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Analysis of the Level of Implementation of Programs for the Efficient use of Energy and Unconventional Sources: Case Study Colombia

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ABSTRACT

At the First Extraordinary Meeting of the Forum of Ministers of the Environment of Latin America and the Caribbean, Johannesburg, August 2002. An initiative for sustainable development in Latin America and the Caribbean was presented. This proposes that the countries of the region should show in their energy distribution minimum participation of 10% of renewable energy sources in the Total Primary Energy Supply (OTEP). The mechanism of action of this initiative is not based on penalizing countries that their natural conditions are not favorable for energy sustainability, but on promoting greater participation of renewable energy sources. Through the analysis of the country's energy demand and energy sources and according to the initiative, the Colombian government, through its entities, organizes programs to improve its energy efficiency and the participation of renewable energy sources and technologies, not conventional. This paper shows the statistics of energy distribution and energy sources in Colombia. Based on this information, we seek to identify the deficient sectors with their problems to implement strategies at the national level that allows them to meet the proposed goals.

Keywords: Efficiency, Energy, Renewable Sources, Sustainability, Total Primary Energy Supply
JEL Classifications: L78, L90, O31, Q20

1. INTRODUCTION

Today it is a fact the importance of transforming the mechanisms of obtaining electric energy into renewable energy (Cronin et al., 2018) to reduce the climate impact in a low-carbon (Solaun and Cerdá, 2019) future so that by 2050 renewable energy will account for 65% of the total consumption of Energy (IRENA, 2018). The use of renewable energies varies differently in each country and does not depend directly on their relative development (Bildirici, 2016), but rather on the availability of non-renewable energy resources (Alvarado et al., 2019). In Latin America, the share of renewable energy is 25% (NU. CEPAL; CAF;, 2013) relatively higher than in other areas of the world thanks to the high participation of hydropower and biofuel (van der Zwaan et al., 2016). Therefore, to establish the contribution of renewable sources in the Total Primary Energy Supply (OTEP in Spanish), it was necessary to homogenize criteria common to the countries of Latin America and the Caribbean, removing the fraction of energy from forest resources that give to the deforestation, this is the one whose extraction rate is higher than its regeneration rate (CEPAL and GTZ, 2003).

When it has to deal with renewable energy, it refers to the natural resources which restore naturally reestablished, and their consumption does not exceed the speed with which they can be restored naturally (Harjanne and Korhonen, 2019). And when it comes to sustainability, it is a little more complex since economic, political, social, and environmental factors are involved (Ashbai et al., 2019). This can be contextualized in three central dimensions: energy security, energy equity, and environmental sustainability of energy systems; these concepts constitute a "trilemma" (WEC and Wyman, 2019). In summary, sustainable energy is one that has efficient management capable of maintaining current and future national demand that is affordable for the population, and that mitigates the environmental impact developed from renewable and low-carbon energies (WEC, 2011). Accordingly, the position adopted by the Economic Commission for Latin America and the Caribbean (CEPAL, in Spanish) identifies renewable energy as a property of the source and sustainability as the property of the way it is used (CEPAL and GTZ, 2004).

In Latin America and the Caribbean (LAC), they have as common energy sources in their energy supply fossil sources such as oil and natural gas with a reserve that exceeds 35 and 40 years, respectively (OLADE, 2019). Hydropower, biomass, firewood, cane products, and geothermal energy. It should be clarified that part of the wood energy is not considered sustainable.

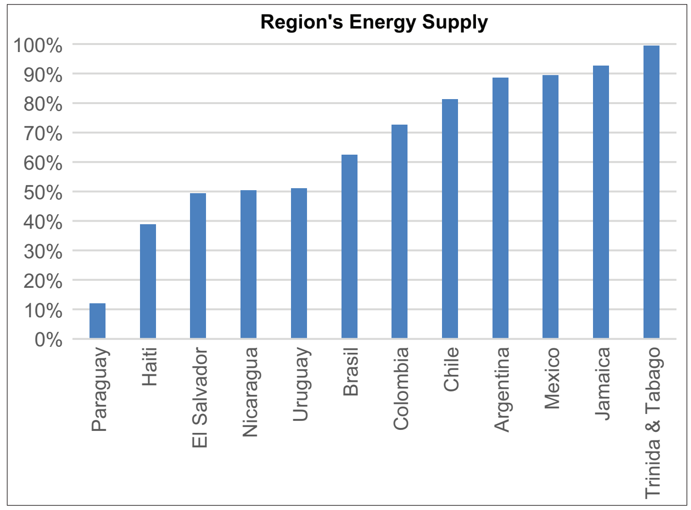
Figure 1 shows the percentage of energy supply for some countries in the region. This shows the energy contribution they have from non-renewable energy sources for the year 2002, in which, for some countries, this contribution is almost all of the energy supply. This non-renewable energy is made up of oil, natural gas, coal, nuclear energy, firewood (not sustainable), among other non-renewable energies. In Figure 2, shows in general, the Latin American and Caribbean region already fulfilled the goals outlined in the Regional Conference for Latin America and the Caribbean on Renewable Energies (Brasilia, October 2003) in which the use of 10% of renewable energy from the total energy consumption (CEPAL and GTZ, 2003).

