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# Fuel saving strategies in the Andes: Long-term impacts for Peru, Colombia and Ecuador

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ABSTRACT

Crude oil exports and imports play a crucial role in the trade balance of Peru, Colombia and Ecuador. These countries are looking into fossil fuel saving measures as a way to deal with increasing demands and decreasing oil production rates. However, studies about the long-term effects of these measures is lacking. Using a combination of energy simulation technics, 17 fuel saving strategies ranging from fuel switching to the investment in underground transport and hydropower capacity expansion were modelled and assessed to evaluate their long-term effect on fossil fuels demand reduction. Our results show that the full implementation of strategies can account for cumulative oil savings of over 550 million barrels of oil by 2030. Findings also point out that Ecuador and Colombia could face the transition from net oil-exporters to importers as soon as the end of the next decade.



## 1. Introduction

The vulnerability of a country to oil price fluctuations depends on whether or not it is a net oil importer or exporter [1–4]. On one hand, oil importing countries, historical evidence suggests a negative relationship between oil price increases and economic development [5–7]. The higher the import bill relative to GDP, the larger the exposure of an economy and the macroeconomic adjustment costs to oil price increase [8]. For oil exporting countries on the other hand, windfall revenues are a significant source of foreign currency and income. These revenues stimulate economic activity and finance productive and social investments. However, they can also promote unsustainable consumption that leads to fiscal crises [9]. Some oil-exporting countries apply energy subsidies to distribute benefits across the population, promote industrialization and economic diversification and create jobs and enhance competitiveness [10]. The efficiency of domestic investments based on oil revenues is constrained by the productivity of tradable sectors [11]. For instance, scaling up public investments too high and too fast could expose the economy to instability due to absorptive capacity constraints, possible Dutch disease and risks of currency depreciation [12,13]. Besides, for oil-exporting countries, high energy consumption can lead to a rapid erosion of their export capacity, increasing the risk of becoming net importers.

Crude oil plays an important role in the economy and trade of Peru, Colombia and Ecuador. These so called 'Andean Countries' (due to the Andes Mountain range), are located in north-western South America and are home to approximately 95 million people (World Bank, 2015). These countries have experienced steady economic growth over the last two decades as evidenced by average GDP growth rates from 3% to 5% from 1990 to 2012, reaching even higher rates in more recent years (World Bank, 2013). Such economic growth has led to increases in gasoline and

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diesel consumption, mostly associated with vehicle ownership and thermal power generation [14–16]. In the last decade, oil production in the Andean countries increased. Peruvian petroleum production grew 46%, reaching 168 kbpd (thousand barrel per day) in 2013 [17,18], mainly due to the production of natural gas liquids in the Camisea project in the Amazon region. In the case of Colombia, for the same period, oil production increased in 145% reaching 1088 kbpd, mainly due to the exploration and discoveries in the Llanos Orientales region [19]. In Ecuador, the production increased in 85% reaching 526 kbpd [20] mainly due to the production in the north-eastern Amazonia region.

Huntington [21] highlights the relevance to model energy scenarios as a way to better understand energy systems and provide quantitative insights. Energy scenarios about oil supply-demand are relevant tools for policy-makers to define targets of energy efficiency programs, fuel switching incentives and their overarching national energy plans. The Andean countries lack of scientific literature related to energy modeling and scenarios. Recent studies in Colombia have focused on transport policies to improve energy use [22], analyse measures for the short-term security supply of natural gas [23] and renewable energy potential assessments [24–26]. In the case of Peru, energy-related scientific literature also addresses tapping of renewable energy resources [27], energy poverty [28], liquefied natural gas exports [29], cogeneration potential [30] and oil supply scenarios [31]. In Ecuador there are studies related to renewable energy resources [32,33], discussions about oil production in the Yasuni reserve [34,35] and an analysis of the country's energy development under the Kuznets curve [36]. However, to our knowledge we could not find published scientific literature with focus in the Andean countries regarding oil products demand and corresponding policies related. What are the energy strategies and policies that these governments enforce regarding oil products consumption? How would fuel demand in Andean countries evolve in the future with the implementation of these policies? These are questions that this study aims to provide insights for.

