

# Electric Power in Colombia

## Power Generation



# 2015



- The outlook for the Colombian energy sector is broadly positive; demand for electricity is steadily growing and the Government has taken several positive steps to encourage investment in the sector. *Business Monitor, 2015.*
- According to Business Monitor, during the period 2015-2019, Colombia's overall power generation will increase by an annual average of 3.6%, reaching 81,300 GWh in 2019. *Business Monitor, 2015.*
- The main driver of this growth is the increase in annual average gains of 4.0% in hydroelectric power generation, while coal and gas-fired generation are forecast to increase by an annual average of 2.7% and 2.5% respectively. *Business Monitor, 2015.*

Profile: Electric power in Colombia -  
Investment opportunities - Power  
Generation



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## Why to Invest in Power Generation in Colombia?

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- **Colombia has a solid and well-established regulatory framework:** Since 1994, 2 reforms (laws 142 and 143) were implemented aiming primarily to foster the private investment in the sector. This has translated into business opportunities for companies that have specific projects. In addition, currently the property of companies in the stages of generation and distribution is mainly from foreign companies.
- **Resources to enhance the expansions:** Colombia has natural resources for power generation: water, coal and the possibility of gas in amounts that allow greater supply than that of the country's demand. *"The hydropower resources inventory conducted in 1979, shows a potential in generation capacity of 93,085 MW."* (Acolgen, *the Expansion of Power Generation, 2012-2018.*)
- The Expansion of Power Generation and Transmission Plan 2012-2018 By UPME (Mining and Power Planning Unit) indicates for 2019-2028 time frame, that **Colombia requires a power installed capacity increase, in order to guarantee the power supply reliability.**
- **The World Bank forecasts that power demand in Latin America will double between 2008 and 2030**, reaching 2,500 TWh by the end of that year. This growth implies the need for an additional 239 GW in the region approaching 330 GW of installed capacity.
- **Attractive international interconnection projects** that will increase energy exports to Latin American countries. Interconnection project between Colombia – Panama (2018), Andean Electrical Interconnection System between Ecuador, Peru, and Chile.
- The **National Interconnected System (NIS)** connects 48% of the national territory and covers 97% 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.
- Thanks to its geospatial position, Colombia has **potential to generate energy from non-conventional resources such as solar, wind, biomass, geothermal and solid waste.**
- **Law 1715 of 2014 integrates non-conventional renewable energy to the national energy system.** This law promotes the development and use of non-conventional energy sources (especially those from renewable sources), in the national energy system, establishes the legal framework and instruments for the use of non-conventional energy sources (FNCE for its acronym in Spanish), especially those from renewable sources, and **creates tax incentives for the investment in this kind of projects.**
- **110 power generation projects under development** in different stages, which add up to 4,974 MW. 97 hydraulic projects which add up to 3,631 MW, 8 thermal projects equivalent to 858 MW, 4 wind projects which estimate to produce 654 MW, and 1 solar with an installed capacity of 19.9 MW

# Power Generation

## Installed Capacity

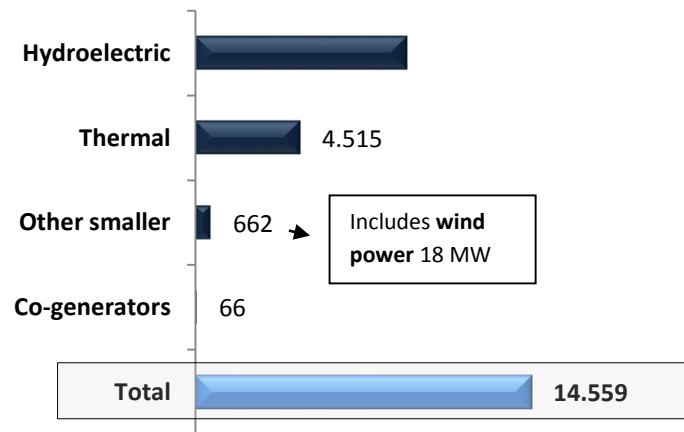
The actual **net installed capacity** in the NIS (National Interconnected System) is **14,559 MW**. XM, 2015.

**Water resources for energy production represent 64% of the country's energy matrix**, followed by **thermal with 31%** and finally other smaller (hydraulic, thermal and wind) and co-generators with 5%.

Hydroelectric and thermal power generation, have increased 1, 4% and 2% respectively in comparison to 2012. Meanwhile, **wind power generation has remained stable** showing a flat production in both years.

This increase is mainly due to the launch of operations of the hydropower plants in *Amoyá la Esperanza* of 80 MW, Darío Valencia Samper 2nd unit with 50 MW and the thermal upgrade of the main fuels, among other reasons. XM, 2015.

Net Effective Capacity of SIN by energy resource in 2013\* (MW)

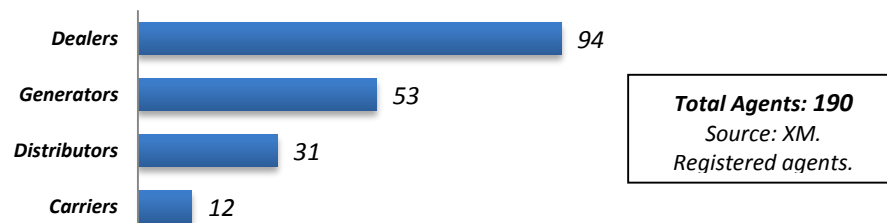


\*2013, December YTD Data.  
Source: XM.

## Agents of the Energy Market in Colombia

In 2013, there were a total of 53 generators available, 5 more than in 2010 (48 generators). In the same year, there were 94 power dealers and 31 energy distributors, while in 2010; there were only 85 and 44 respectively. In terms of carriers there were 12 in 2013 vs. 11 in 2010.

Registered Agents of the Energy Market in Colombia - 2013

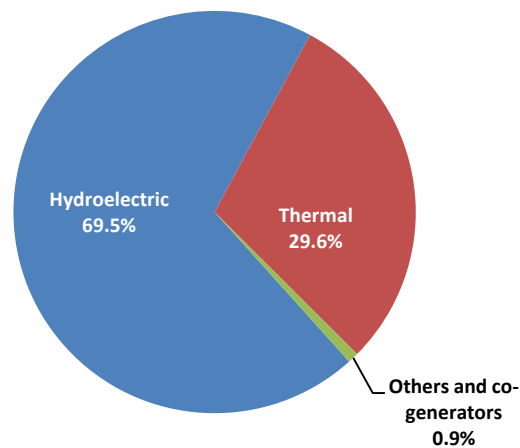


# Energy Production

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- Historically, **the main source of power in Colombia is hydropower**. In 2014, hydropower produced 44,734.11 **GWh**, followed by **thermal energy** with 19,043.64 **GWh** and other co-generators and generators with less than 549.89 GWh.
- In recent years, **power generation in Colombia has shown a steady average growth of 2.8%**. Between 2010 and 2014, power generation increased by 13%.
- In 2014, power generation grew by 3.4% to 64,327.65 GWh in comparison to 2013.
- At the end of 2013, the **annual generation of electric power in Colombia was 62,196.6 GWh**, that is 3.7% higher than 2012, in the same period (59,988.9 GWh). This positive development was mainly due to the increased demand and exports to Venezuela and Ecuador. *XM, 2015.*