The renewable energies found in the region are Hydro energy, industrial and residential firewood, agricultural firewood, charcoal, cane products, geothermal energy, among others.

The energy obtained by the dams or reservoirs called hydropower makes an important contribution to the OTEP in the LAC region and is considered a form of energy production that is part of non-renewable energy. However, this point is under consideration, even though conceptually it is a renewable resource, it may become an unsustainable resource due to its environmental and social impacts (CEPAL and GTZ, 2004) (WEC, 2015). Despite this, hydropower is still less harmful than others (Calderón et al., 2016). Colombia is the third country with the largest installed hydroelectric capacity in South America in 2018 (Pupo-Roncallo et al., 2020) and was ranked eighth in the World Economic Forum, the first non-European country in the top 10 (World Economic Forum, 2017).

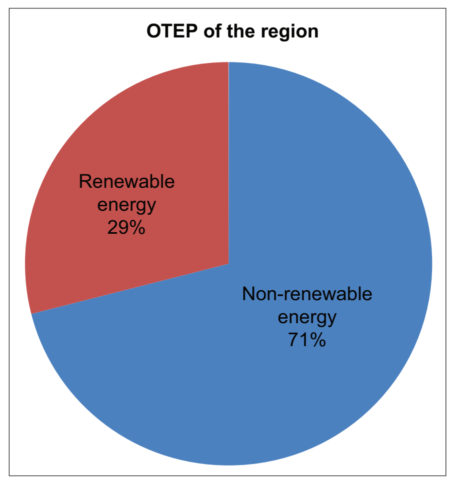
The energy resources condemned to the different productive sectors and the way this influences energy demand are topics on which the Colombian government works continuously (UPME, 2018) without neglecting the quality of life of its citizens with respect to climate change and the decrease in The latter is a result of the work to improve energy efficiencies in the consumption sectors and the implementation of new technologies for the use and production of renewable energy sources in the country's energy market (Prias, 2010).

Figure 1: Non-renewable energy supply of Latin America and the Caribbean year 2002



Source of data: Prepared by the authors based on data from (CEPAL and GTZ, 2003)

Figure 2: Total supply of primary energy (OTEP in Spanish) in Latin America and the Caribbean in 2002



Source of data: Prepared by the authors based on data from (CEPAL and GTZ, 2003)

Colombia is in the 49th position worldwide, with a BCA balance degree according to the trilemma score of 69.3 (WEC and Wyman, 2019), and this has been progressing since it got down to work on the issues of energy efficiency and renewable energy. At the Latin American level, progress has been uneven and slow. However, having an appropriate legal framework, laws, programs, and projects that promote the improvement of energy efficiency makes an important contribution to achieving the objectives of the region's agenda (CEPAL, 2017). These programs are headed by the Ministry of Mines, which through law 697 of 2001 and decree 3683 of 2003 (Gobierno Nacional, 2001) (Gobierno Nacional, 2003). This was entrusted with the responsibility for the programs for the rational and efficient use of energy (URE in Spanish) and create the Rational and Efficient Use of Energy and other unconventional forms of energy program (PROURE in Spanish). This is just the beginning of the joint work of the government and the Ministry of Mines and Energies that are constantly working on the development of new mechanisms, including the financial support fund for the energization of non-interconnected areas (FAZNI in Spanish) (Gobierno Nacional, 2008). That financially supports projects that seek to connect non-interconnected areas (ZNI in Spanish), giving special attention to projects that promote the efficient use of energy and non-conventional energies.

2. PANORAMA OF ENERGY IN COLOMBIA

Colombia is a country with a great variety of energy resources, the potential of renewable energy sources is high, and it practically owns resources from all renewable energy sources, although the largest is from electricity generation in the National Interconnected System (SIN in Spanish) is found in hydropower. PROURE through the Energy Mining Planning Unit (UPME) identifies energy potentials and the inclusion of unconventional energies in the country's energy market, as well as the definition of energy-saving goals.

2.1. Internal Power Supply

In Figure 3, the gross domestic supply (OIB in Spanish) of primary energy sources for the year 2017 was 1,878,448 TJ, in which Petroleum (PT) had the largest share with 801,661 TJ, followed by natural gas (GN) with 403,675 TJ, coal ore (CM) 225,031 TJ, hydropower (HE) 221,162 TJ, firewood (LE) 105,566 TJ, bagasse (BZ) 96,077 TJ, other renewables (OR) 24,808 TJ and Recovery/Waste (RC) 467 TJ (Table 1).

The gross domestic supply of secondary energy shown in Figure 4, for the year 2017 was 861,164 TJ with greater participation of Diesel oil (DO) with 283,232 TJ, motor gasoline (GM) 226,100 TJ, electrical energy SIN (EE SIN) 212,472 TJ, Kerosene, and Jet fuel (KJ) 50,933 TJ, liquefied petroleum gas (GL) 42,350 TJ, fuel oil (FO) 32,571 TJ, auto-generation, and cogeneration (AUT COG) 11,950 TJ, coke (CQ) 1,261 TJ, charcoal (CL) 295 TJ, fuel alcohol (AC) 0 TJ, and biodiesel (BI) 0 TJ.

