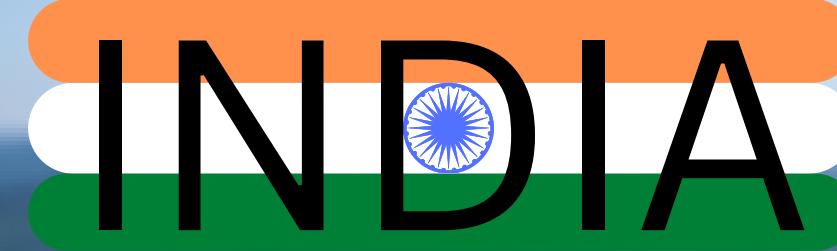


SWITCH ENERGY CASE COMPETITION



Team Vidyut 

#197

Mentor :-

Moosa Dhillon



Colombia

Darshan Jain Ayrika Chakrabarti Avnish Sinha Aryandeep

A wide-angle photograph of a natural landscape during sunset. The sky is filled with large, billowing clouds that are illuminated from behind by the setting sun, creating a warm orange and yellow glow. In the foreground, there's a body of water, possibly a lake or a wide river, with some ripples on its surface. On the left side, there's a dense forest of tall trees. In the background, there are several hills or low mountains covered in green vegetation. The overall atmosphere is peaceful and scenic.

OVERVIEW

Population Trends

Total Population in 2021 - 51,265,841

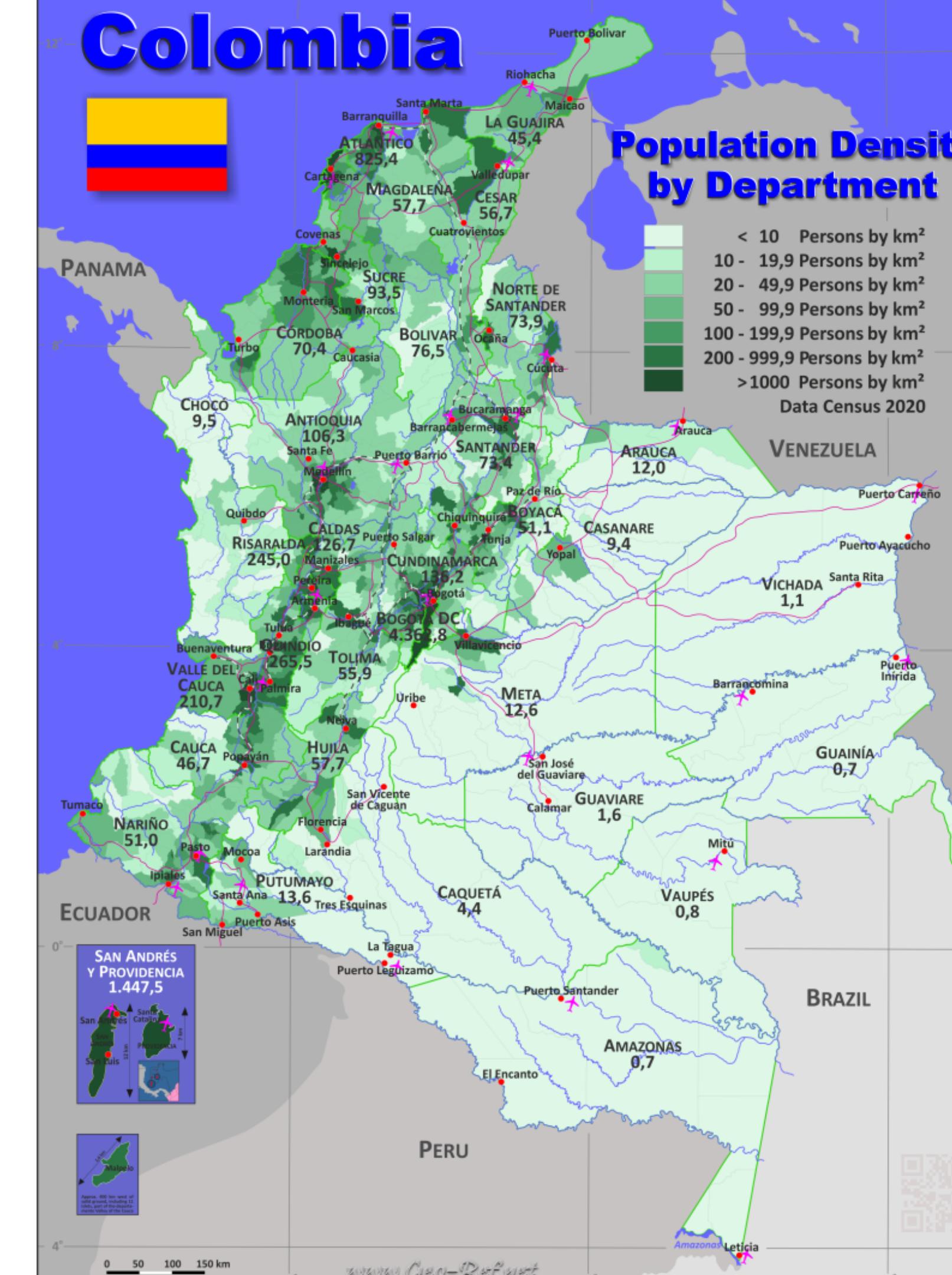
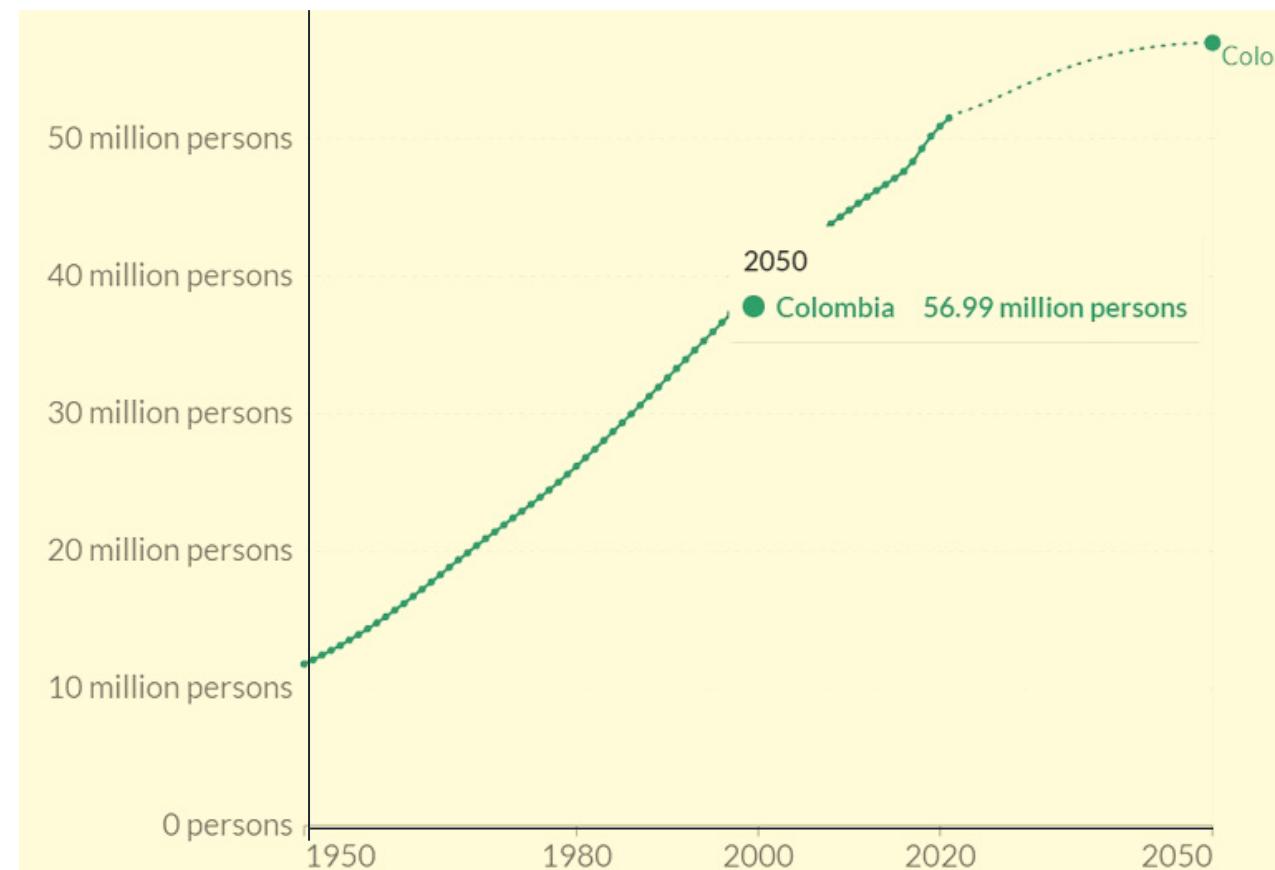
Source: World Bank

Population Density in 2020 - 46inhab/sq. km

Source: World Bank

Expected Population in 2050 - 56,990,000

Source: [OurWorldinData.org](https://ourworldindata.org)



Energy Consumption

Colombia could provide itself completely with self-produced energy. The total production of all electric energy producing facilities is 75 bn kWh, which is 110% of the countries own usage.

[Source: WorldData.info](#)

Energy Balance

Electricity	total	Colombia per capita
Own consumption	68.25 bn kWh	1,331.30 kWh
Production	74.92 bn kWh	1,461.40 kWh
Import	378.00 m kWh	7.37 kWh
Export	460.00 m kWh	8.97 kWh

100.0% of the country's population (as of 2020) has access to electricity.

[Source: WorldData.info](#)