## Breakdown of the Generation of SIN in Colombia During 2014



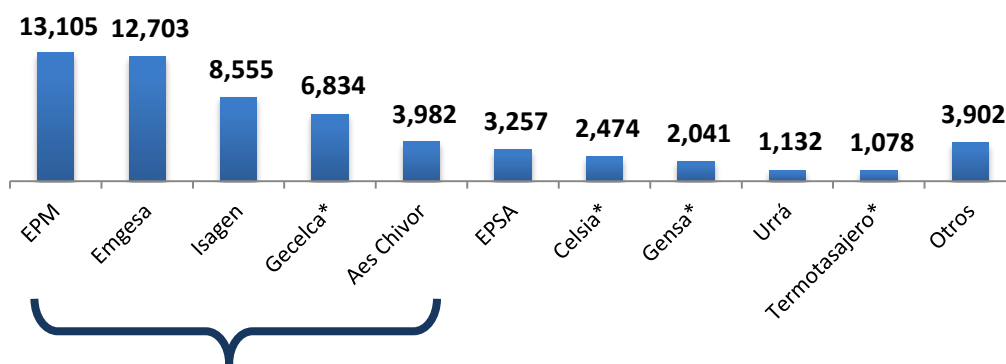
**Total generation 2014: 64,327.65 GWh**

Source: XM.

## Power Generation Agents

- Of the 53 **power generators** in Colombia, the production is mainly driven by **ten large companies** that are able to generate **about 93% of energy** in the country. Small power generation agents produce the remaining 7%.
- Currently, power generation is led by **EPM, EMGESA and ISAGEN** with a total production in 2014 of **13,105 (29.3%), 12,703 (28.4%) and 8,555 (19.1%) GWh** respectively. In 2015, with the start up production of Hidrosogamoso Hydroelectric Plant (820 MW), ISAGEN will become the second largest producer in Colombia.

Main Power Generating Agents (GWh) - 2014

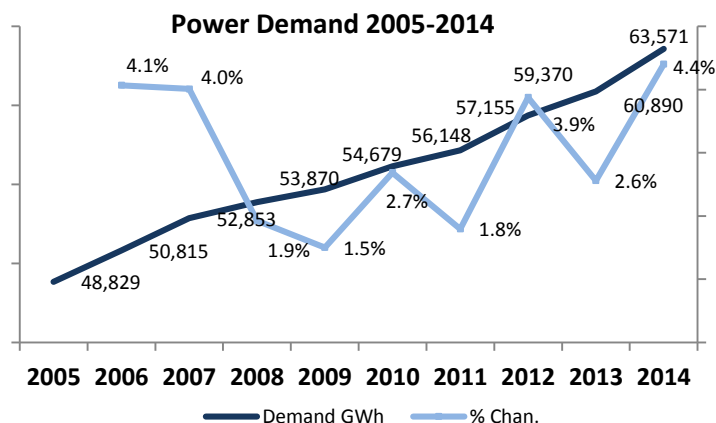


Source: XM. \*Data 2013.

**86%** of the total power

## Energy Demand

- In 2014, Colombia reached its highest growth in energy demand in the past 10 years (4.4%) with a consumption of **63,571 GWh**. XM, 2015.
- This was mainly because the energy demand of the **regulated market increased 5%**, given the increase in mining and quarrying industries. XM, 2015.



Fuente: XM



Meanwhile, **the non-regulated market represented 32.4% of the total demand** growing by 2.5% in comparison to 2012.

### Regulated and Non-regulated Market

**Non-regulated users (also known as Large Users)** are those who consume more than 100 kW, or its equivalent in power consumption of 55 MWh/month. These users can sign bilateral contracts with dealers where prices and quantities are negotiated freely between the two parties.

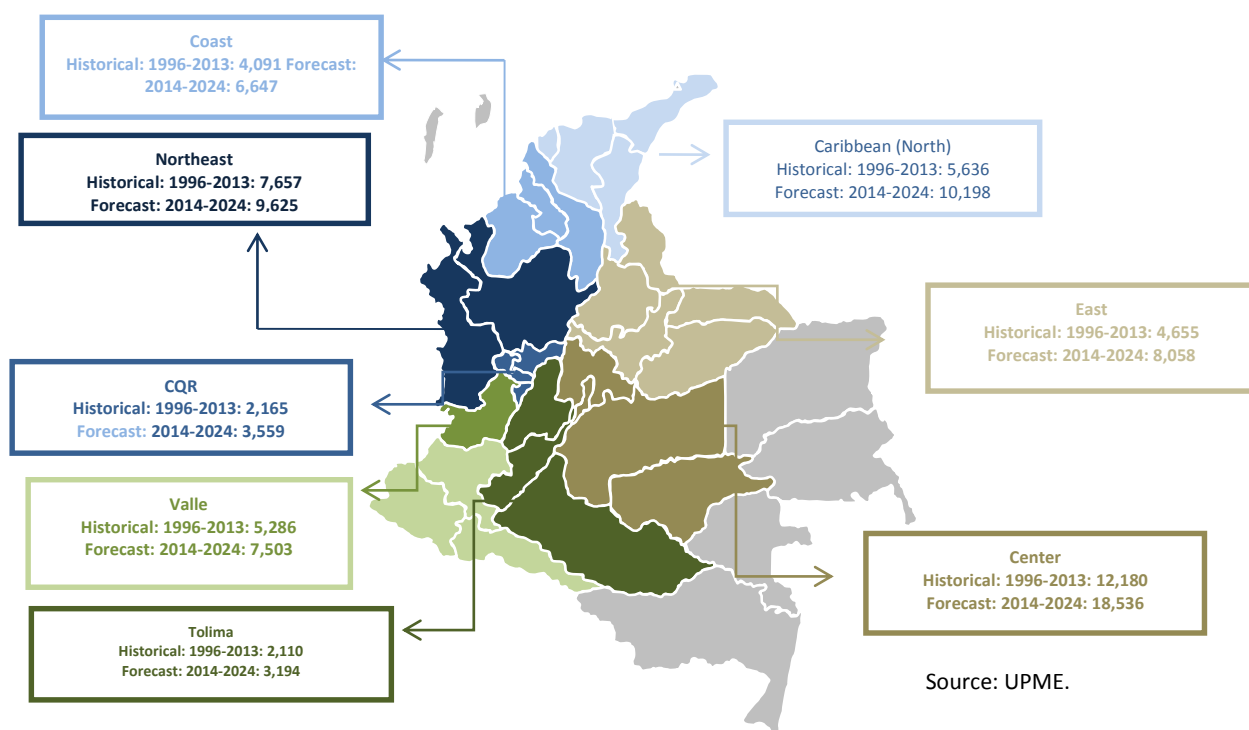
Users who do not fit within this category are classified as **Regulated Users** and therefore, subject to CREG (The Energy and Gas Regulation Commission) regulated rates that are subject to having a general pricing structure.