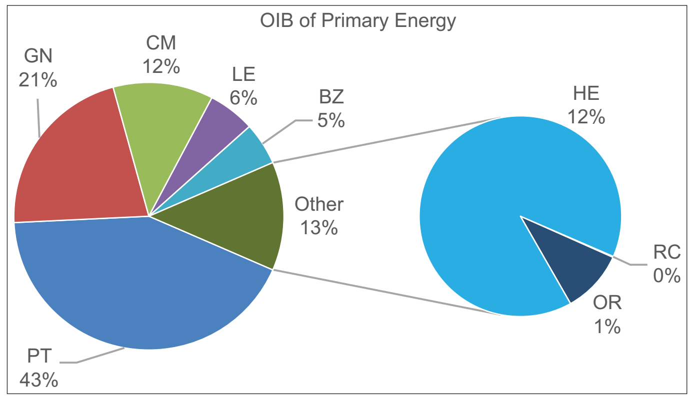
Figure 5 shows the total supply of primary energy in Colombia during the last 8 years. In the total supply, the production of mineral

Table 1: Name abbreviations of primary and secondary energetics

Energetic	Abbreviation
Bagasse	BZ
Mineral carbon	CM
Natural gas	GN
Hydroenergy	HE
Firewood	LE
Petroleum	PT
Recovery/waste	RC
Other renewables	OR
Fuel alcohol	AC
Biodiesel	BI
Coal firewood	CL
Coke	CQ
Diesel oil	DO
Auto&cogenereation	AUT&COG
Electric power of Interconnected Energy System (SIN in Spanish)	EE SIN
Fuel oil	FO
Industrial gas for high oven	GI
Petroleum lquid gas	GL/GLP
Engine gasoline	GM
Kerosene and jet fuel	KJ

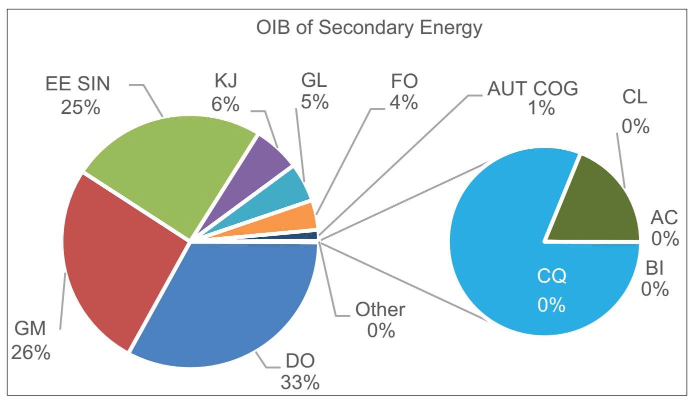
Source of data: Prepared by the authors based on data from (UPME, 2017)

Figure 3: Gross domestic supply (OIB in Spanish) of primary energy sources for the year 2017



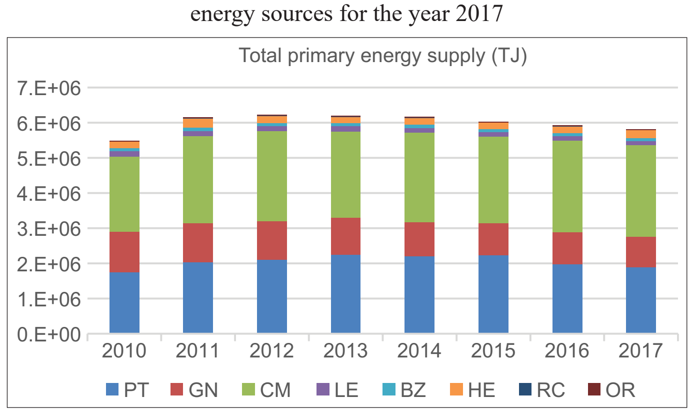
Source of data: Prepared by the authors based on data from (UPME, 2017)

Figure 4: Gross domestic supply (OIB in Spanish) of secondary energy sources for the year 2017



Source of data: Prepared by the authors based on data from (UPME, 2017)

Figure 5: Gross domestic supply (OIB in Spanish) of secondary energy sources for the year 2017



Source of data: Prepared by the authors based on data from (UPME, 2017)

coal and oil predominates with a participation of 32.6% and 44.7% in 2017. Oil production has been showing a slight decrease in the last 2 years due to different factors such as the lack of investment in equipment and technical problems in some fields. On the other hand, the production of mineral coal remains at a more or less constant rate, although in the last 5 years it has increased by 5%.