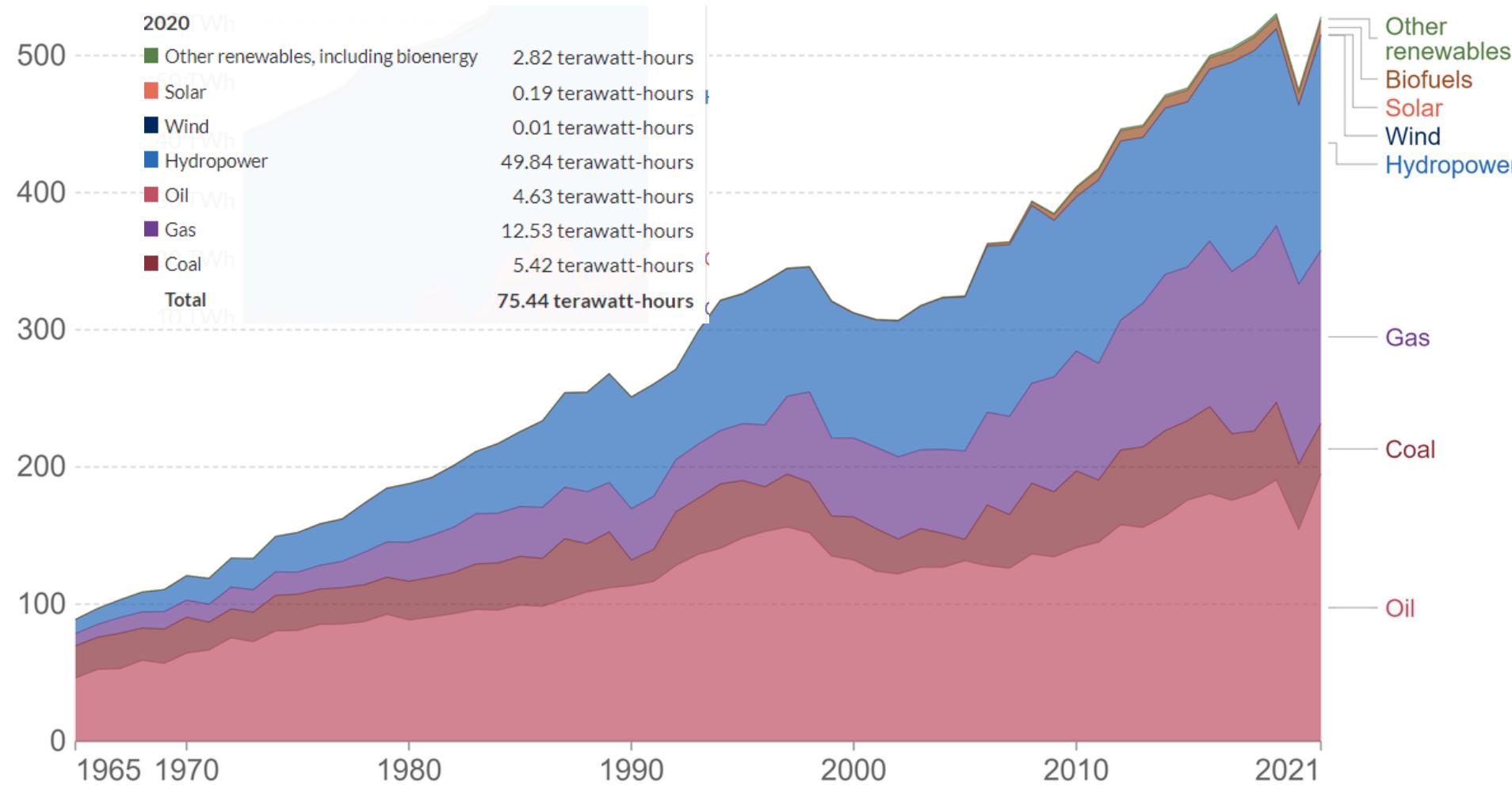
Colombia imports electricity from Ecuador to help meet demand. In 2020, Colombia imported 1.3 gigawatthours of electricity.⁴³ Colombia's and Ecuador's electrical grids are linked by dual 230-kilovolt power lines spanning 132 miles.



Energy Consumption Breakdown

Energy consumption by source, Colombia

Primary energy consumption is measured in terawatt-hours (TWh). Here an inefficiency factor (the 'substitution' method) has been applied for fossil fuels, meaning the shares by each energy source give a better approximation of final energy consumption.

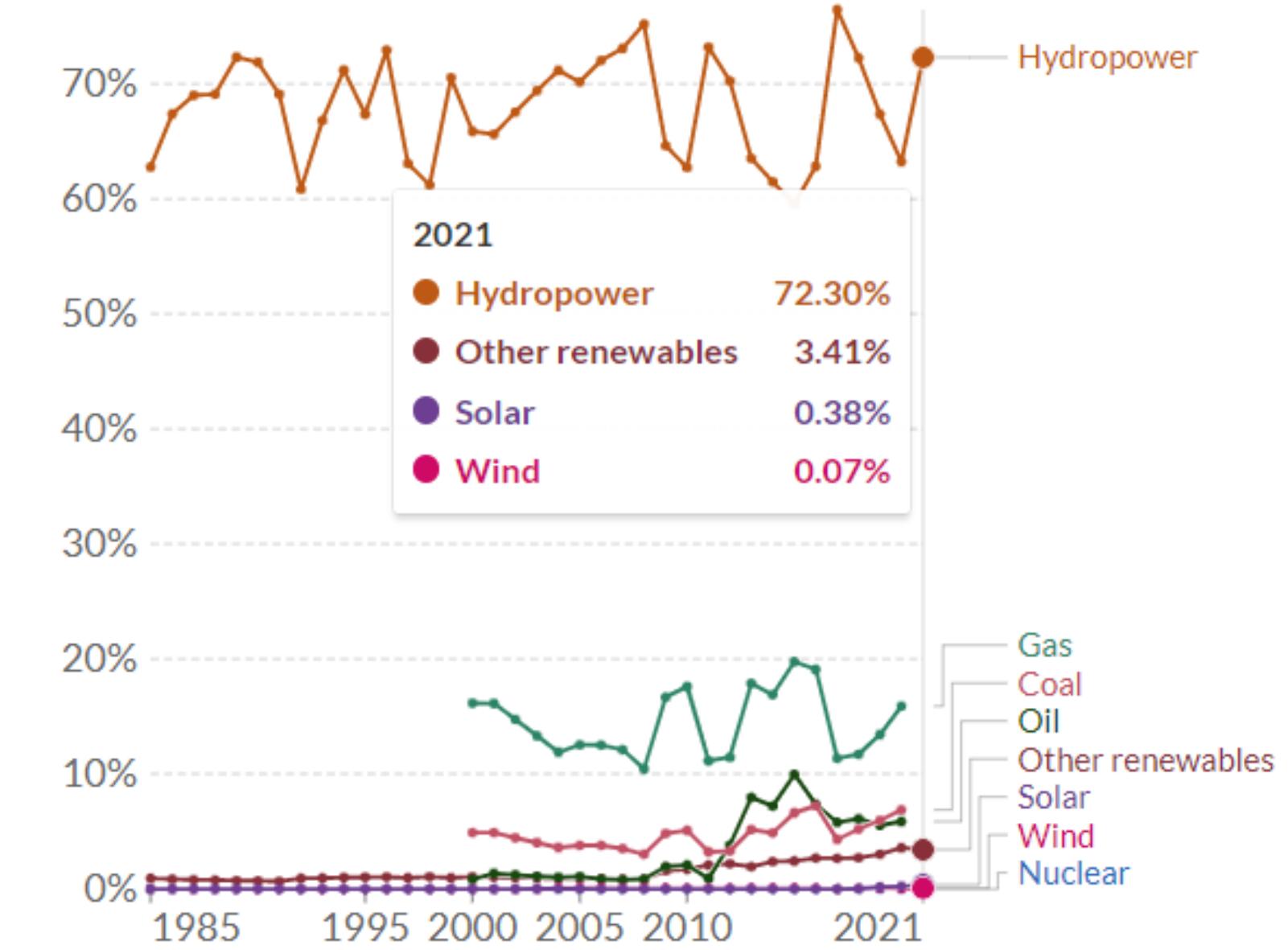


Source: BP Statistical Review of World Energy

Note: 'Other renewables' includes geothermal, biomass and waste energy.

OurWorldInData.org/energy • CC BY

Source: Our World in Data



Source: Our World in Data based on BP Statistical Review of World Energy & Ember
OurWorldInData.org/energy • CC BY

Source: Our World in Data

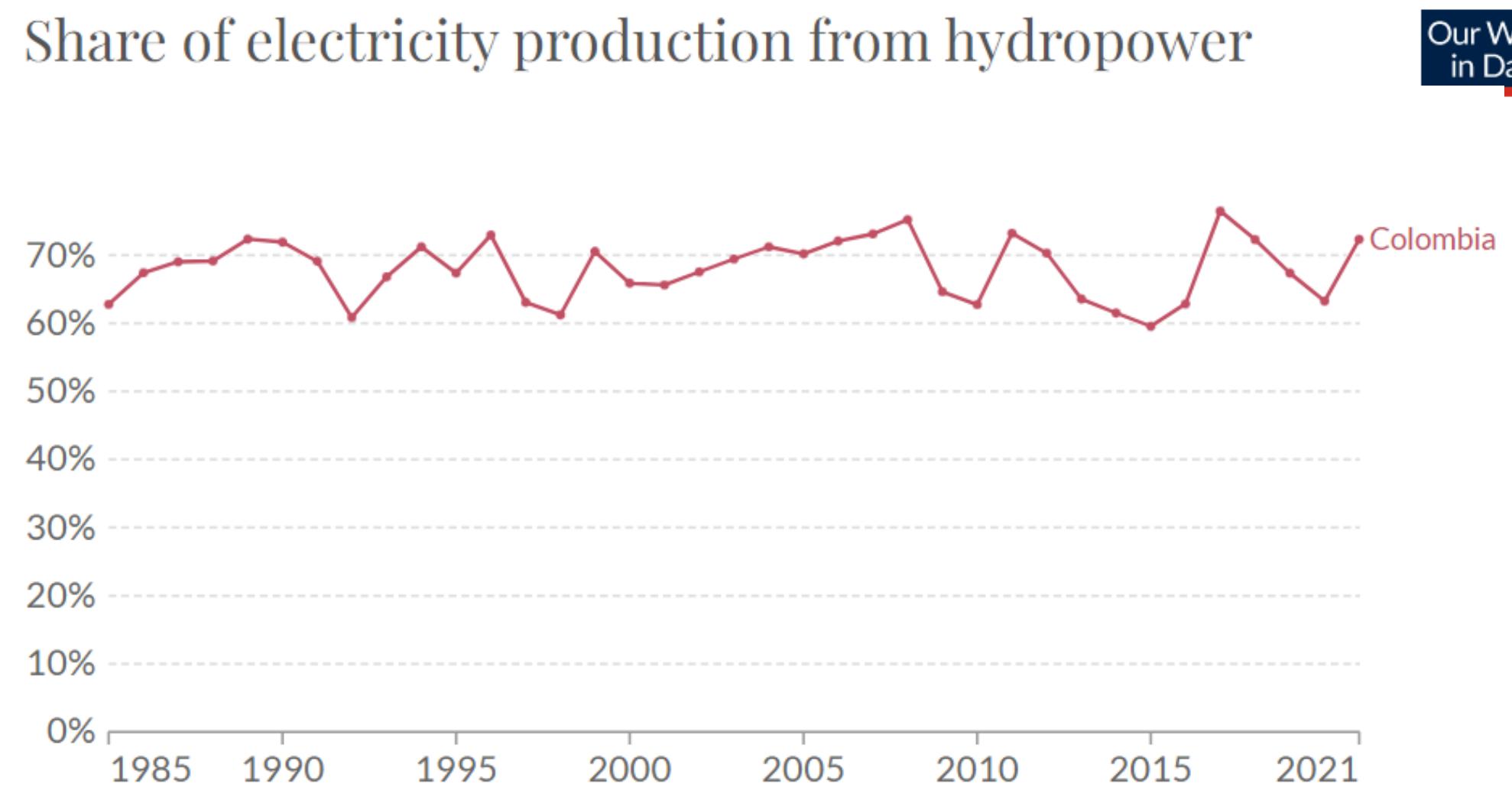
CHALLENGES

A photograph showing a woman from behind, walking away on a dirt path. She is wearing a white short-sleeved shirt and pink rain boots. The path is surrounded by green vegetation and trees. In the background, there's a building with a red door and a satellite dish antenna. The overall scene suggests a rural or semi-rural environment.

Excessive Dependency on Hydropower

The Colombian power system significantly depends on hydroelectricity, which meets approximately 65% of the country's electricity demand, making it vulnerable to droughts, particularly those caused by the El Niño–Southern Oscillation.