### Energy Demand by Region

Between 1996 and 2013, the regions that demanded the largest amounts of energy were **the central regions with an average of 12,120 GWh**, followed by the **northwestern region** with an average demand of **7,657 GWh**. *UPME, 2015.*

According to the energy expansion plan in Colombia, the Coffee Triangle region is the area that will have a higher energy demand growth rate between 2014 and 2024 (5.3%). The second region will be the Caribbean with an average growth rate of 3.6% and the Eastern area with 3.5% in the same period. *UPME, 2015.*

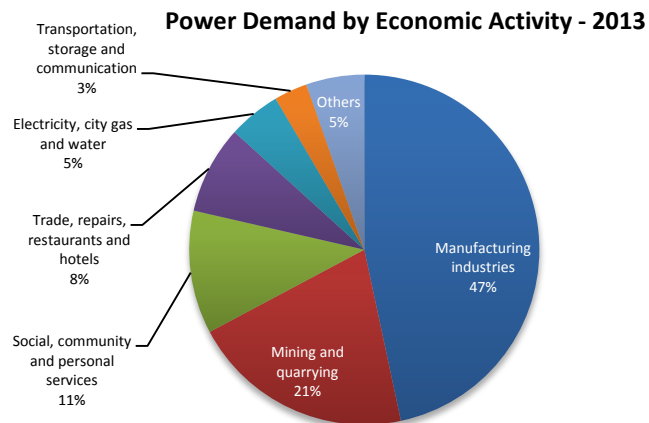
Energy Demand by Region - Historical and Forecasted - (GWh)





## Energy Demand by Industry

- The manufacturing industry was the largest user of energy, demanding 9,546 GWh, followed by mining and quarrying (4,386 GWh) and in third place social, community and personal services with 2,423 GWh.
- The demand of these three sectors represented 73% of the total demand of nonregulated market.

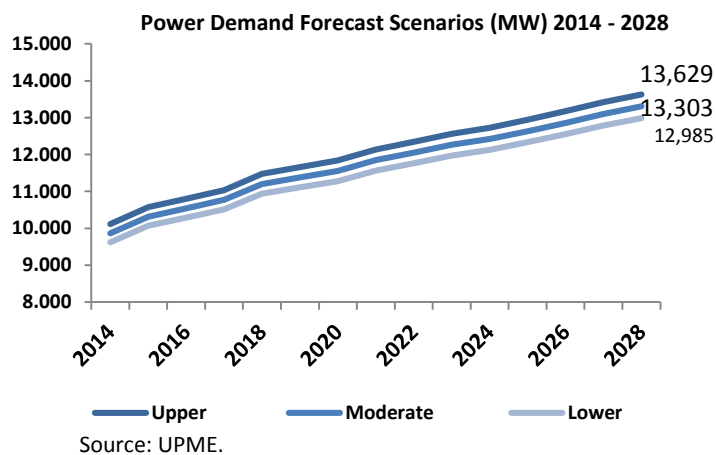


Total demand: 20,867 GWh

Source: XM.

## Power Demand Forecast (Installed Capacity)

- From 2022, energy production will tend to present a deficit thanks to the delay in specific projects such as Ituango and the non-execution of Porvenir II project.



In the short term, forecasted between 2014 and 2019, it can be determined that the plants governed under the Reliability Framework and those that are in development, can meet the criteria for energy reliability established by the regulation taking into account the assumptions included in this plan, and possible project delays. UPME

For the long-term period (2019-2028), an installed capacity increase is required to achieve the "cargas de confiabilidad" criteria.

- The UPME has been evaluating several options to diversify the power generation matrix. In this regard, the "Expansion and reference plan of power generation and transmission 2014-2018" approaches those exercises, leveraged also with the Law 1715 of 2014 (nonconventional renewable energy).
- The results have established important reciprocities between renewable resources of Non Conventional Energy Sources - NCES, and water alternatives traditionally contemplated.

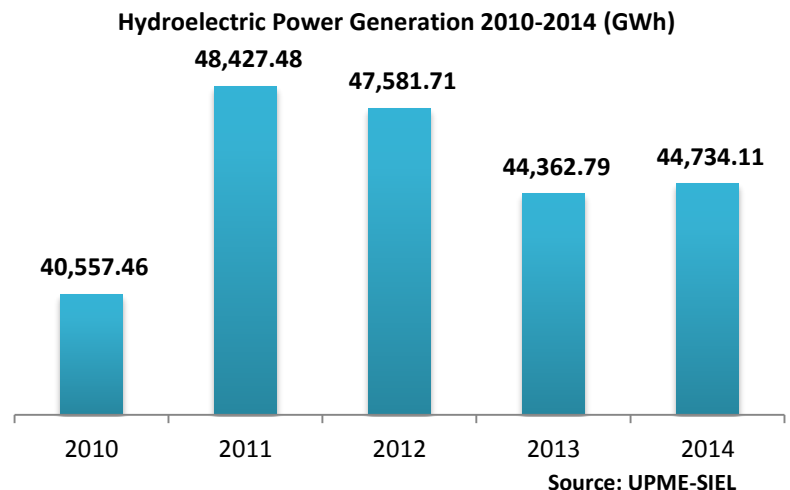
## International Power Network

- Currently, Colombia is structuring and participating in several regional projects for power network expansion. For instance, there is a project with Panama for the Central America interconnection. This project would have a capacity of 100 MW.
- For 2018, a new interconnecting network is expected with Ecuador. This project would have a total transport capacity of 300 MW and is also a great effort to develop the 'Andean Power Interconnection System' with Bolivia, Chile, Ecuador and Peru.

## Hydroelectric Power Generation

- In 2014, **hydroelectric power** generation represented **69.5%** of the total production in the country.