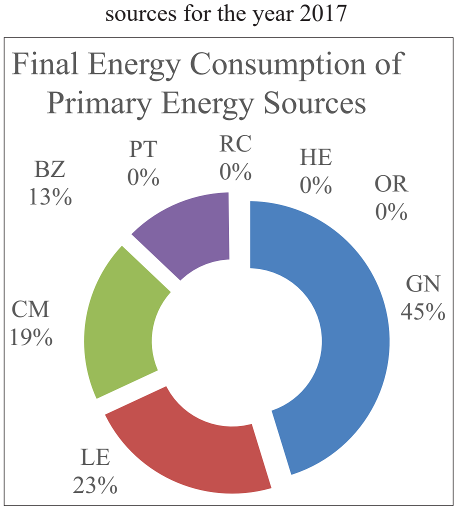
2.2. Final Energy Consumption

The energy in its different forms is a fundamental service for the good development of the industry and the inhabitants of the region. Colombia is a country with a great diversity of energy products that supply the internal demand. In 2017 the final energy consumption 1,255,123 TJ. In Figure 6, it can be seen that much of the final energy consumption of primary energy sources belong to natural gas with 206,777 TJ, followed by firewood with 57,824 TJ, mineral coal with 87,237 TJ, and bagasse with 57,854 TJ. To a lesser extent, oil with 406 TJ, recovery, or waste with 467 TJ. Hydro energy, despite having considerable participation in the gross domestic supply, is not shown in this graph since it is sent to the national interconnected electrical energy system (EE SIN in Spanish).

In 2017, the final energy consumption of secondary energy sources shown in Figure 7, was 798,545 TJ, with strong participation of Diesel oil with 247,319 TJ, followed by motor gasoline 231,952 TJ and the EE SIN with 212,454 TJ. To a lesser extent are kerosene and jet fuel with 48,979 TJ, liquefied petroleum gas with 31,466 TJ, fuel oil 13,048 TJ, auto/cogeneration 11,950 TJ, coke 1,261 TJ and charcoal 295 TJ.

However, in order to have a clear vision of the country's final energy consumption, it is necessary to realize how it is distributed among the different consumption sectors of the country. It can be seen in Figure 8, the sector with the highest consumption is the transport sector with 507,519 TJ, followed by the industrial sector with 299,045 TJ, the residential sector 253,603 TJ. The commercial sector has 75,562 TJ of consumption, and the agricultural, mining, construction, unidentified and non-energy sectors have a total consumption of 119,667 TJ.

Figure 6: Final energy consumption of primary energy sources for the year 2017



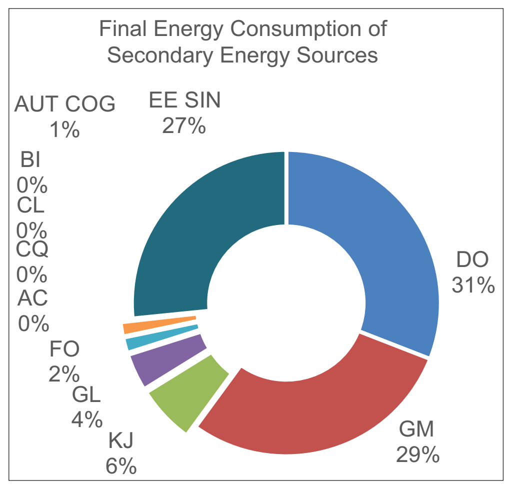
Source of data: Prepared by the authors based on data from (UPME, 2017)

It can be seen that the transport sector has the highest energy consumption, followed by the industrial and residential sectors. The different organizations that promote the efficient use of energy and the use of renewable energy sources must know what type of energy each sector consumes for their research and development of the different mechanisms to achieve the goals in terms of energy efficiencies.

3. PROGRAM FOR RATIONAL USE OF ENERGY AND UNCONVENTIONAL SOURCES IN COLOMBIA

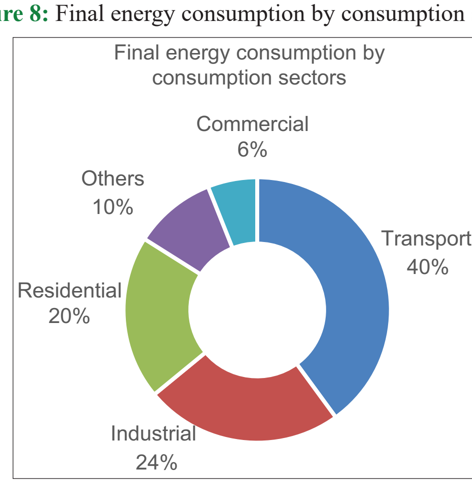
The PROURE program seeks to contribute to increasing energy efficiency, and for this, it uses various strategies that are not only framed in reduction policies and the transformation of energy sources and one hundred percent renewable energy technologies. The rational and efficient use of energy is a concept of productive chain, dynamic and permanent change in accordance with the approaches of sustainable development relating the environmental impacts and the increase in productivity with the efficient

Figure 7: Final energy consumption of primary energy sources for the year 2017



Source of data: Prepared by the authors based on data from (UPME, 2017)

Figure 8: Final energy consumption by consumption sectors



Source of data: Prepared by the authors based on data from (UPME, 2017)

management of resources in production processes. Accordingly, PROURE implements mechanisms of the greater impact that guarantee the energy supply without overflowing with the excessive use of non-renewable energy.

According to the investigations made, Colombia would need to invest close to US $ 730 million in equipment and technologies that allow a 10% reduction in energy consumption, that is, 6300 GWh, if it cannot meet this goal, the country would be forced to make a greater investment to supply future energy demand (Prias, 2010).