Source: [Frontiersin.org](https://frontiersin.org)



From the graph, it is very clear that the production value decreases significantly during El Nino years and the country has to manage the energy supply by importing the energy

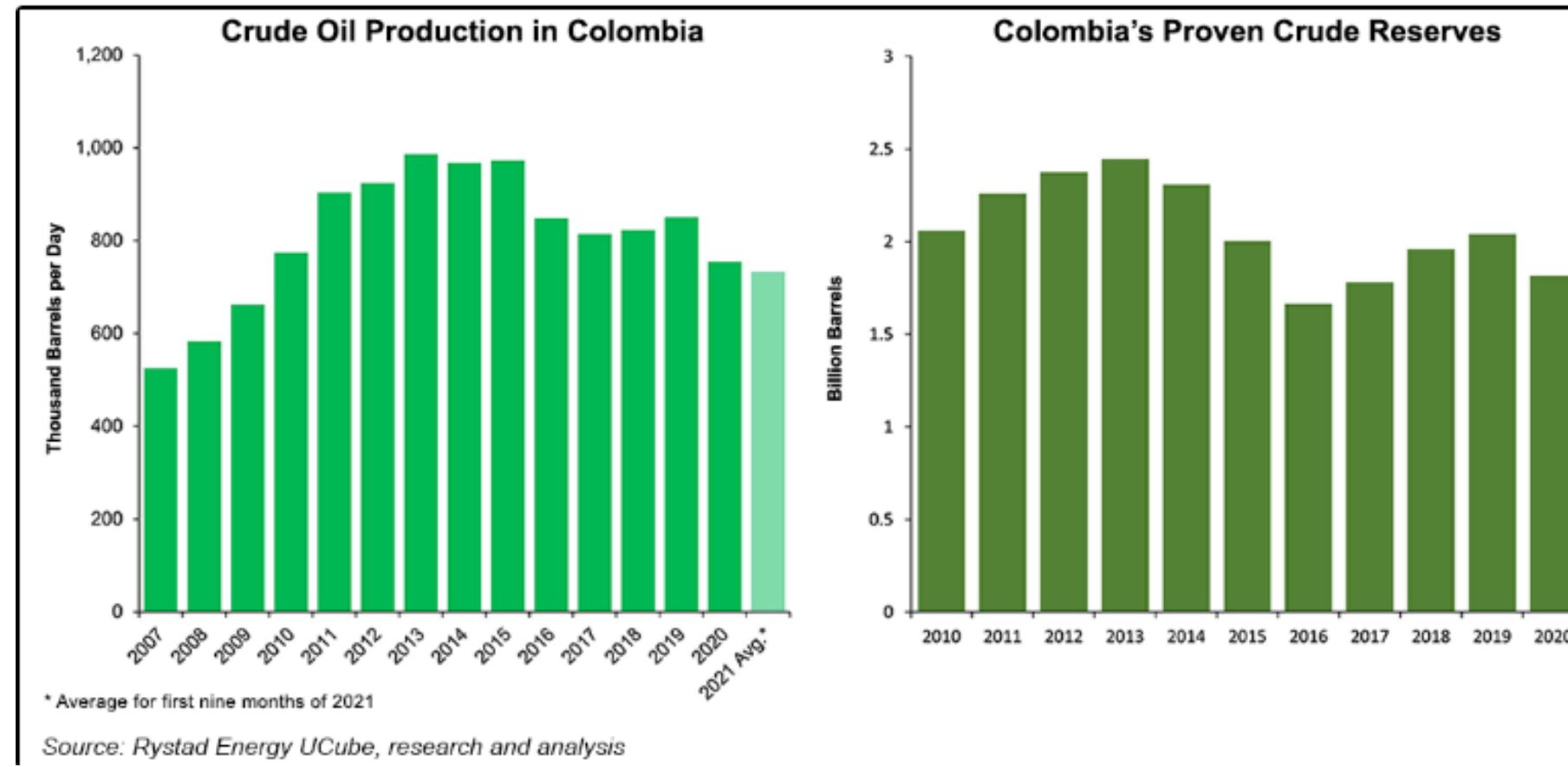
Source: Our World in Data based on BP Statistical Review of World Energy (2022); Our World in Data based on Ember's Global Electricity Review (2022); Our World in Data based on Ember's European Electricity Review (2022)
OurWorldInData.org/energy • CC BY

Source: [OurWorldInData](https://OurWorldInData.org)

Declining Oil & Natural Gas Reserves

Colombia's oil and gas production along with its proven reserves are falling and investment will likely fail to recover to pre-Covid-19 pandemic levels this decade, according to new analysis from Rystad Energy.

source- article1



Crude oil production in 2021 hit its lowest level since 2009.

Production declines for the last several years were the result of shut-ins driven by Covid-19-related lockdowns and associated delayed exploration, in addition to social protests and attacks by guerilla groups on key midstream oil infrastructure.

source- article1

source- article 2



Unequal Energy Distribution and Consumption per capita

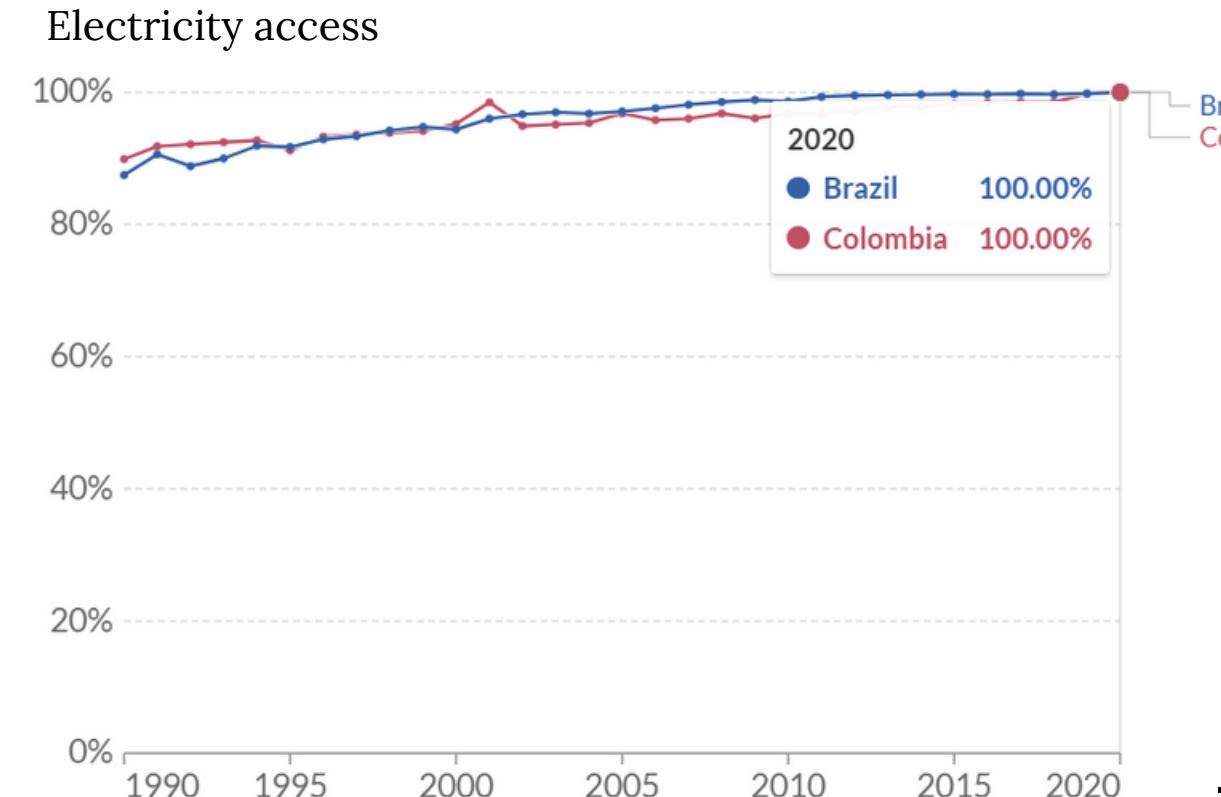
The inequality in electricity consumption (EC) in Colombia is assessed based on the per capita electricity consumption (ECpc) and the Gini coefficient.

The ECpc was defined with the total electricity consumption and population for each department and rural and urban areas.

The results showed significant asymmetries in the ECpc between departments, urban and rural populations, and socioeconomic strata. The national Gini coefficient of EC and the GDP is higher than 0.5, indicating significant inequities countrywide.

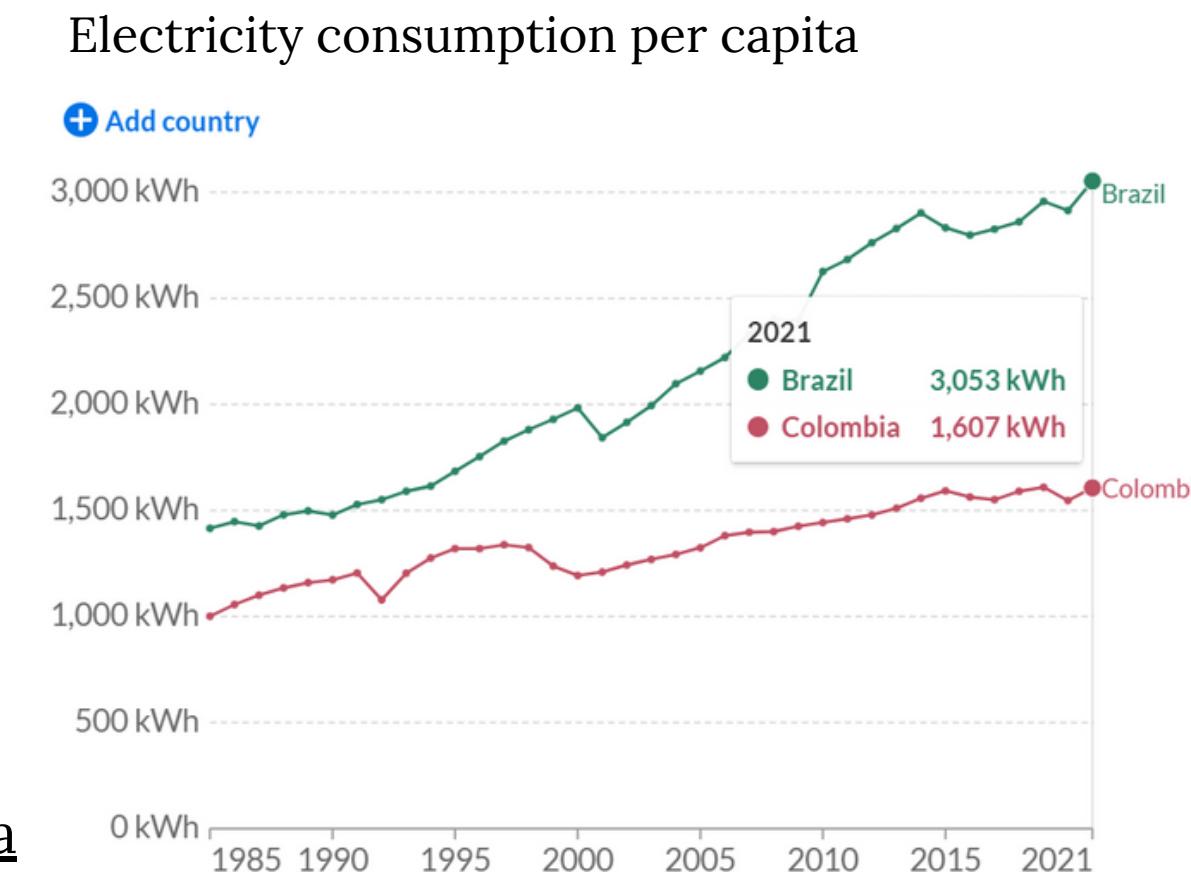
These results stress the need to complement the current policies more focused on achieving full access to electricity and less oriented to address the need for higher EC in households to improve welfare for the low-income and rural citizens.

source- abstract of a jornal



Comparison
between Brazil and
Colombia to give
an idea of the
scenario

Source - OurWorldinData



A scenic view of a town with white buildings, red-tiled roofs, and green hills under a blue sky.