- The **availability of water resources** to generate power in Colombia is determined, amongst other factors, by the geographical location of our territory, the topography and its interaction with the Intertropical Convergence Zone (ITCZ), determining the annual rainfall patterns in each region. *UPME, 2015.*



- Under normal conditions and in most of the country, there are **two rainy seasons that supply reservoirs**; however, climatic phenomenon (e.g. *El Niño* phenomenon) have affected the normal conditions during some years. *UPME, 2015.*

- Rainfall levels in Colombia vary** within the different regions, ranging from **500 mm (19 inches) per year in the Guajira** in the north of the country to **2,000 mm (78 inches) in Chocó** located in the western side of the nation. *Blue planet.<sup>1</sup> Planeta azul, 2015.*

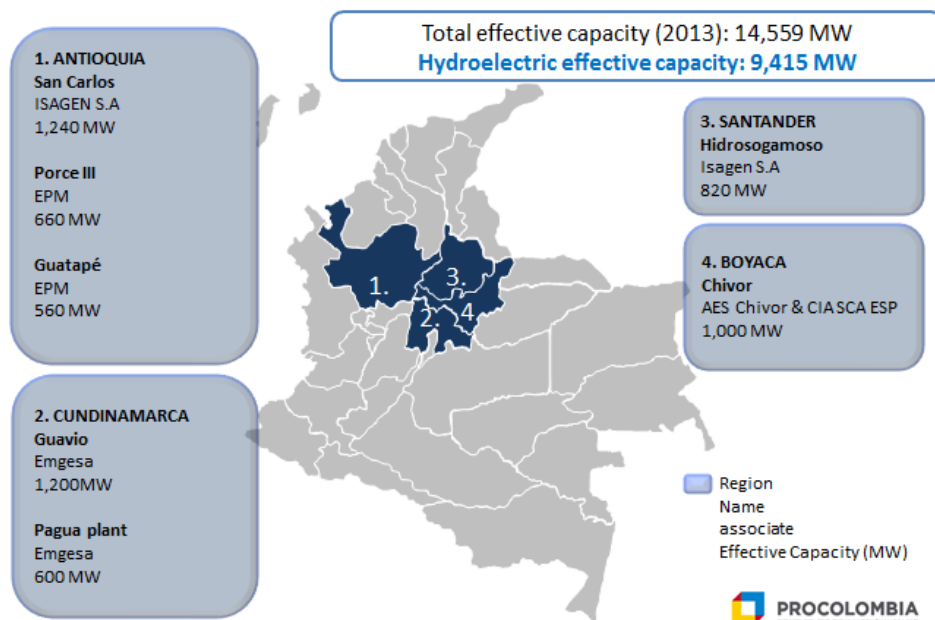
- Between 2014-2018, hydroelectric power production will increase by 5,443 GWh per month** as a result of the launch of the first stage of the projects: Ituango and Porvenir II (2018-2020). In addition,

1. Banco de Occidente - Planeta azul. See bibliography.

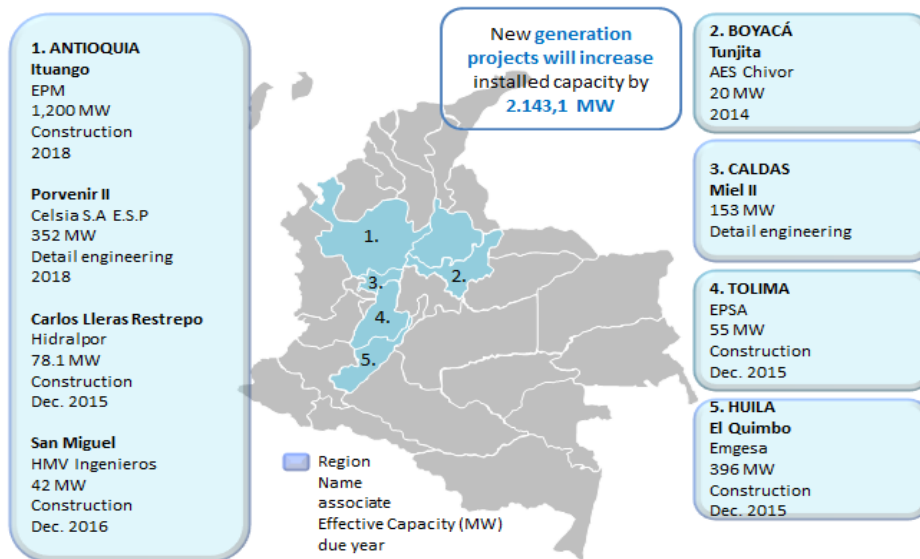


with the launch of the second stage of Ituango, hydroelectric generation is expected to reach a production of 6,200 GWh per month (2022-2028).<sup>2</sup> UPME, 2015.

### Main Hydropower Plants in Colombia and future projects



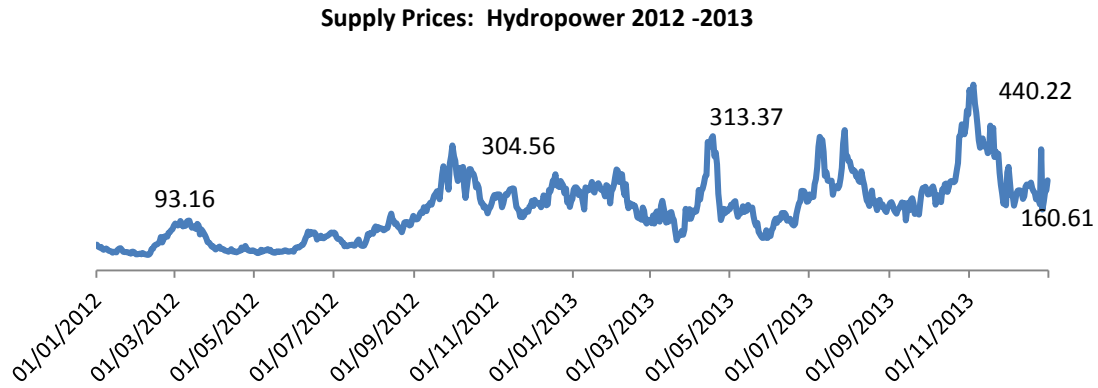
### Generation projects – Under construction



2. UPME. Expansion plan and reference, p. 272.

## Price of Hydropower Generation<sup>3</sup>

- The price of hydropower has been flat in recent years varying close to 0.7%.



Source: XM

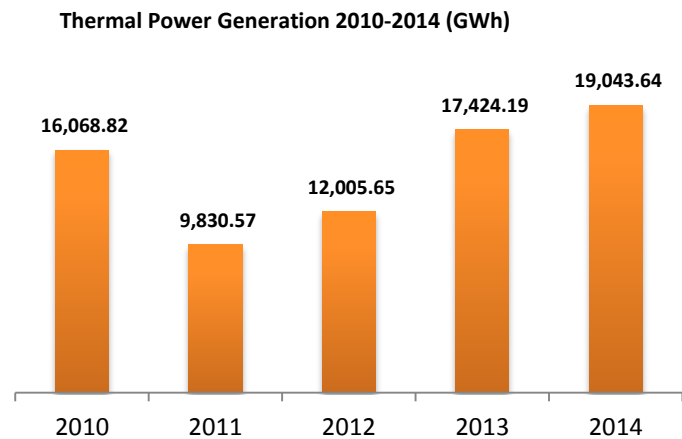
- The price of energy has fluctuated in the last two years from \$ 452.81 COP/KWh (0.24 US\$/KWh) , to \$73.29 COP \$ /kWh (0.04 US\$/kWh) since November of 2013.