In accordance with decree 3683 (Gobierno Nacional, 2003) in which Law 676 of 2001 regulates PROURE:

- It has the participation of public and private agents from the energy sectors, and it is allowed to enter into administrative agreements with other entities.
- Promote sustainable strategies that allow the strengthening of executing entities for the rational and efficient use of energy
- Promote the creation of funds that allow the development of programs and activities that meet the stated objectives
- Develop tax, economic, and recognition incentives with entities that comply with regulations.

Among other activities that fulfill the objectives of the program. Some of the funds created are:

- FAZNI, Financial Support Fund for the Energization of Non-interconnected Areas.
- PRONOE, Electrical Network Normalization Program
- FOES, Social Energy Fund.
- FAER, Financial Support Fund for the Energization of Interconnected Rural Areas.
- FNR, National Royalties Fund.
- FENOGE, Non-conventional Energy Fund, and Efficient Energy Management.

PROURE, from the moment it was created, had in mind the need to create schemes that study energy production in the country and give measurable results of the impact, energy sustainability, and clean energy production. One of its indicators will be energy intensity. PROURE for the current year has a better vision of the prospects of the different energy, environmental, and productive sectors with verification of social impact, quality of life, and productivity (MINMINAS, UPME, 2016).

One of the technological tools that today are the result of PROURE's approaches since its inception is the Colombian energy balance (BECO in Spanish) that today contributes to the country's energy analysis.

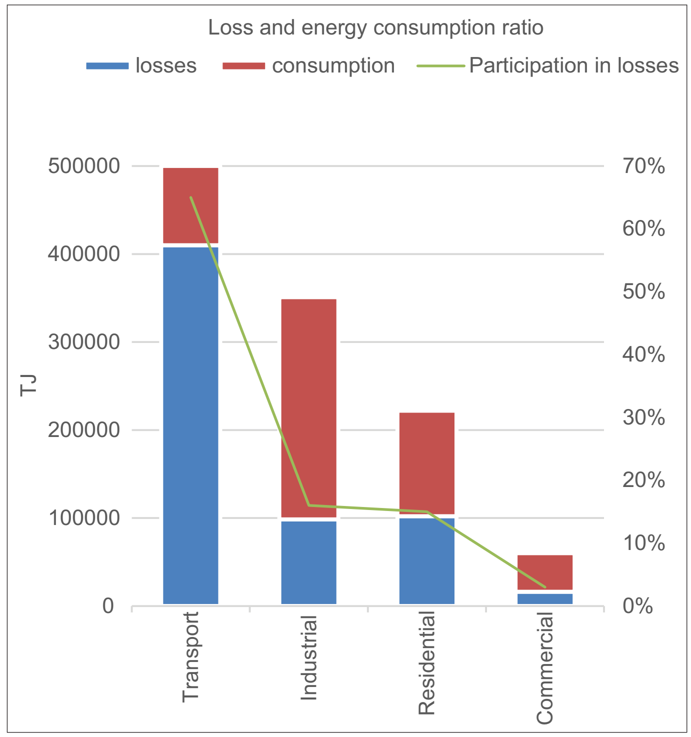
3.1. National Panorama in Energy Efficiency

For the year 2015, the energy wasted in the country amounts to estimated costs of $ 4.7 billion/year. That is, the energy losses of the energy matrix were 52%, and the portion of useful energy was consequently 48%. That is why PROURE considers that Colombia has significant savings potential by improving energy efficiency.

In Figure 9, it can be seen that in one of the sectors with the highest energy losses corresponds to the transport sector with 65%, followed by the industrial sector with 16% and the residential sector with 15%. Therefore, it is of utmost importance to act on the energy efficiency of each sector. For this, it is necessary to know specifically the energy consumption discriminated by energy classes by sector. In this way, PROURE will present solutions for improving energy efficiency.

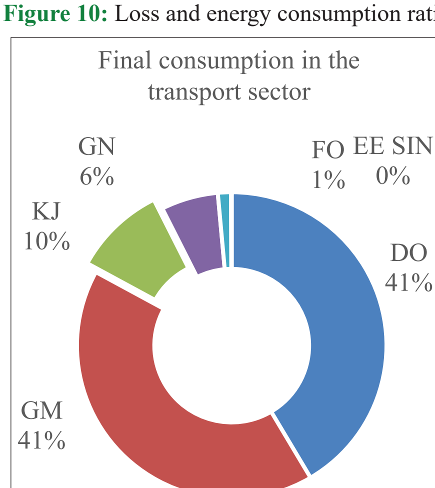
In Figure 10, it is seen in the transport sector that its energy consumption is mostly diesel oil (DO) with 206,679 TJ, followed by motor gasoline (GM) with 229,651 TJ, and in a lower percentage with 20,851 TJ. The transport sector is the sector with the highest consumption of energy and this due to the

Figure 9: Loss and energy consumption ratio



Source of data: Prepared by the authors based on data from (MINMINAS, UPME, 2016)

Figure 10: Loss and energy consumption ratio



Source of data: Prepared by the authors based on data from (UPME, 2017)

geography and demography of the country. This sector presents particularities that make its energy consumption high, such as the distance between the ports and the main cities. In 2017, the final consumption of the transport sector was 507,518 TJ.