The objective of this study is to model a full set of demand-side strategies and actions that are being implemented to replace and lower oil (fuel) consumption, aiming at energy security, diversification and mitigation of climate change in Peru, Colombia and Ecuador up to 2030. These policies are within the Nationally Determined Contributions (NDCs) that each country presented in the United Nations Climate Change Conference held in Paris in2015.[1] We use a bottom-up modeling method combining several technics that serve as input to the Long-range Energy Alternatives Planning System (LEAP). By using bottom-up models we quantify the effectiveness of current strategies by assessing how much oil these would save in the long term. The analysis provides new insights on the impact of national fuel-saving strategies, their trade-offs and interactions with each other. The study also sets a benchmark of quantitative data for regional policy-makers to address the challenges of reaching peak oil and becoming net oil-importing countries. The study is innovative for the region in the sense that oil demand and demand-side policies are often overlooked due to the traditional abundance of energy resources. This study reveals the significant potential that implementing fuel-saving strategies can have in terms of economic value as well as for extending the treasured net oil-exporter status. This paper is organized as follows. The next section compiles current fuel demand strategies in the Andean countries. Section 3 presents the methodology and details scenario storylines. Section 4 shows the main findings. Finally, the last section highlights the main conclusions of the work and proposes insights for further research.

[1] http://www4.unfccc.int/submissions/INDC/.

## 2. Current fuel demand strategies in the Andean Countries

This section presents a compilation of the fuel saving strategies and measures, which are currently being implemented in Peru, Colombia and Ecuador, and will support the creation of scenarios further below. The analysed strategies are divided in 4 sectors: residential, services and industry, transport, and electricity generation and consumption. Table 1 summarizes the energy saving strategies by country and sector. Fig. 1 displays the final energy consumption by sector in the year 2015 for Colombia, Peru and Ecuador. Colombia accounts the highest consumption with 1.2 million TJ, while the final consumption in Peru and Ecuador was 0.8 TJ and 0.56 TJ, respectively. The highest consumption of energy was from the transportation sector for the three countries.

### 2.1. Residential sector

The strategies discussed here include only those that directly affect the consumption of oil products, natural gas and electricity consumption for heating and cooking purposes. Actions that reduce electricity consumption in this sector are discussed in section 2.4. Peru is implementing a natural gas program, which involves a liquefied natural gas (LNG) distribution system from the Pampa Melchorita plant to eleven cities in Peru [37]. The project plans to increase access from 400 thousand households in 2015 to 1.2 million by 2020. In addition, the National Program of Family Cook Stoves – "Cocina Peru" aims to distribute 1 million liquefied petroleum gas (LPG) cook stoves by 2016, replacing the use of firewood within the framework of the National Plan for Universal Access to Energy 2013–2022 [38].

In Ecuador, the government is financing the substitution of LPG cook stoves by electrical induction cook stoves. In 2013, 92% of LPG supply was consumed by the residential sector [39]. The introduction of 2.6 million electrical induction cook stoves is planned until 2017 to reduce consumption of LPG in the residential sector [40]. This measure seeks to reduce an approximate spending of US$ 522 million per year on LPG subsidies, 75% of which is imported [41]. In the case of Colombia, there were no policies considered for the residential sector.

### 2.2. Services and industrial sector

In Peru, the Referential Plan for Energy Use 2009–2018 [42] focuses on the optimization and modernization of 60% of the country's industrial boilers by 2018. This will be achieved through the implementation of good practices in operation (2% savings), air-fuel ratio control (3% savings), and purges automation (1%) [43], which will save the use of fuel oil and natural gas used for steam production.

In Colombia, the following initiatives will affect industrial energy demand: a) electricity savings in mechanical drive through the replacement of motors and improvements in operation; b) operational optimization of boilers; and c) efficient lighting. The implementation of these actions are estimated to save 11% of the sector's final energy consumption [44]. For Ecuador, no fuel oil policies for the industrial sector were considered in this study.

### 2.3. Transport sector

For the case of the transport sector, the policies consider effects on the demand of oil products, natural gas and electricity consumed for mobility purposes. In Peru, the electric transport systems of Lima and Callao were approved in December 2010 [45].