## Thermal Power Generation

- In 2014, **thermal power generation reached its highest share in total power generation in Colombia (29.6%)** with an increase of 9.3% compared with 2013.

- The **net effective thermal power generation capability in 2013 was 4,556 MW, representing 31.2%** of total capacity. *UPME, 2015.*

- The **main resources used in thermal power generation in Colombia are natural gas** with a participation in 2013 of **21.5%**; followed by **coal with 6.5%** and other liquids with less than 1% (ex. fuel oil, diesel fuel, Jet A1 as well as industries waste production processes). *UPME, 2015.*



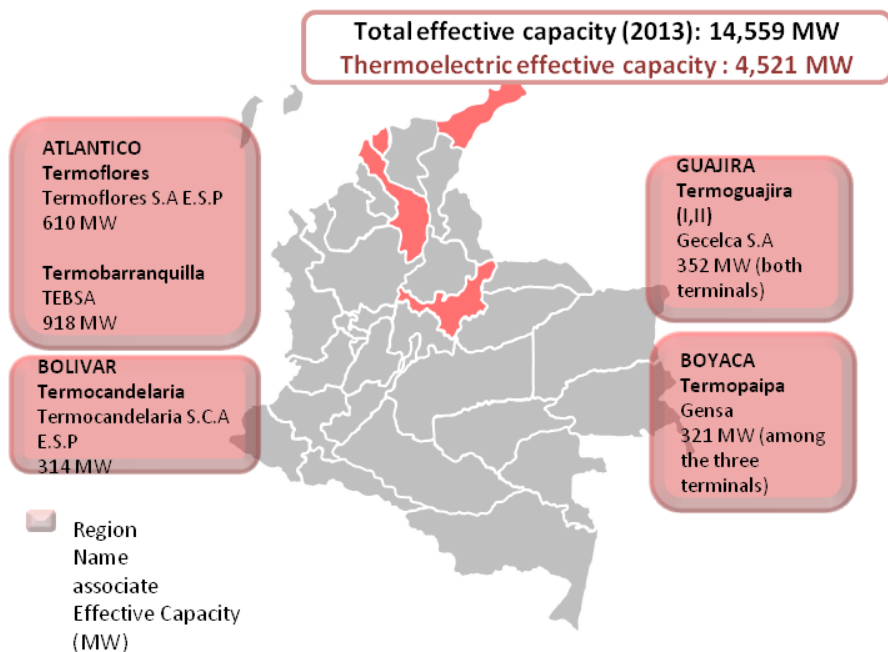
Source: UPME-SIEL

3. The prices of technology supply are calculated as a weighted average for technology, in this case, thermal.

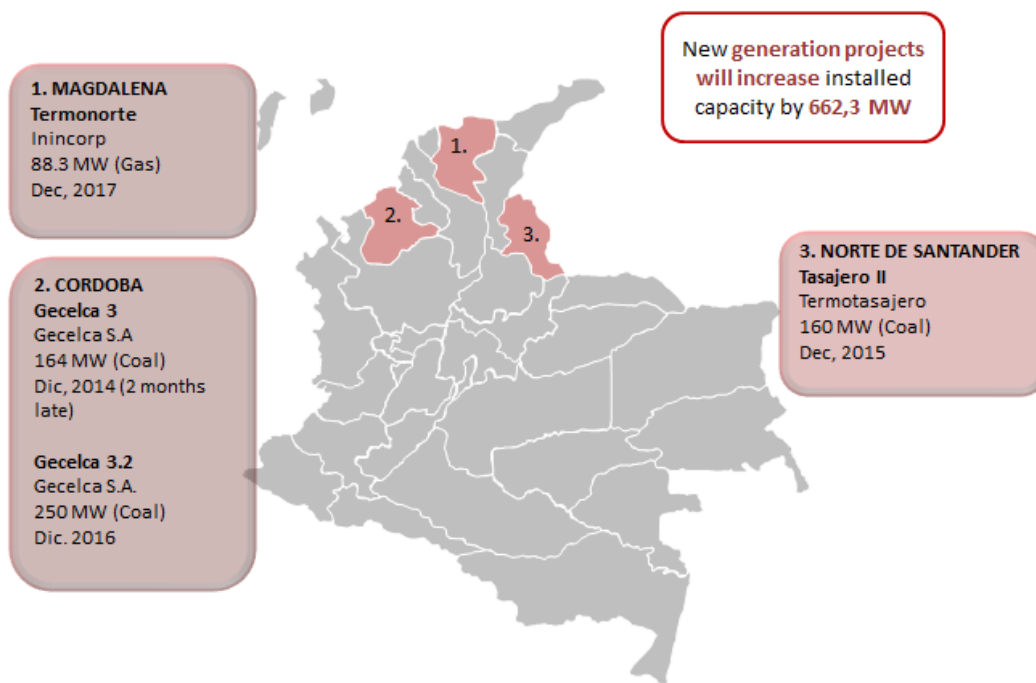


Thermal power generation has grown 9.4% on average between 2010-2014. In 2011, there was a drop as a result of an increase in hydropower generation driven by favorable precipitation conditions.