OBSERVATIONS

Utilisation of Unused Energy Potential

Colombia has huge potential for non conventional energy sources



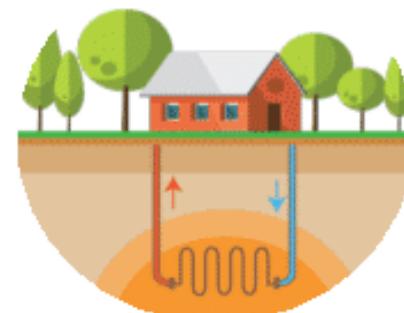
Biomass energy



Hydro energy



Wind energy



Geothermal energy



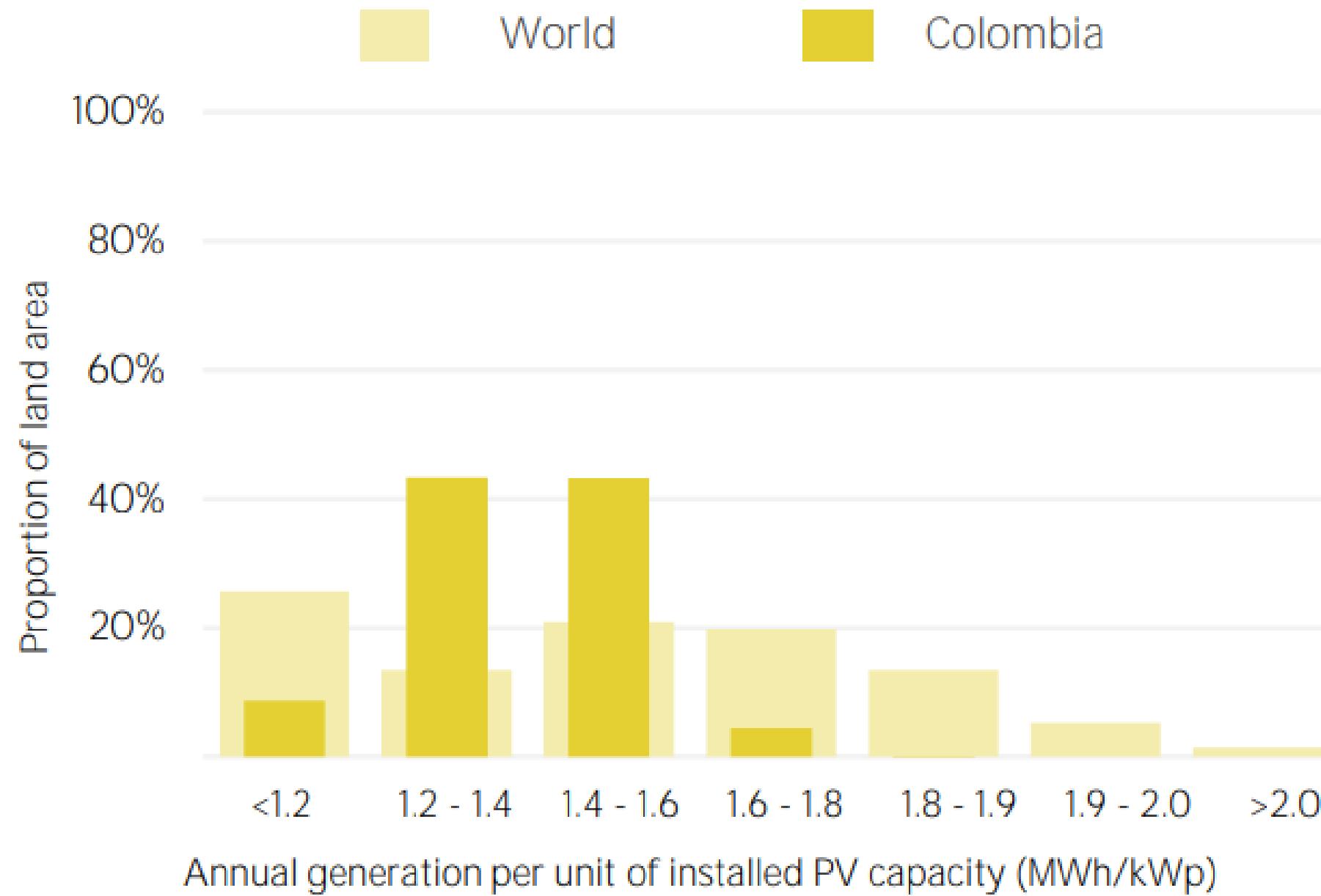
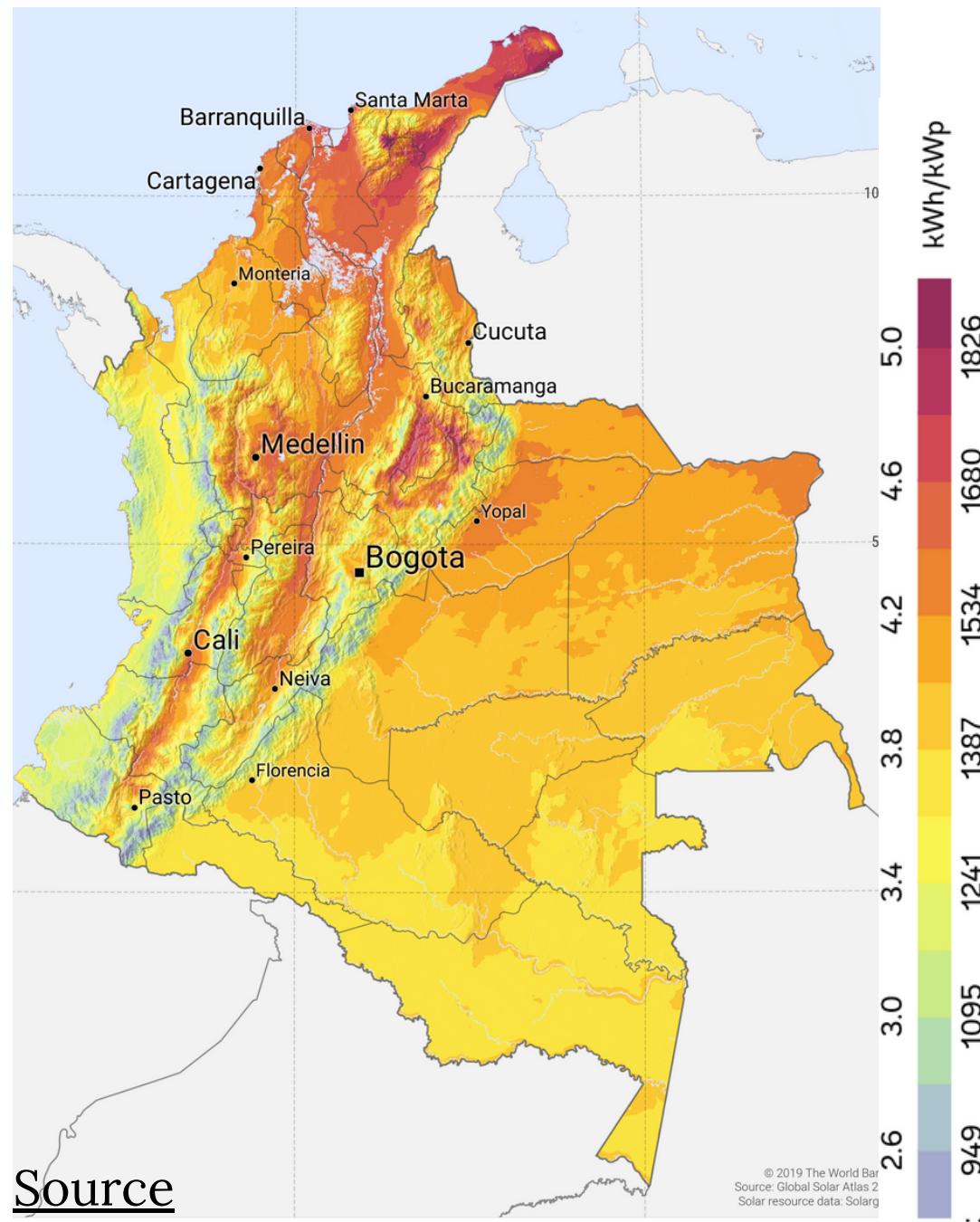
Solar energy



Solar Energy

- Located on the equator, Colombia has high solar radiation (with levels 60% higher than the world average) in several areas of the country, including La Guajira, the Caribbean and the eastern plains, among others.

Source: [Frontiersin.org](https://frontiersin.org)

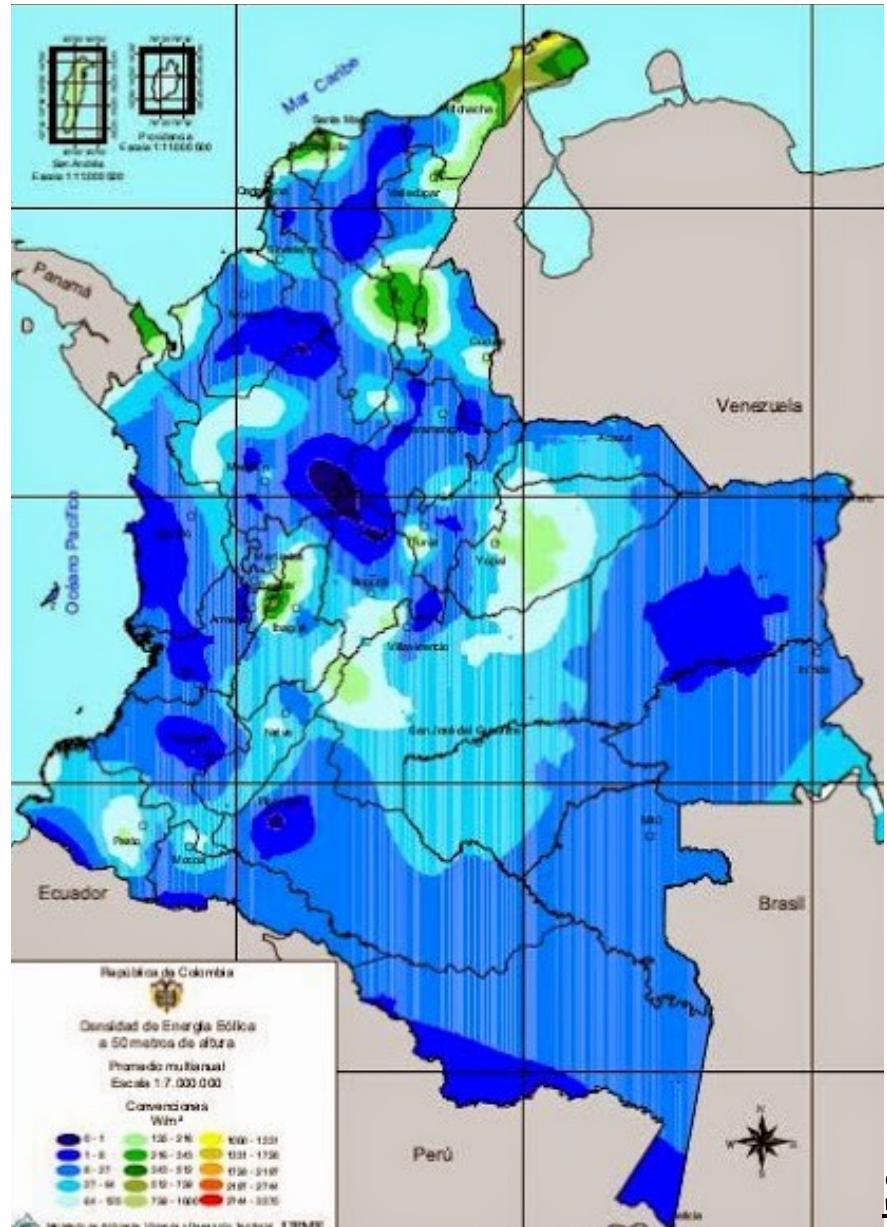


Wind Energy

There is a small wind farm with a capacity of about 19 MW along the north coast of the country and a 10 MW solar farm in the south-western, which together contribute to less than 0.02% of the total demand.

