstruct renewable energy sources from contributing to the electricity market in Colombia, mainly in its non-interconnected areas.

The energy sources analysed are solar photovoltaic power, wind power, biomass, geothermal and small hydroelectric power (less than 20 MW electricity). Obstacles and energy alternatives are included in an assessment model by means of Analytical Network Process. The method permits ranking the barriers and energy sources according to their influence in the network. That means, the more conflictive the obstacles and the more obstructed the energy sources, the higher their values. Four experts participated in the procedure representing different stakeholders in the electricity market of Colombia.

The research showed the most important barriers are costs of investment and operating, lack of public and private coordination and lack of development planning for renewable energy sources. The most influenced (hindered by barriers) sources are wind power and geothermal power. However, the experts did not fully agree on those results and differences are discussed. The paper ends with some recommendations for overcoming the main obstacles against the participation of renewable energy sources in the Colombian electricity market.

### 1. Introduction

Colombia is one of the main emerging economies of the South American continent with an ever growing energy demand. Electricity consumption is not only increasing but also changing from a matrix almost completely based on Hydropower, to a mix, where fossil fuels are ever more prevalent [1]. Furthermore, there is a large portion of the country's surface where electricity distribution cannot reach consumption, and diesel engines are mostly providing the demanded electricity supply.

To match the electricity demand and the interconnection of the pending country areas, a low carbon economy has been set as a strategic priority for the Colombian government [2]. To fulfil this objective, one of the main strategies is the use of renewable energy sources. These include conventional (i.e. hydropower) and the so-called non-conventional renewable energy technologies (FNCE by its initials in Spanish): Solar Photovoltaic, Wind, Small Hydro, Geothermal and Biomass power, among others.

The approval of law 1715 in May 2014 seeks to integrate FNCE into the national energy system. In order to do so, it tries to enhance their

participation in the current electricity market and their penetration in the non-interconnected zones (ZNI by its initials in Spanish). However, in spite of this law, FNCE are still encountering different barriers against their development

In this paper, obstacles to the development of FNCE in the Colombian electric sector are identified and prioritised by means of the help of four Colombian experts and the implementation of Analytical Network Process (ANP).

#### 1.1. Energy market in Colombia

##### 1.1.1. Energy demand and mix

According to the UPME (Mining and Power Planning Unit), Colombian primary energy consumption has increased more than 200% in the past 3 decades. As a matter of fact, it has increased from 205,150 GWh in 1980 to 454,260 GWh in 2012 [1] (last available data). However, the final energy consumption per unit of GDP has declined by 50% during this period. Hence, the country has made a noticeable effort in implementing energy efficiency measures while increasing its primary energy consumption.

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In 2012 [1], fossil fuels provided approximately 78% of the domestic primary energy demand. Of this energy, 45% was used for transport, 22% for industry, 19% for residential use and 7% for the government and businesses.

### 1.1.2. Electrical energy mix

The Colombian electricity sector has a constantly evolving regulatory framework. Currently, generation and supply work under open market competition, while transmission and distribution remain as regulated monopolies [3]. Electricity consumption in 1975 was 11,275 GWh while during 2012 this consumption rose to 59,988 GWh. This represents an increase of more than 500% in 37 years [1]. The Colombian electricity mix is dominated by hydroelectric production, which used to represent around 80% until recently.

Due to the enormous water resource dependence of the country, and the weather phenomena "El Niño" and "La Niña" Southern Oscillation (ENSO), the contribution of hydropower electricity production can vary between 45% and 95% [4]. In 2014, hydropower accounted for 69.5% of the electricity production [1]. Thermal generation backs this variation in hydropower production. But, as electricity demand increases, thermal power plants are gradually supplying more and more electricity, accounting for 29.6% of the supply in 2014 [1].

### 1.1.3. Interconnected systems and non-interconnected zones

The National Interconnected System (SIN by its initials in Spanish) connects 48% of the national territory and covers 95% of the population. The ZNI account for 52% of the country's area (17 departments and 1441 municipalities) and 625 thousand people (see Fig. 1). Currently, these zones produce electricity mainly with diesel generators [5]. Moreover, ZNI are characterized by their important FNCE potential, and for being located at remote sites, often inaccessible and/or with great ecological and ethnic interest [6].

### 1.1.4. Law 1715 for the integration of FNCE in the national energy system

As mentioned before, Law 1715, enacted in May 2014 [7] promotes the development and use of non-conventional energy sources (especially those from renewable sources), in the national energy system. This law establishes the legal framework for the use of FNCE and creates tax incentives for the investment in these kinds of projects. These

are:

- Incentives for investment in FNCE projects in ZNI, which substitute diesel generation.
- Tax incentives:
  - Income tax deduction.
  - Value Added Tax (VAT) exemption for goods and services used in the development of FNCE projects.
- Tariff incentives: Exemption from payment of customs duties when importing machinery and equipment to be used in the development of new FNCE projects.
- Accounting incentives: Accelerated depreciation of assets.

Nevertheless, no incentives and tax exemptions have been applied until today because the regulation was still pending and not all incentives have been regulated yet.

- There is a lack of regulations for self-generation, sales of self-generated electricity and the maximum capacities for FNCE projects.
- A long bureaucratic process without clear parameters is required to certify FNCE projects.
- Specific regulation for the ZNI where the electricity surplus cannot be sold to the national grid.

Although law 1715 helps to overcome some barriers to the development of FNCE, such barriers are still present in Colombia. For instance, [6,8] emphasises the need of energy policy in Colombia in order to support expansions on the grid, development of renewable energy and to address market stability and sustainability. Moreover, this law was not intended to promote key policies or mechanisms that have been proved successful such as:

- Investment in the grid in order to overcome the technical challenges that will be generated by FNCE [9].
- Renewable purchase obligations for a percentage of the total traded energy [10].
- Procedures to adjust incentives to future market and technology situations [11].



■ The **National Interconnected System (NIS)** connects 48% of the national territory and covers 96% of the population.

■ The **Non-connected zones (ZNI)** account for 52% of the country's area (17 departments and 1,441 municipalities) and 625 thousand people. Currently, these zones produce energy with Diesel.

Fig. 1. ZNI and SIN (NIS) in Colombia [1].

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