### Main Thermal Plants in Colombia



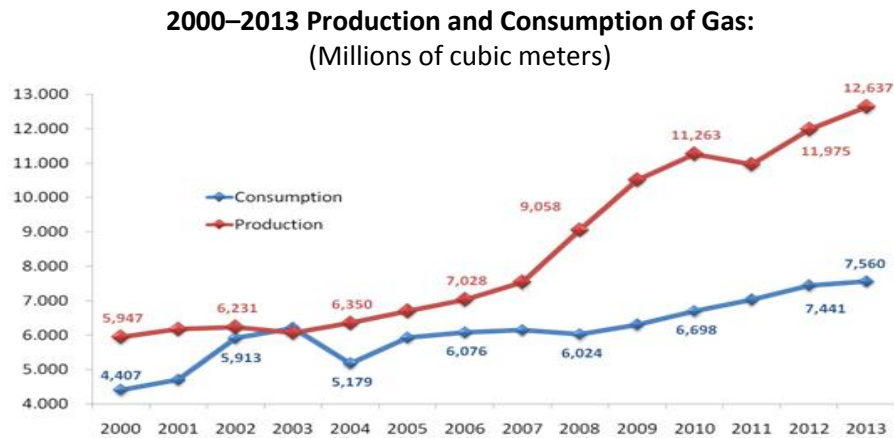
### Main Thermal Projects



## Top Thermal Resources for Energy Production

### Production and consumption of gas in Colombia

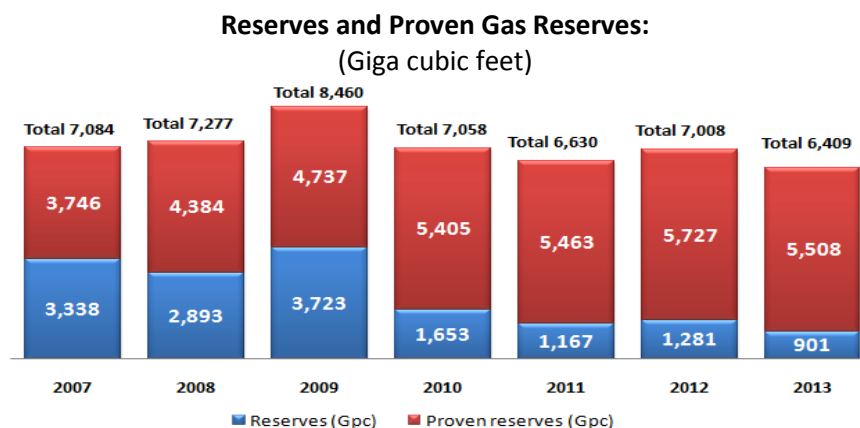
- In the last ten years gas production has grown on average 6.8% equivalent to 9,099 billion cubic meters. Meanwhile, the average consumption has reached 6,416 billion cubic meters resulting in a 2.5% growth.



Source: BP Statistical Review of World Energy, 2014.

### Gas Reserves in Colombia

- Between years 2007-2013, the **proven gas reserves increased on average by 6.9%**. In 2013, combined gas reserves and **proven reserves totaled 6,409 giga cubic feet**. However, in 2013, gas reserves in Colombia were the smallest seen in recent years, with 901 GCF (giga cubic feet), a drop of 3.8% compared to 2012.



Source: ANH, 2014.

## Price of Thermal Generation with Gas Resources<sup>4</sup>

- The electricity gas prices have remained on average at \$247.38 COP /kWh (0.13 US\$/kWh) between 2012 and 2013, with an average variation of 0.7%.

**Power Price Produced with Gas, 2012-2013**

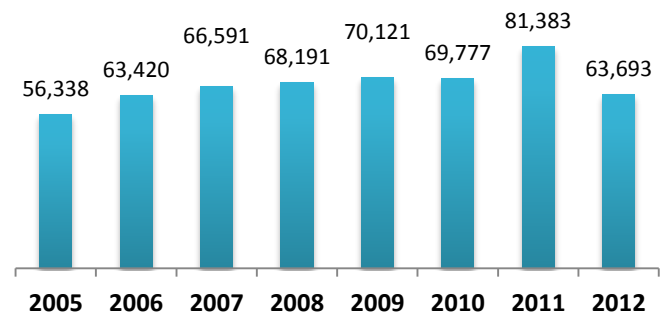


Source: XM.

## Coal in Colombia

- Between 2010 and 2013, the average growth rate of coal production was 4.3%.
- In 2012, (latest figures) **94.4% of the total coal production** in Colombia, was **destined to produce thermal coal used for power generation**.
- The production of thermal coal reached 67.97 mt at an average growth rate of 2.5% between 2005 and 2012. *SIMCO, 2015.*

**Thermal Coal Production 2005-2012**  
(Million tons)

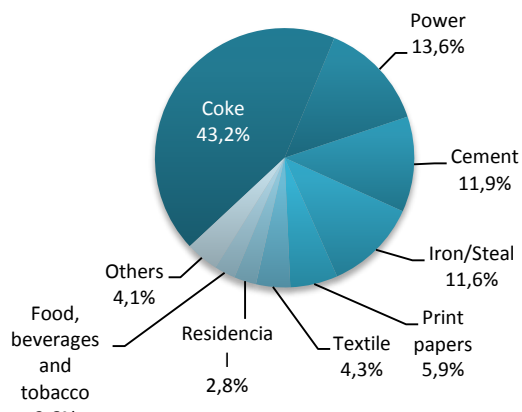


Source: UPME-SIMCO.

- Coal is mainly used in the manufacturing of coking coal (43%), followed by the generation of electricity (13.5%) and cement manufacturing (11.8%).
- In 2011, the average price per ton reported by the thermoelectric power plants was US \$60.3/t.

4. The prices of technology supply are calculated as a weighted average for technology, in this case, gas.

**Coal consumption by sector, 2011**



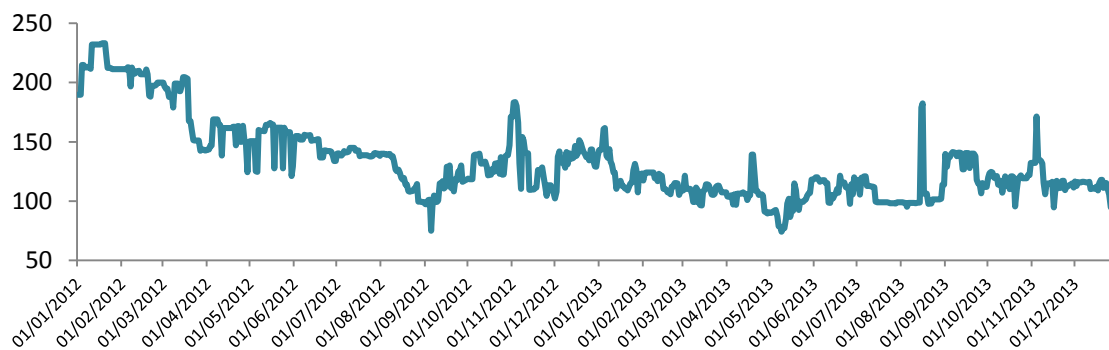
According to 2011 data, **proven coal reserves in Colombia amounted to a total of 6,507.6 million tons**, of which 84% are concentrated in the northern part of the country in the departments of La Guajira and Cesar. Other regions of Colombia with coal reserves are Córdoba, Cundinamarca and Boyacá, with an 11.6% share.

Source: UPME-SIMCO.

## Price of Energy Generated from Coal Resources<sup>5</sup>

The variation in price per kilowatt generated from thermal coal has been steady between 2012 and 2013, where the average variation rate was only 0.2%. The average price was \$132.57 COP /kWh during this period.

**Supply Price: Power Produced by Coal, 2012-2013**



Source: XM.

## Renewable Nonconventional Energy Generation

**Law 1715 of 2014**, (the Renewable Energies Law) established tax, customs and accounting incentives in favor of generating energy using non-conventional sources mainly renewable.

- **Incentives for FNCE projects in non-interconnected zones:** Incentives will be developed for power providers in non-interconnected zones, which substitute diesel generation. *Pending regulatory framework.*

5. The prices of technology supply are calculated as a weighted average for technology.



- **Tax incentives:**
  - Income tax deduction. *Pending regulatory framework.*
  - VAT exemption for goods and services used in the development of FNCE projects. *Pending regulatory framework.*
- **Tariffs incentives:** Exemption from payment of customs duties when importing machinery, equipment to be used in the development of new FNCE projects. *Pending regulatory framework.*
- **Accounting incentives:** Accelerated depreciation of assets. *Pending regulatory framework.*

## Connected and Non-connected Zones in Colombia



■ 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.