- The wind speed, at 9 m/s, doubles that of other places in the world, and represents a potential of 25 GWh of energy.

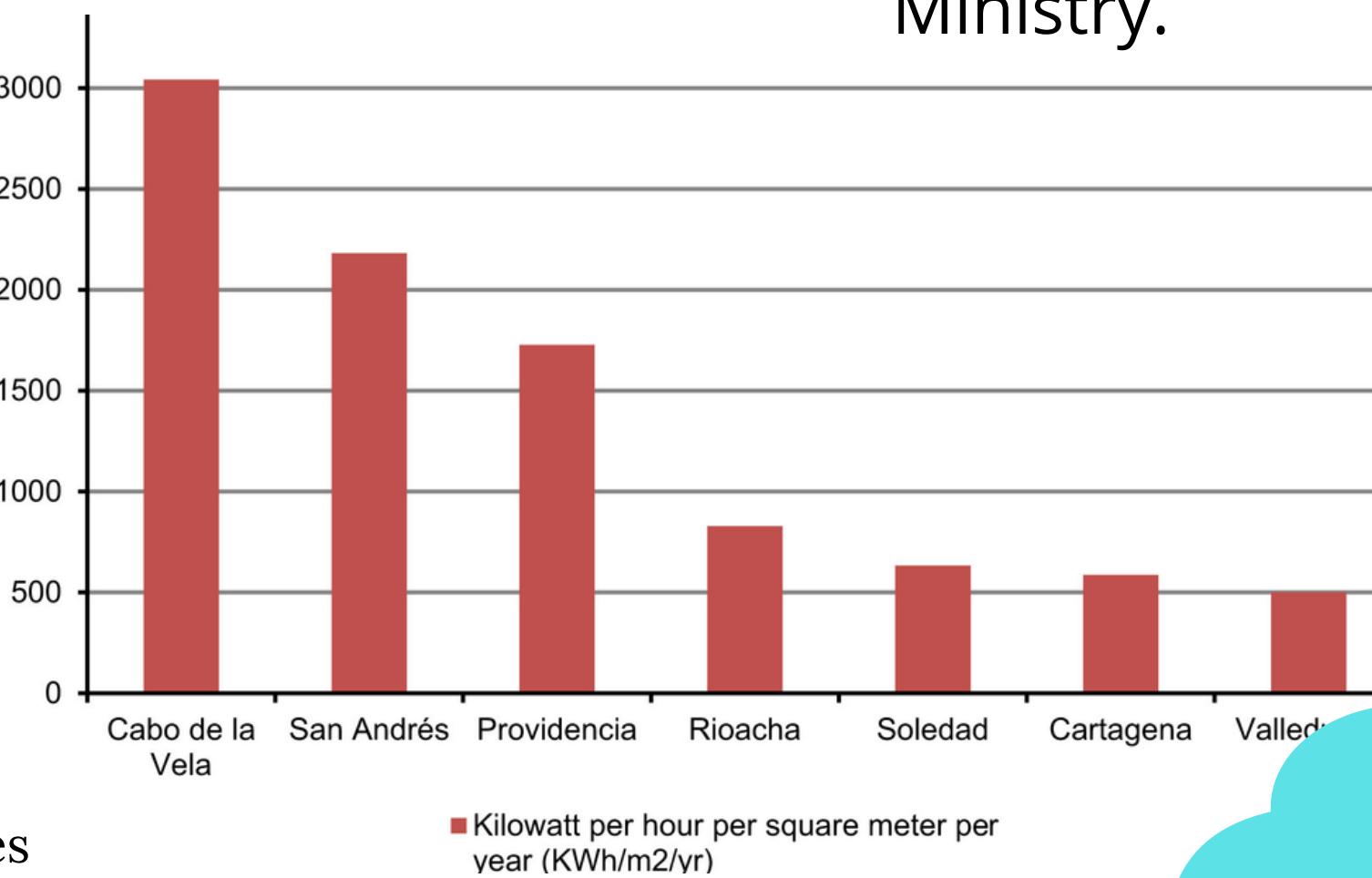
Source: Frontiersin.org



Source ewwind.es

There are, three wind power projects in the country's northern region registered for development at the Mines and Energy Ministry.

Source ewwind.es

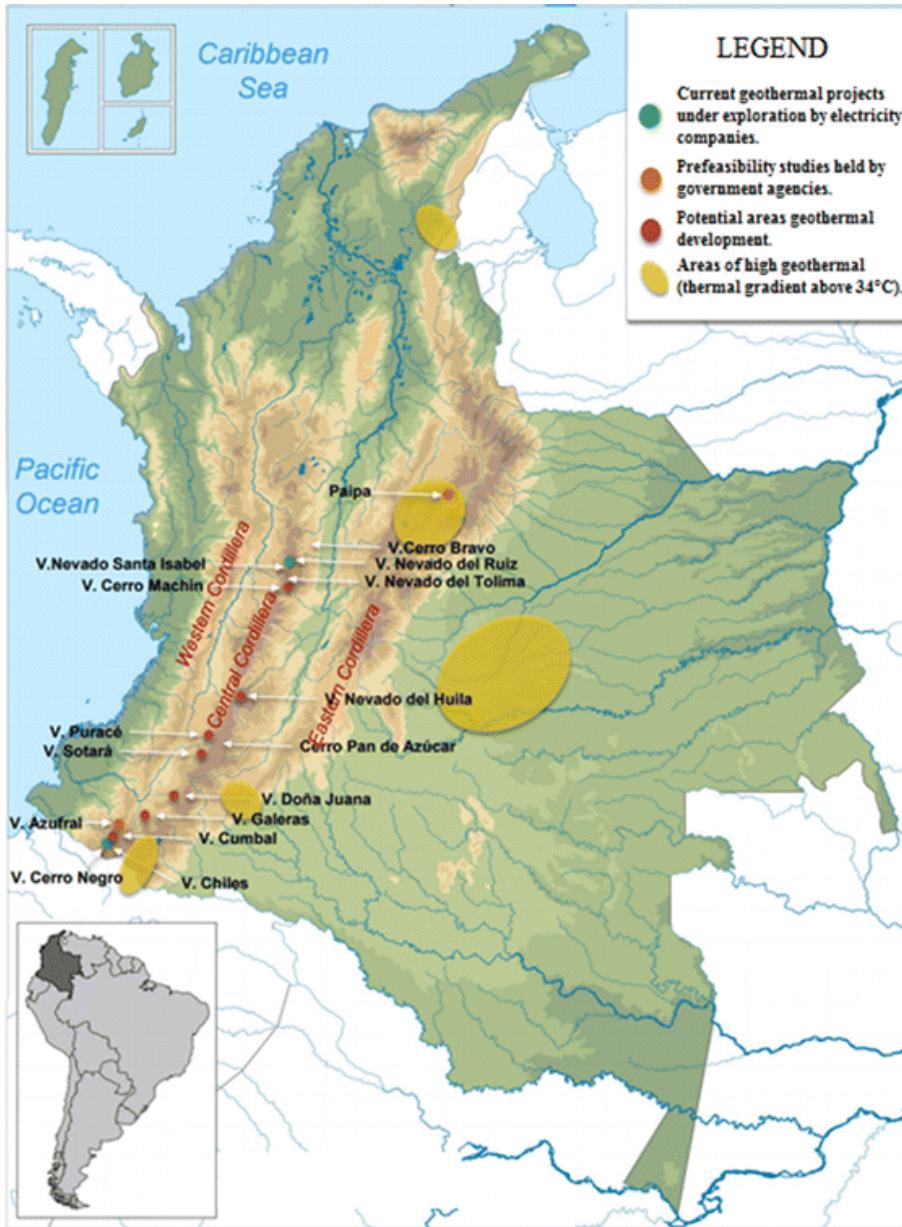


■ Kilowatt per hour per square meter per year (KWh/m2/yr)

Geothermal Energy

Colombia's location is an active tectonic zone, such as the Pacific Ring of Fire, and the presence of volcanoes such as Caldas, Risaralda and Tolima, among others, makes geothermal generation another high potential energy source.

[Source: Frontiersin.org](#)



By 2025, geothermal sources are expected to generate at least 1400 GWh of electric power per year, equivalent to 1.65% of total electricity estimate demand in Colombia. If the full potential that has been assessed were exploited, generation capacity could reach up to 17,400 GWh/year (equivalent to close to 20% of the country's demand) by 2025.

[Source Springeropen](#)

[Source geoenergymarketing.com](#)

Biomass Energy



The Colombian palm oil, sugarcane and banana sectors are interesting for energy and bio-based economy applications from the perspective of both sustainability and scale (medium to large).

Medium to large scale initiatives are possible here: e.g. CHP(process improvement), biogas production, and solid biomass processing for export.

Industry	Reference Product	P (kt/Year)	Biomass	R (t br/t Product)
Oil palm ^a	Fresh fruit bunches	5612.3–7172.8	Empty fruit bunch	0.23
			Oil palm kernel	0.06
			Mesocarp fiber	0.12
			Oil palm trunks	0.51
			Oil palm fronds	1.08
Sugar cane ^b	Raw sugar	2118.5–2371.2	Tops and leaves	2.4
			Sugar cane bagasse	2.5
Sugar cane (p) ^c	Panela	1098.2–1183.4	Tops and leaves (p)	3.7
			Sugar cane bagasse (p)	2.5
Coffee ^d	Green coffee	813.4–885.1	Coffee husks	0.38
			Coffee wood	0.34
Rice ^e	Green paddy rice	1988.2–2591.7	Rice husks	0.23
			Rice straw	1.43
Cocoa ^f	Dry cocoa beans	54.8–60.5	Cocoa pods	8
			Cocoa husks	0.12

If all the biomasses were processed in a gasification plant (22.2–24.0% efficiency), as proposed in this study, then the installed capacity—if the plant-use factor was 85%—would range between 1696.7–2111.3 MW.