UPME divides the transport sector into five subsectors. Air transport consumes 47,977 TJ or 9% of the energy of the sector. Likewise, maritime transport consumes 10,065 TJ or 2%, river transport 438 TJ or 0.09%, rail transport 348 TJ or 0.07%, and finally, road transport consumes 448,691 or 88% of the total energy in the sector. The latter is the one with the highest consumption.

Being of vital importance for the solutions that can be taken against the different consumption sectors of the country and as a sample of the transport sector, it is divided in detail, resulting in the participation of the different segments of road transport that present significant consumption in front of others. Interurban passenger transport represents 27% and private urban passenger transport 21%, and to a lesser extent, public passenger transport represents 12% of the energy consumption of the road transport division (UPME, 2017).

According to the analysis of the transport sector, PROURE proposes some guidelines and goals that help reduce the consumption of liquid fuels and contribute to the reduction of polluting gases. As some are the beginning of mass transport projects in the main cities of the country, the change of cargo vehicles and public transport to new vehicles that meet international standards and the conversion of gasoline vehicles to a compressed natural gas system.

In addition to resolution 186 of 2012 (MADS-MME) that regulates the tax incentives of the exclusion of value-added tax (VAT in Spanish) and deduction of liquid income for clean technologies.

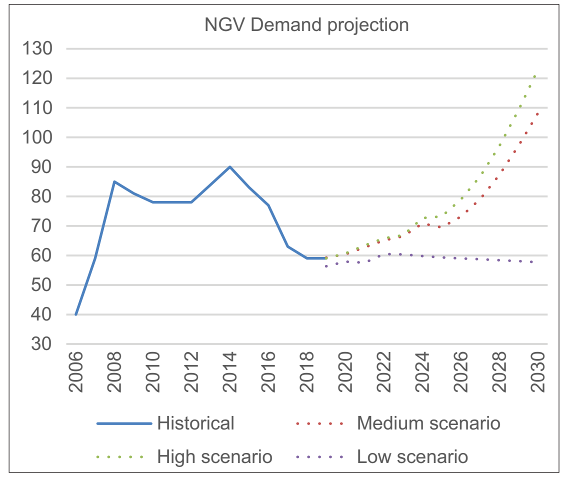
4. PROSPECTS AND PROJECTIONS

Following the analysis of the transport sector as a sample of all the actions that PROURE accompanied by the Ministry of Mining and Energy and its other estates, in the different productive sectors of the country is presented as a quantitative result than that in the transport sector in the year 2017 the reduction in fuel consumption is approximately 994.63 TJ/year and as an externality or desired side effect, the reduction in greenhouse gas emissions is 72,932.23 ton CO_2/year (UPME, 2018).

In Figure 11, the low scenario is assumed for the maintenance and even the decrease in consumption of vehicles that use natural gas for vehicles, and the high and medium scenario is expected due to the increase in consumption caused by the entry of heavy-duty transport vehicles running on vehicular natural gas and in conjunction with the entry of the Pacific regasification plant by 2024 (UPME, 2019).

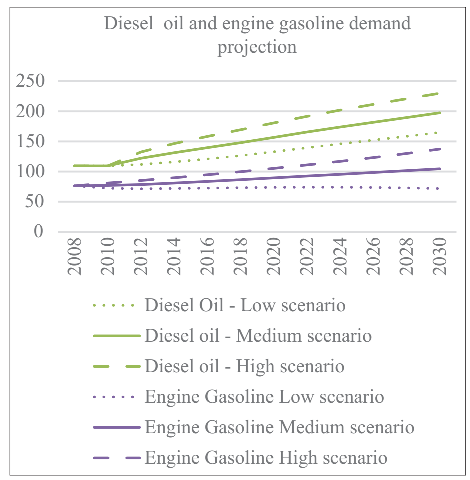
In accordance with this, in Figure 12, the energy mining planning unit (UPME in Spanish) foresees a behavior of the demand for the main fuels. Gasoline will increase the growth rate despite the fact that in recent years it had a reduction, for Diesel that maintains its growth rate, although with gradual reductions and for vehicular natural gas, its growth rate is reactivated as in previous decades (UPME, 2010).

Figure 11: Projection of the demand for vehicular natural gas



Source of data: Prepared by the authors based on data from (UPME, 2019)

Figure 12: Projection of the demand for diesel oil and motor gasoline



Source of data: Prepared by the authors based on data from (UPME, 2010)

On the other hand, in the indicative action plan for energy management of PROURE presented for the periods 2017-2022, it was estimated that the net energy savings in the transport sector in the period would be 424,408 TJ (UPME, 2018).

To achieve these goals, PROURE proposes time-bound measures for the transport sector; some of the measures include:

- That by 2023, an additional 10% must be added to the fleet of inter-municipal public transport passenger vehicles, that is, 6,071 vehicles in total, compared to the base scenario of 3,602 vehicles running on NGV. On the other hand, 24,216 must enter vehicles running on diesel oil compared to 24,182 vehicles planned in a base scenario, and 570 vehicles must enter hybrid vehicles. Also, in this approach, 3,173 gasoline vehicles are considered to be out of circulation. With these measures, PROURE intends to generate an impact not only in consumption but also in emissions, ceasing to generate 1,304,616 MTon of CO_2.