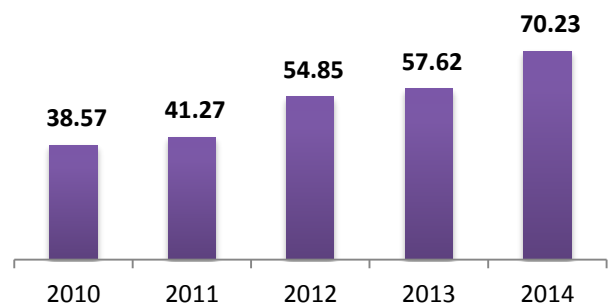
## Wind Power Generation

■ Between 2010 and 2014, wind power represented on average 0.1% of energy generated in Colombia. In that same period, Colombia produced an average of 52.2 GWh from wind sources.

■ In 2014, 70.2 GWh were generated. During 2014 wind generation grew by 21.9% compared to the 2013.

■ The net installed wind generating capacity is 18 MW (2013), which equates to 0.1% of the country's total net generating capacity.

Wind Power Generation 2010-2014 (GWh)

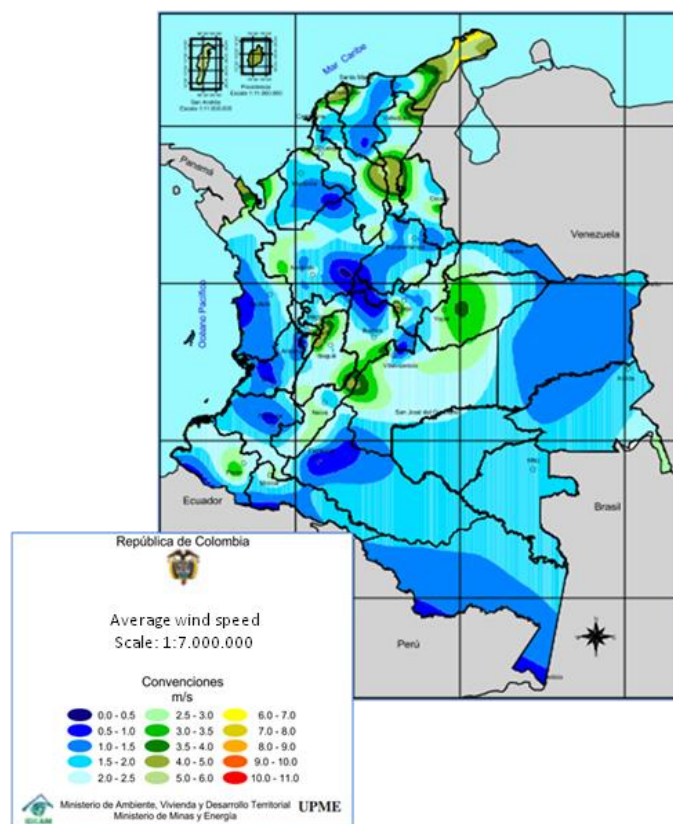


Source: UPME-SIEL

## Regions with Electricity- Producing Potential

- In **La Guajira department**, wind speed remains at 5 m/s during the year, optimum speed for producing wind energy. **This region presents the main opportunity to develop wind projects.** IDEAM, UPME.
- In the departments of **Bolívar, Atlántico, Norte de Santander and Cesar**, average winds in the open countryside can exceed 5 m/s during some months of the year. IDEAM, UPME.
- In the department of **Bolívar wind speed can reach 11 m/s**, but in the month of April there is a significant reduction in the intensity of winds towards the center of the country because of the presence of the Intertropical Convergence Zone, where winds are weaker. IDEAM, UPME.

## Wind Park in Colombia La Guajira and wind potential map



Source: XM.



# Solar Power Generation

Colombia has high potential for solar energy and advantages because solar radiation throughout the country is uniform during the year.

Regions with potential:

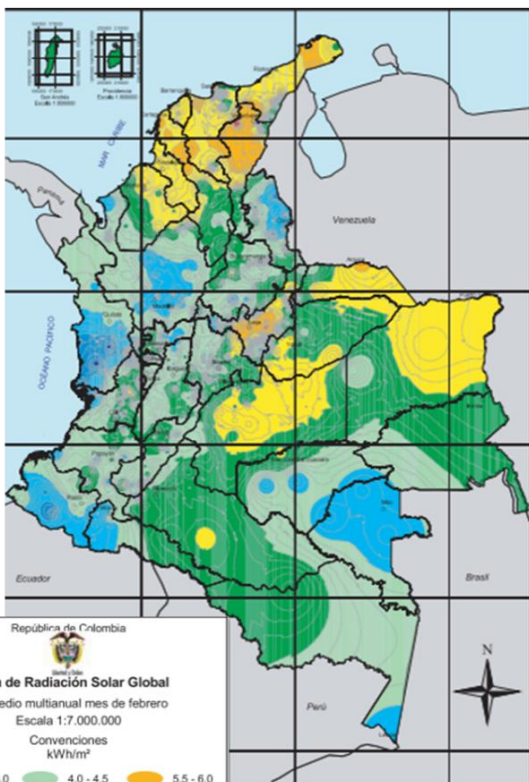
- Magdalena, La Guajira, San Andres, and Providencia: 5 to 6 kWh/m<sup>2</sup>
- Casanare, Arauca, Guainía, Guaviare, Amazonas, Putumayo, and Vaupés: 4 to 5 kWh/m<sup>2</sup>
- The Pacific Coast: The lower radiation is around 3kWh/m<sup>2</sup>

Average Availability of Solar Energy	
Region	kWh/m <sup>2</sup> /year
Guajira	2,190
Atlantic Coast	1,825
Orinoquia	1,643
Amazon	1,551
Andean	1,643
Pacific Coast	1,278

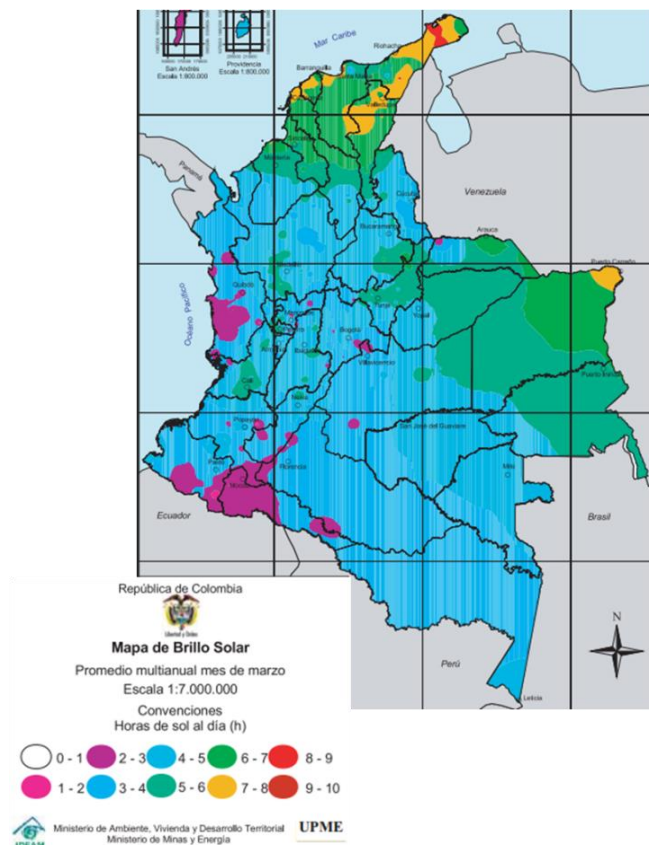
Source: IDEAM.