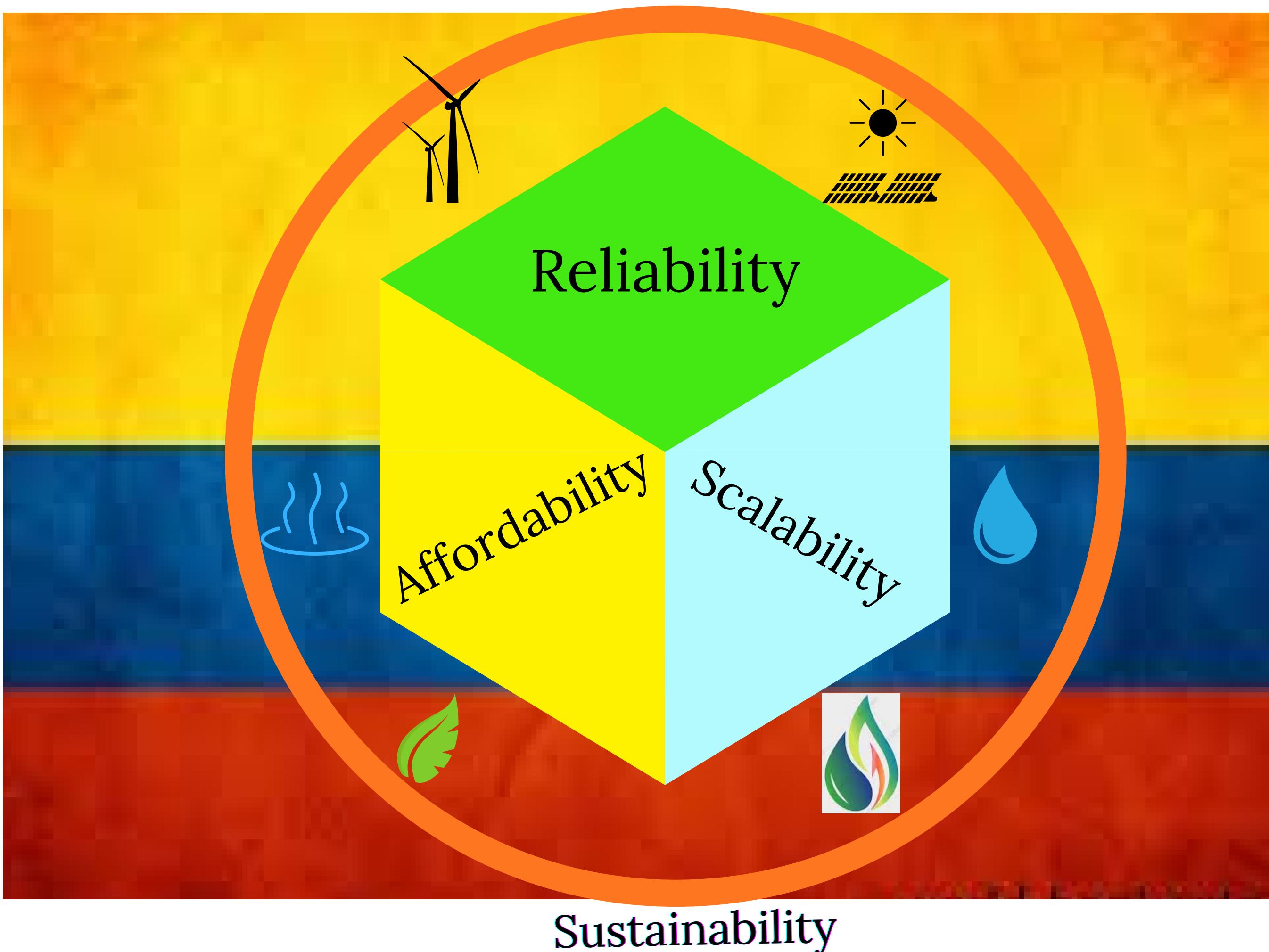
[Source Article in mdpi.in](#)



A scenic landscape featuring a waterfall cascading down a rocky cliff into a pool of water. The background consists of lush green hills and mountains under a clear blue sky.

Solution

AIM



Solar Energy

Solutions

Already several Projects of Portfolio Value 796 MW Under process and was auctioned by colombian Government to companies like Canada Solar,Trina Solar,Enel,etc.

Projects(utility grid)



Location	Area	PV Cell	Total Power
La Guajira	210 Acres	440 Watt PERC	176.9 MW
Cesar	120 Acres	440 Watt PERC	168 MW

Cost = \$0.65(per watt)*440*No. of Solar panels installed

NOTE : To increase No. of hours exposed to sun we have installed Solar actuators.



Solar Energy Contd...

Solutions

Individuals can make small scale commercial solar farms to sell the electricity to others.

AS COOKING FUEL ALTERNATIVE

As colombia's most staple food is rice, solar cookers can be advised to use instead of cooking to reduce the use of unhealthy cooking fuels in some locations.

Work of Government:

- 1.)To make regulations to make sure electricity prices are feasible
- 2.)Provide incentives and solar loans at attractive interest rate for small scale businesses, schools and hospitals.



Wind Energy

Project type: Onshore Wind farm development

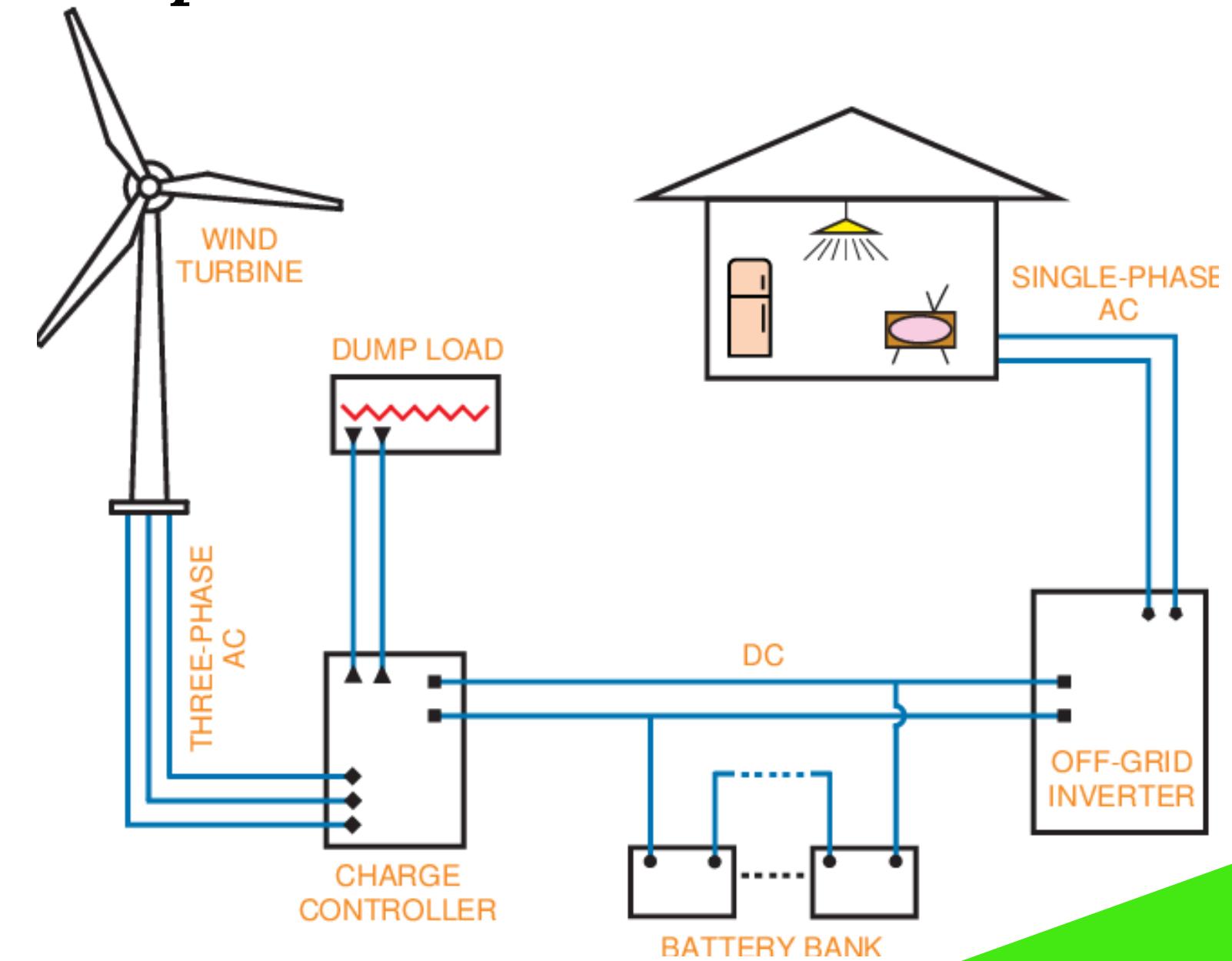
In 2021, wind represented less than 1% of Colombia's installed capacity with 56 MW.

We propose to install small scale onshore wind farms(budget 45 Million USD).

Subsidies and incentives for locals to install off grid Wind turbines.

Considering average wind speed is about 6.5 m/s, giving an average power output of 900W (from power curve).

Average energy per day is $900\text{W} \times 24\text{h} = 21,600\text{ Wh}$ or 21.6 kWh.



Wind Energy Contd...

Project type: Offshore Wind farm development

A project can developed near Barranquilla, the capital of Colombia's Atlantico province, is expected to have an installed capacity of 350 megawatts (MW) and could bring up to \$1 billion in investments.

·La Guajira has the offshore potential (519.57 TWh/year) to generate 7.7 times the energy needed to cover the national.

Location

San Andres

Providencia

Power Rated

180 MW

64 MW

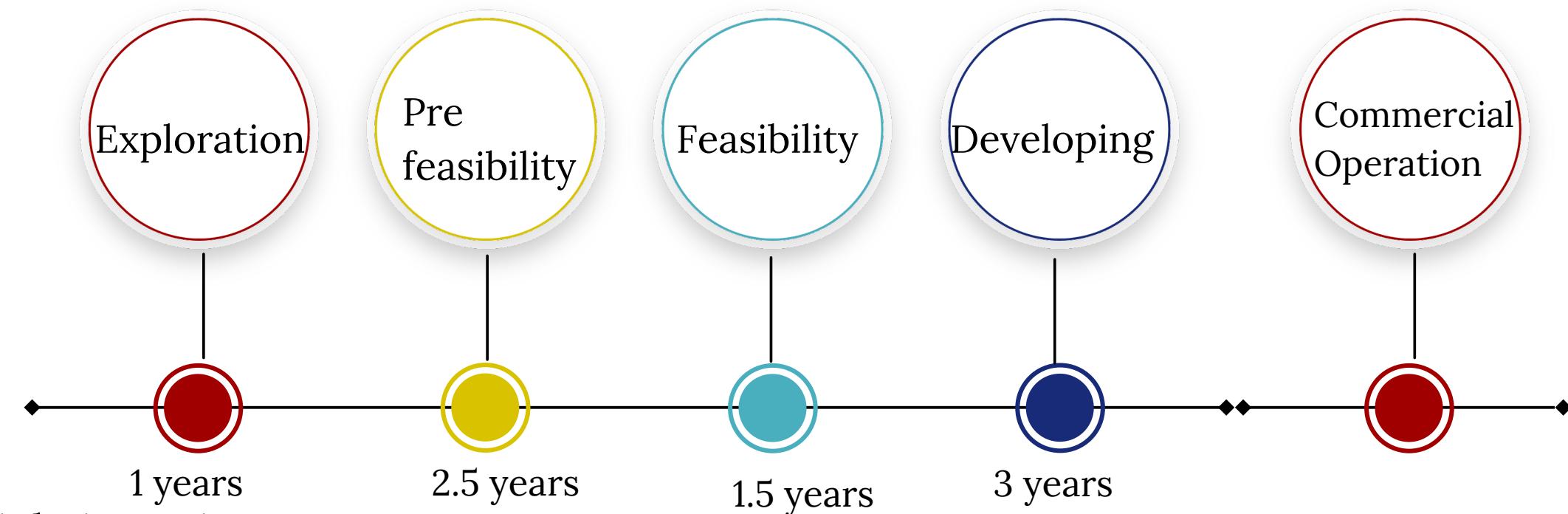


Geothermal Energy



The foreseen growth in demand in Colombia indicates that it is necessary to undertake new electricity generation projects to cover such demand, and geothermal energy is likely to play an important role, because in addition to being a renewable source of energy, it would help diversify the energy sources of the country's electric grid.