- Taking into account that the fleet of motorcycles, automobiles, campers, and trucks make up 91% of the total. PROURE proposes the entry of 2,082 electric vehicles by 2023, which would mean 0.015% of the automotive fleet. With this measure, the program aims to save net energy by 2,073.6 TJ and stop generating 154,164.4 CO_2.

It is also proposed that by 2025, 1.64% of the total national fleet of private passenger vehicles should enter using liquefied petroleum gas as substitutes for gasoline and Diesel Oil. And in a tractor-trailer or cargo vehicle, 0.010% of the total national fleet must enter as substitutes for gasoline and Diesel Oil for liquefied natural gas. In general, the measures implemented by PROURE would generate a 1.65% reduction in energy consumption in the transport sector.

5. CONCLUSIONS

Colombia has a variety of natural resources that allow it to supply its own energy demand; it also has water resources with high potential for the use of hydropower; It also has high potential natural resources to convert them into non-renewable energy.

Colombia must overcome the barrier of conventional energies and give greater participation to renewable energy sources, taking advantage of a large scale of the renewable energy potentials that it has in its territory and not only hydropower.

It is necessary that the strategies proposed by PROURE continue and are carried out fully so that the projections are reflected in the real figures, in addition to the fact that these measures of change must be increasingly encouraged by promoting new strategies in what converges to technological change in the automotive fleet with vehicles that comply with global energy efficiency regulations, and greater inclusion of hybrid and electric vehicles in public passenger transport systems, as well as the better organization in freight transport logistics to reduce trips empty and the promotion of cargo vehicles that use liquefied natural gas or liquefied petroleum gas.

The necessary measures are being taken to comply with the goals proposed at the Latin American level. However, the PROURE program has been in operation for 17 years, and the results of its execution have only just begun to be implemented, so the proposed results may be seen over the course of the following years.

Colombia needs not only changes in its incentive policies for the use of renewable energy sources, but it also requires a greater economic effort in investing in non-conventional renewable energy projects.

In the course of PROURE's operation in Colombia, it has been possible to create a framework of policies starting from 697 of 2001, the creation of the intersectoral Commission for the rational and efficient use of energy and unconventional sources (CIURE in Spanish). An indicative Action Plan is created, adopted by the Ministry of Mines and Energy.

The characterization of the country's energy matrix and the identification of the four priority sectors were achieved: transportation, industry, residential, and tertiary. And the creation of six programs that represent technical and economic support for the best in the country's energy efficiency, in addition to incentives such as tax exclusion tax benefits and liquid income deduction for investment in efficient systems and equipment in the industry and the transport.

The country's savings potential calculated by the UPME only for the transport and industrial sector and evaluating only some savings actions in particular for each one is 3,977 BPD and 13,471 TJ/Year, respectively.

REFERENCES

Alvarado, R., Ponce, P., Alvarado, R., Ponce, K., Huachizaca, V., Toledo, E. (2019), Sustainable and non-sustainable energy and output in Latin America: A cointegration and causality approach with panel data. Energy Strategy Reviews, 26, 1-10.

Ashbai, A., Gang, F., Iqbal, W., Abass, Q., Mohsin, M., Iram, R. (2019), Novel approach of principal component analysis method to assess the national energy performance via energy trilemma index. Energy Reports, 5, 704-713.

Bildirici, M. (2016), The Relationship between hydropower energy consumption and economic growth. Procedia Economics and Finance, 38, 264-270.

Calderón, S., Álvarez, A., Loboguerrero, A., Arango, S., Clavin, K., Kober, T., Daenzer, K., Fisher-Vanden, K. (2016), Achieving CO2 reductions in Colombia: Effects of carbon taxes and abatement targets. Energy Economics, 56, 575-586.

CEPAL, GTZ. (2003), Sostenibilidad Energética en America Latina y el Caribe: El Aporte de Las Fuentes Renovables. Brasilia: CEPAL. Available from: https://www.repositorio.cepal.org/handle/11362/2764. [Last accessed on 2020 Mar 25].

CEPAL, GTZ. (2004), Fuentes Renovables de Energía en América Latina y el Caribe: Situación y Propuestas de Politicas. Santiago: CEPAL. Available from: https://www.cepal.org/es/publicaciones/31904-fuentes-renovables-energia-america-latina-caribe-situacion-propuestas-politicas. [Last accessed on 2020 Mar 26].

CEPAL. (2017), Avances en Materia de Energías Sostenibles en América Latina y el Caribe: Resultados del Marco de Seguimiento Mundial, Informe de 2017. Santiago de Chile: Santiago CEPAL. Available from: https://www.repositorio.cepal.org/handle/11362/42552. [Last accessed on 2020 Mar 26].

Cronin, J., Anandarajah, G., Dessens, O. (2018), Climate change impacts on the energy system: A review of trends and gaps. Climatic Change, 151, 79-93.