## Approximate Multiyear Average Availability of Solar Energy by Region

Solar radiation in Colombia



Solar brightness in Colombia

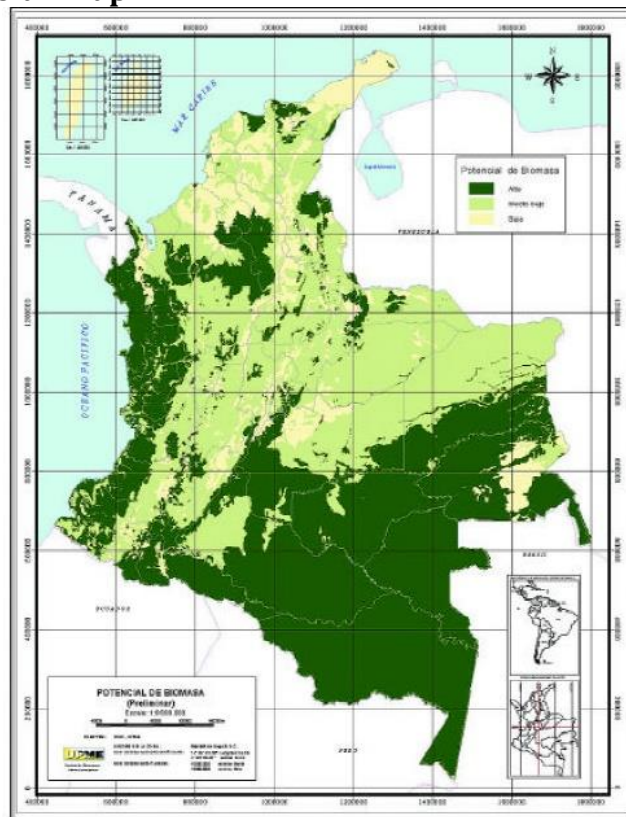


# Biomass Power

Colombia has preliminary biomass studies about:<sup>6</sup>

- Cane bagasse: Annual production is estimated at 7.5 million tons of bagasse, much of which is used for heat production. The installed capacity of biomass power production is estimated at 25 MW.
- Rice husk: More than 457,000 tons are produced annually; the major producers are the regions of Santanderes, the Eastern Plains and the Atlantic Coast.
- 


## Biomass in Colombia - Map



Source: UPME.

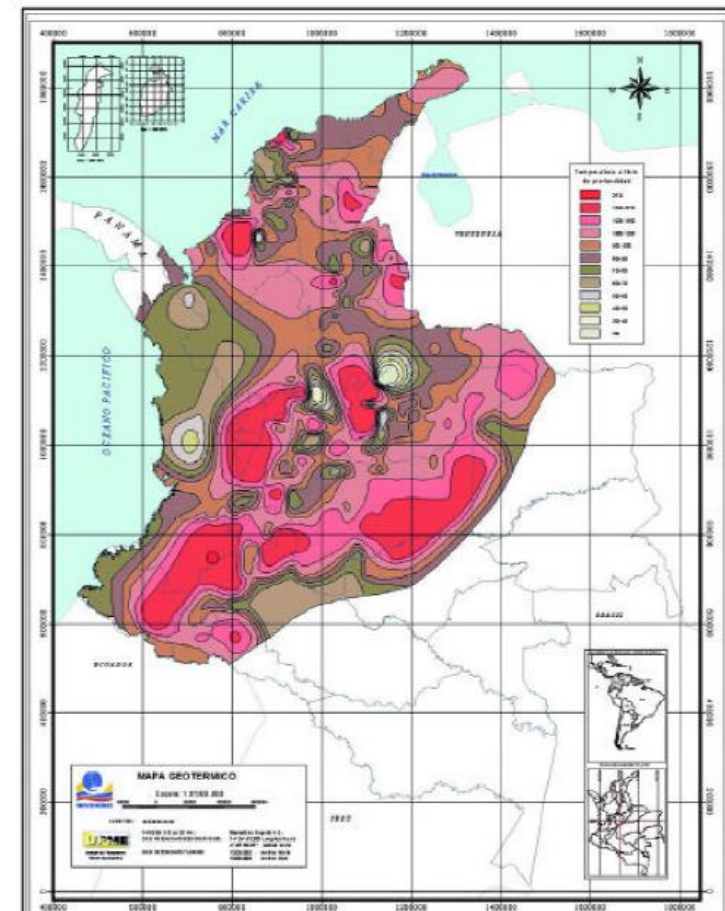
6. UPME - Renewable energy: description, technologies and uses.

# Geothermal Power Generation

 The Colombian Geothermal Atlas highlighted 4 areas with great potential for power production:<sup>7</sup>

- Border with Ecuador: in Volcanes Chiles - Cerro Negro
- In the department of Nariño, Azufral volcano.
- 
- National Natural Park of Los Nevados.
- Paipa geothermal area - Iza in Boyacá.

## Geothermal in Colombia



Source: UPME.

7. UPME: renewable energy: description, technologies and uses.

## Bibliography

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- 📄 **Business Monitor International**
- 📄 **UPME (Unidad de Planeación Minero Energética)** En: Plan de expansión de referencia generación - Trasmisión 2014-2018. "Expansion and plan reference of power generation and transmission, 2014-2018.
- 📄 **UPME:** Energías Renovables: descripción, tecnologías y usos finales. Renewable energy: description, technologies and uses.
- 📄 **SIEL:** Sistema de información de energía eléctrica - Electric power information system.
- 📄 **SIPG:** Sistema de información de petróleo y gas - Oil and gas information system.
- 📄 **XM:** Informe de operación del SIN y administración del mercado. INS operation information.
- 📄 **BP:** Statistical review of world energy, June 2014.
- 📄 **IDEAM:** Atlas de viento y energía eólica de Colombia y Atlas de radicación solar en Colombia - Wind and wind energy atlas in Colombia and solar radiation atlas in Colombia.
- 📄 Front photo: © Alfonso Giraldo – Photography.

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