Timeline – For Development of Geothermal Power Plant



[Source Article in Springeropen.com](#)



Geothermal Energy Contd...

Projects Proposed

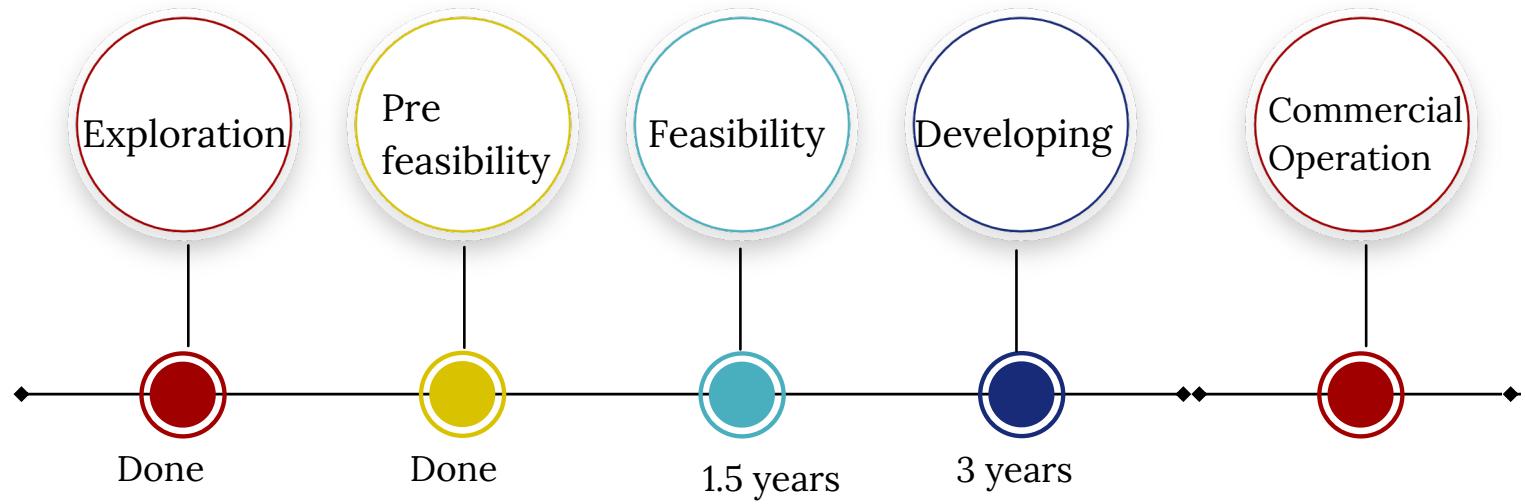
1. Construction of power plants in Nevado Volcanic Zone

Scale

Power

Large

50 MW



2. Exploration and Development of Power Plants near Geothermal Sites

Small

400 MW
Combined



Bio-Energy

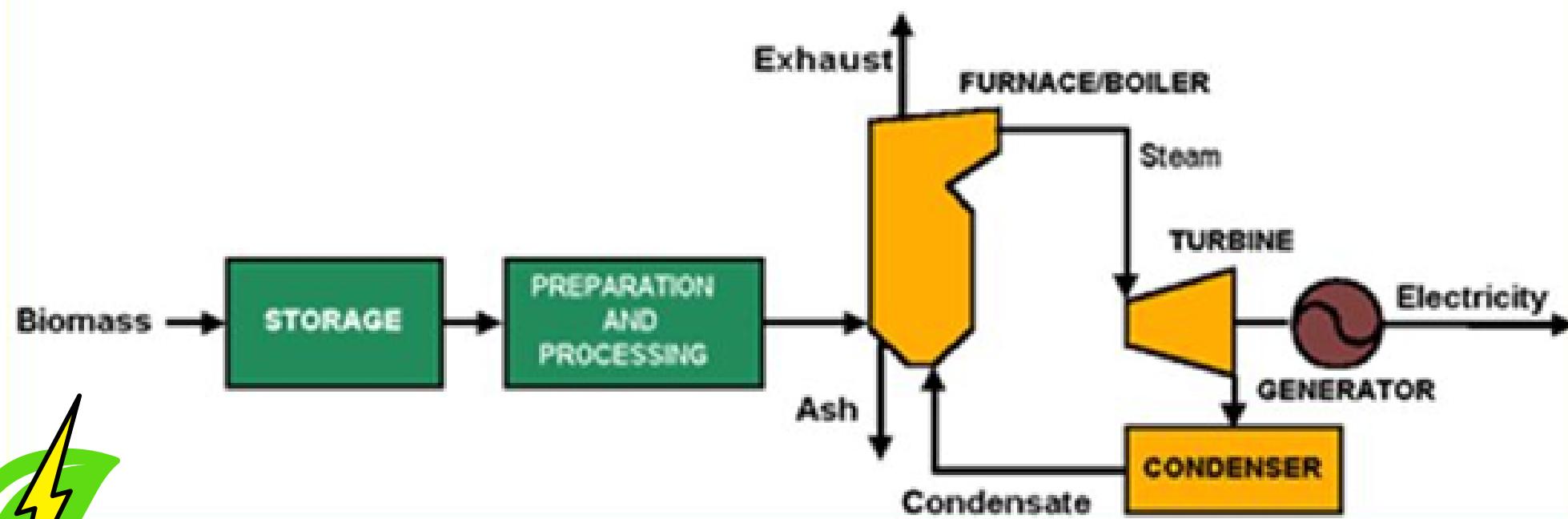


Some ways to increase Efficiency

- Use of technologies like pyrolysis, or gasification can aid to overcome these barriers. In total, the use of CHP systems(combined heat and power systems) as a waste-to-energy approach for biomass wastes can increase the sustainable biomass share in the end-use energy mix up to 15–28%.
- Conversion of biomass into pellets to increase calorific value.

Process

Direct Combustion / Steam Turbine System



Direct combustion systems feed a biomass feedstock into a combustor or furnace, where the biomass is burned with excess air to heat water in a boiler to create steam.

Boiler fuel can include wood chips, pellets, sawdust, or bio-oil. Steam from the boiler is then expanded through a steam turbine, which spins to run a generator and produce electricity.



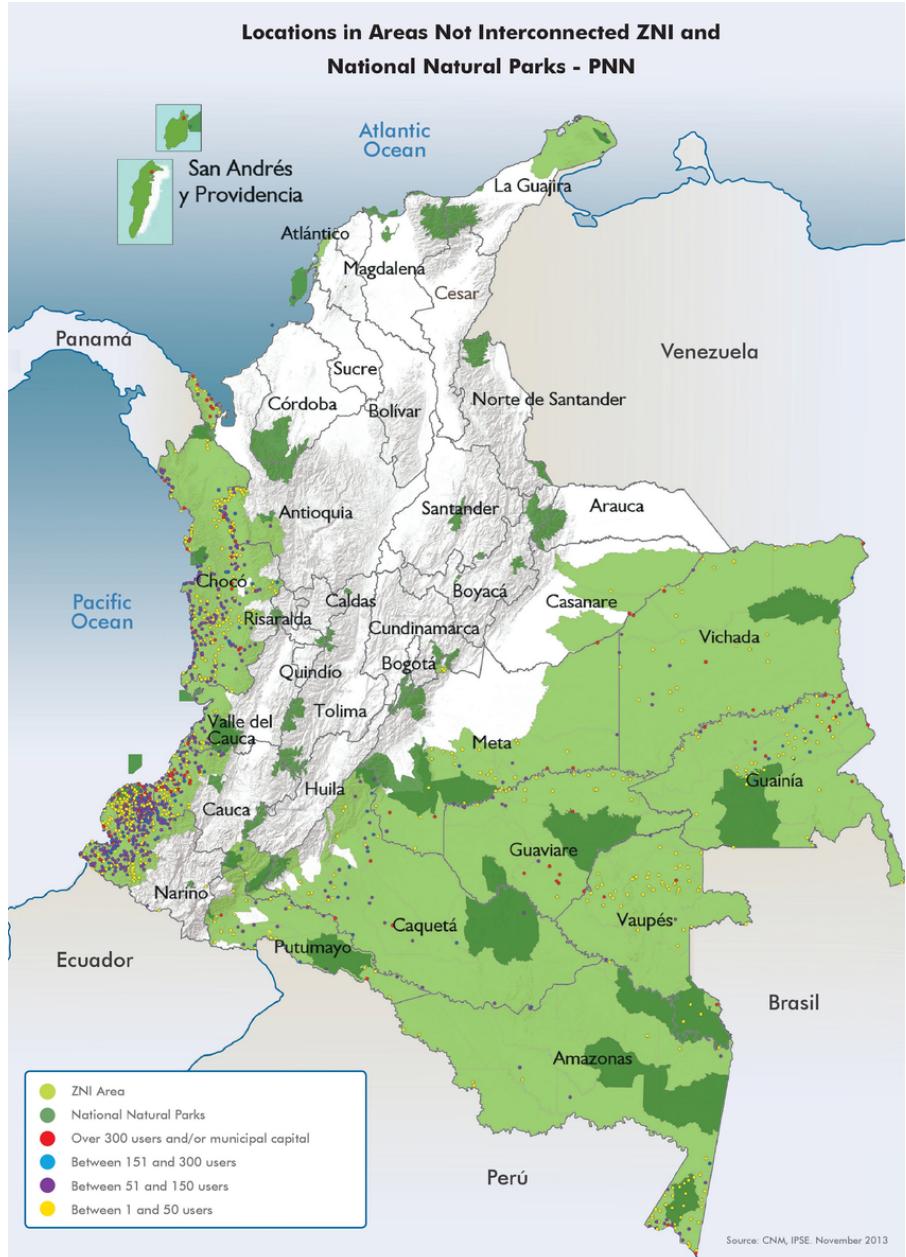
Bio-Energy

Contd...

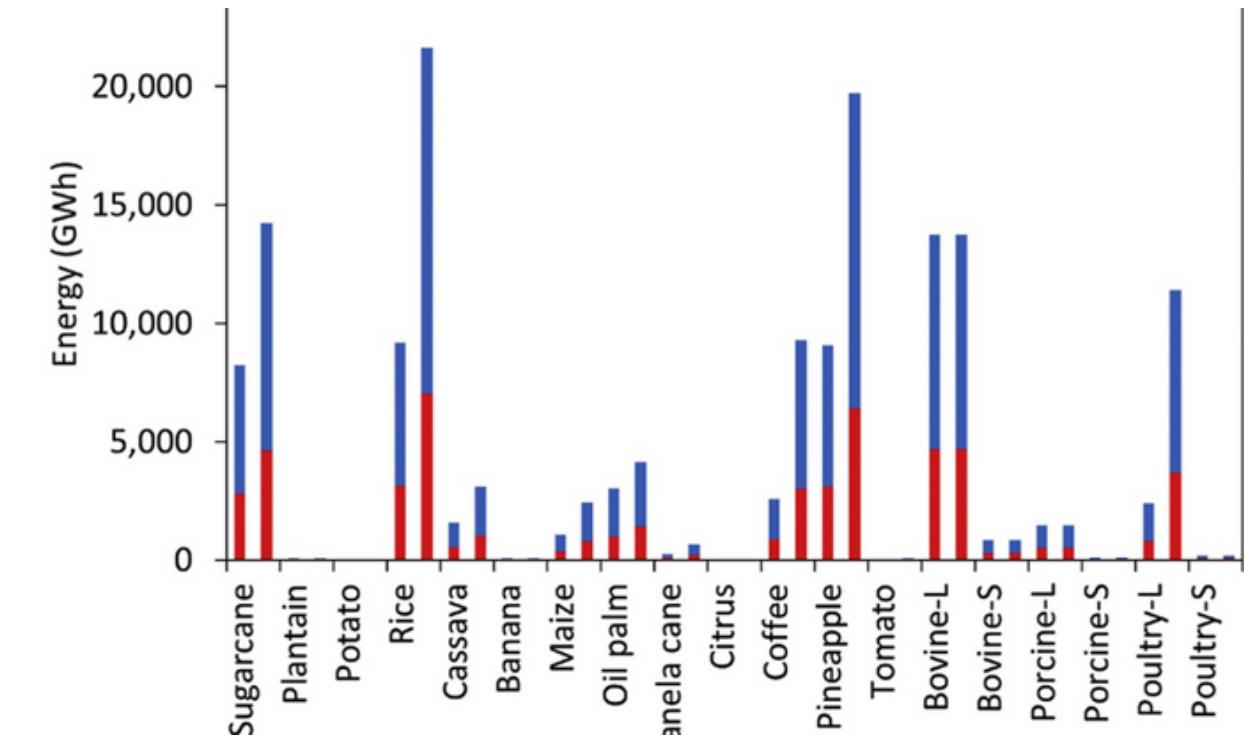
Project Proposal

1. Setting Up Small Scale Biomass Electric Plants at ZNI (Not Interconnected Zones)

- Small-scale biomass electric plants have installed costs of \$3,000 to \$4,000 per kW, and a Levelized cost of energy of \$0.8 to \$0.15 per kilowatt hour (kWh).