Gobierno Nacional. (2001), Ley 697. Mediante la Cual se Fomenta el Uso Racional y Eficiente de la Energía, se Promueve la Utilización de Energías Alternativas y se Dictan Otras Disposiciones. Bogotá, Colombia: Congreso de la República. Available from: https://www.funcionpublica.gov.co/eva/gestornormativo/norma.php?i=4449. [Last accessed on 2020 Mar 26].

Gobierno Nacional. (2003), Decreto 3683 de 2003, Por el Cual se Reglamenta la Ley 697 de 2001 y se Crea Una Comisión Intersectorial. Bogotá, Colombia: Gobierno Nacional. Available from: https://www.funcionpublica.gov.co/eva/gestornormativo/norma.php?i=11032. [Last accessed on 2020 Mar 26].

Gobierno Nacional. (2008), Decreto 1124 de 200, Por el Cual se Reglamenta el Fondo de Apoyo Financiero Para la Energización de Las Zonas no Interconectadas-FAZN. Bogotá, Colombia:

Gobierno Nacional. Available from: https://www.minenergia.gov.co/normatividad?idNorma=21603. [Last accessed on 2020 Mar 26].

Harjanne, A., Korhonen, J. (2019), Abandoning the concept of renewable energy. Energy Policy, 127, 330-340.

IRENA. (2018), Global Energy Transformation: A Roadmap to 2050. Abu Dhabi: IRENA. p1-76. Available from: https://www.irena.org/publications/2018/apr/global-energy-transition-a-roadmap-to-2050. [Last accessed on 2020 Mar 26].

MINMINAS, UPME. (2016), Plan de Acción Indicativo de Eficiencia Energética 2017-2022. Bogotá, Colombia: MINMINAS. Available from: https://www.1.upme.gov.co/paginas/plan-de-acci%c3%b3n-indicativo-de-eficiencia-energ%c3%a9tica-pai-proure-2017---2022.aspx. [Last accessed on 2020 Mar 27].

NU. CEPAL, CAF. (2013), Energía: Una Visión Sobre Los Retos y Oportunidades en América Latina y el Caribe. Egypt: CEPAL, CAF. Available from: https://www.cepal.org/es/publicaciones/1505-energia-vision-retos-oportunidades-america-latina-caribe. [Last accessed on 2020 Mar 28].

OLADE. (2019), Enerlac. Enerlac, 3(2), 12. Available from: http://www.biblioteca.olade.org/opac-tmpl/documentos/hm000752.pdf.

Prias, O. (2010), Programa de Uso Racional y Eficiente de Energía y Fuentes no Convencionales (PROURE). Bogotá DC: Ministerio de Minas y Energía.

Pupo-Roncallo, O., Campillo, J., Ingham, D., Hughes, K., Pourkashanian, M. (2020), Renewable energy production and demand dataset for the energy system of Colombia. Data in Brief, 28, 105084.

Solaun, K., Cerdá, E. (2019), Climate change impacts on renewable energy generation. A review of quantitative projections. Renewable and Sustainable Energy Reviews, 116, 109415.

UPME. (2010), Proyección de la Demanada de Combustibles Líquidos y GNV en Colombia. Bogotá, Colombia: UPME. Available from: http://www.sipg.gov.co/sipg/documentos/proyecciones/2010/proyecc_dem_do_gm_gnv_sept_2010.pdf. [Last accessed on 2020 Mar 29].

UPME. (2017), BECO. Available from: https://www.1.upme.gov.co/informacioncifras/paginas/becoconsulta.aspx. [Last accessed on 2020 Mar 30].

UPME. (2018), Informe de Gestión 2017-2018. Bogotá, Colombia: UPME. Available from: http://www.1.upme.gov.co/informesgestion/informe_de_gestion_2018_19092018.pdf. [Last accessed on 2020 Mar 26].

UPME. (2019), Proyección de Gas Natural en Colombia 2019-2033. Bogotá, Colombia: UPME. Available from: http://www.sipg.gov.co/portals/0/demanda/proyeccion_demanda_gn_dic_2019.pdf. [Last accessed on 2020 Mar 26].

van der Zwaan, B., Kober, T., Calderon, S., Clarke, L., Daenzer, K., Kitous, A., Labriet, M. (2016), Energy technology roll-out for climate change mitigation: A multi-model study for Latin America. Energy Economics, 56, 526-542.

WEC, Wyman, O. (2019), World Enegry Trilema Index. London: WEC. Available from: https://www.worldenergy.org/publications?cat=69. [Last accessed on 2020 Mar 26].

WEC. (2011), Policies for the Future: 2011 Assessment of Country Energy and Climate Policies. London: WEC. Available from: https://www.worldenergy.org/publications. [Last accessed on 2020 Mar 26].

WEC. (2015), World Energy Resources: Charting the Upsurge in Hydropower Development 2015. London, United Kingdom: WEC. Available from: https://www.worldenergy.org/publications/entry/charting-the-upsurge-in-hydropower-development-2015. [Last accessed on 2020 March 26].

World Economic Forum. (2017), Global Energy Architecture Performance Index Report 2017. Cologny, Geneva, Switzerland: World Economic Forum. Available from: http://www.3.weforum.org/docs/wef_energy_architecture_performance_index_2017.pdf. [Last accessed on 2020 Mar 26].