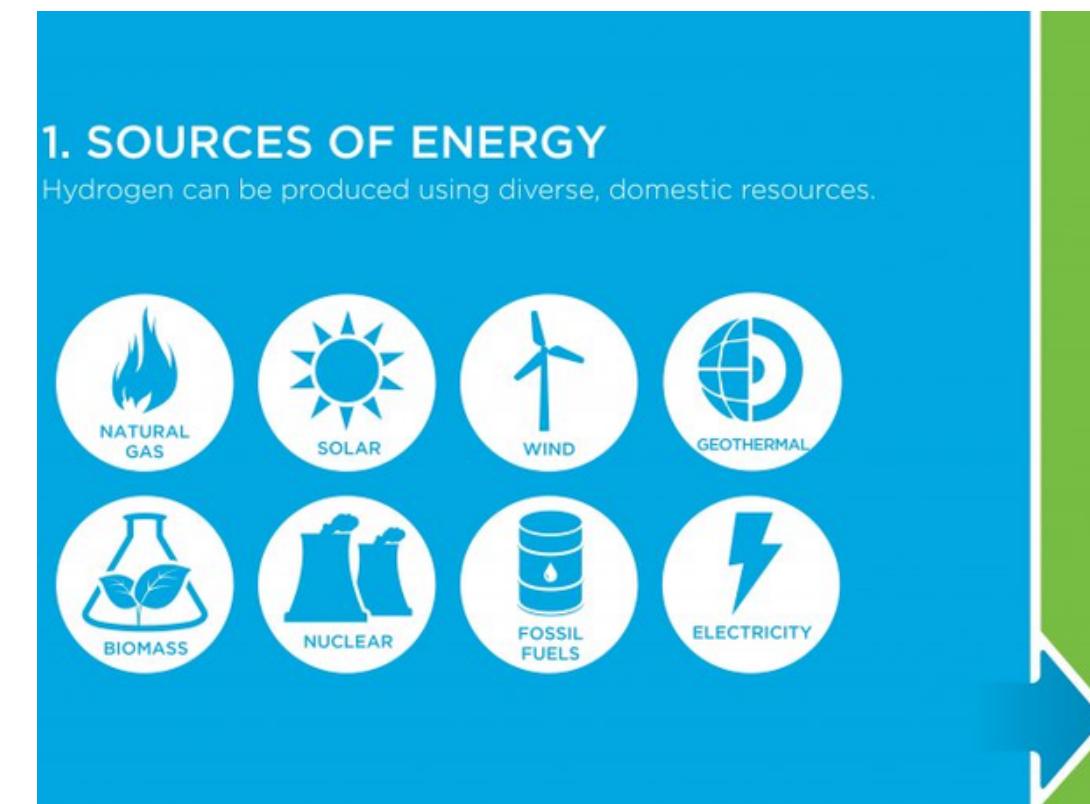
2. Replacing traditional unhealthy cooking fuel with biofuels



HYDROGEN

- The Ministry of Mines expects that by 2030 there could be between 1 and 3 GW of installed electrolysis capacity for green hydrogen (produced through an electrolysis process using non-conventional renewable sources) at competitive prices of 1.7 USD/ kg and 2.4 USD/ kg and 50 kt for blue hydrogen, by capturing CO₂ from gas and coal.

In Colombia, one of the goals of the Hydrogen Route is to create 50 kilotons of blue hydrogen and one to three gigawatts of installed electrolysis capacity to produce green hydrogen.



The development of hydrogen is expected to help the country to save between 2.5 and 3 million tons of CO₂ over the next decade, with investments in this sort of project attracting between 2,500 million and 5,500 million dollars by 2030.



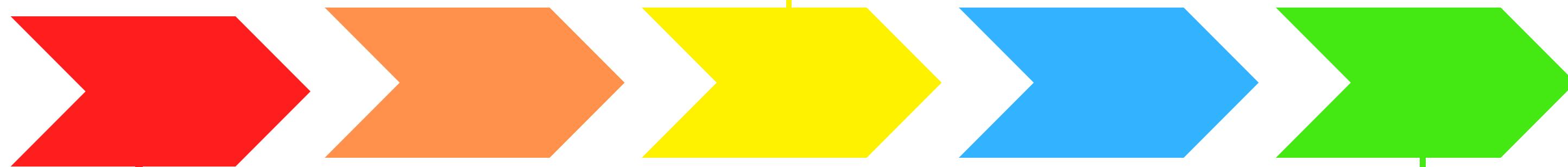
Implementation Timeline

2023 - 2033

Aim: focus mainly on unutilised solar energy potential



Providing clean cooking fuel through bio-energy in rural areas



- installation of photovoltaic cells at Atlantico, Antioquia, and Valle de Cauca,



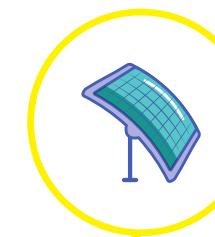
Increasing sustainability through decarbonization projects, including energy efficiency projects, leakage and venting reduction of existing thermal powerplants



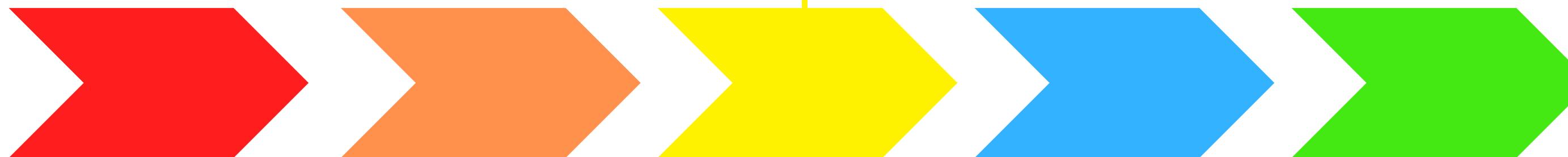
Implementation Timeline

2033 - 2043

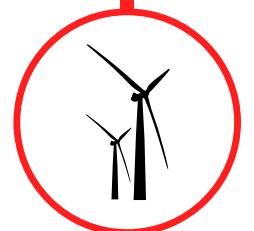
Aim: Wind farm development and off grid production of electricity using solar energy



- Setting up off grid solar power generation systems in the Andean and Pacific regions of Colombia &
- Setting up of microgrid in cities of low population & rural region



- Construction of wind farm in La Guajira, Cabo de la Vela, San Andrés, Providencia, Rioacha



- Utilisation of bio mass energy



Implementation Timeline

2043 - 2053

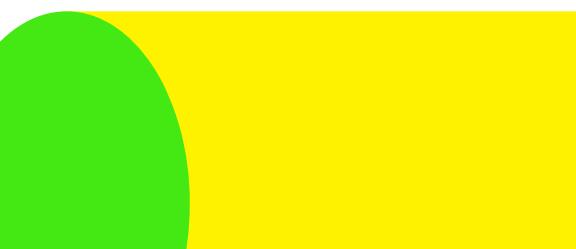
Aim: To completely reduce dependency on hydro-powerplants and non-renewable energy sources



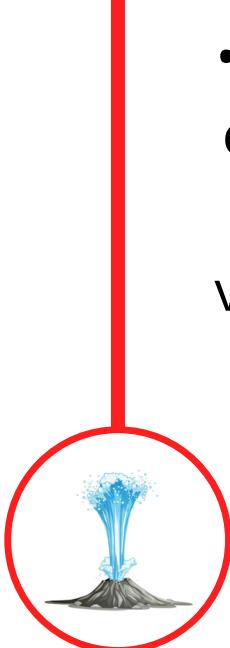
- Setting up large scale H₂ electrolysis generators in order to produce green energy 2.5 times that produced by natural gas



Colombia -
One Step
Closer To
Sustainability



- Utilisation of geothermal energy for on grid supply through the presence of volcanoes such as Caldas, Risaralda and Tolima



A background image showing a hand holding a magnifying glass over a stack of gold coins. Next to the hand is a large sack filled with gold coins. The scene is set against a light blue gradient background.

Solution

Geothermal Projects

Project	Estimated Years	Overall Cost	Process Completed	First Functioning
Nevado Volcanic Zone	4.5 Years	125 Million USD	Development of plant	2030
Paipa	5 Years	90 Million USD	Pre Feasibility under process	2035
Azufral	5 Years	90 Million USD	Development of Plant	2037
Active Volcanic zones in Andean region	7-8 Years	150 Million USD	To begin Exploration	2040



Geothermal Project

Cost Breakdown -

Setting of Plant - $\$2500/\text{kW} * \text{Project size(in kW)}$

Maintenance Cost - $.\$01/\text{kW} * \text{Project size(in kW)}$

Exploration and other cost - 15% of total Cost

Potential Investors-



Inter American
Development
bank



Parex Resources



Chevron



Minergia

Bio-Energy Projects

Project	Estimated Years	Cost
Building Bio-Energy Generation Plants in ZNI	3-4 Years	75 Million USD
Developing clean biofuels to replace lpg and wood	2 Years	100,000 USD
Developing Bio-Energy to make it one of most	7 Years	115 Million USD



Bio-Energy Projects

Cost Breakdown -

Setting of Plant - \$500,000/MW * Project size(in MW)

Levelised Cost Of Electricity - \$.25/kWh

Potential Investors -



can form an Alliance with Brazil to develop Bio-Energy
in Colombia.

Wind Projects

Project	Estimated Years	Cost
Onshore Small Scale and off grid Projects	7 Years	90 Million USD
San Andres	6 Years	190 Million USD
Providencia	4.5 Years	80 Million USD



Wind Projects

Cost Breakdown -

Setting up on grid wind farm: 1.3 million USD /MW

Levelised Cost of Electricity: \$0.089 / kWh

Potential partners -



Capstone Turbine Corporation



Acciona SA



Enel Green Power





Potential Threats & Preventive Measures

Implementational Threat -

- 1.) Lack of Adequate Technology
- 2.) Lack Of Funds

Socio-cultural Threat-

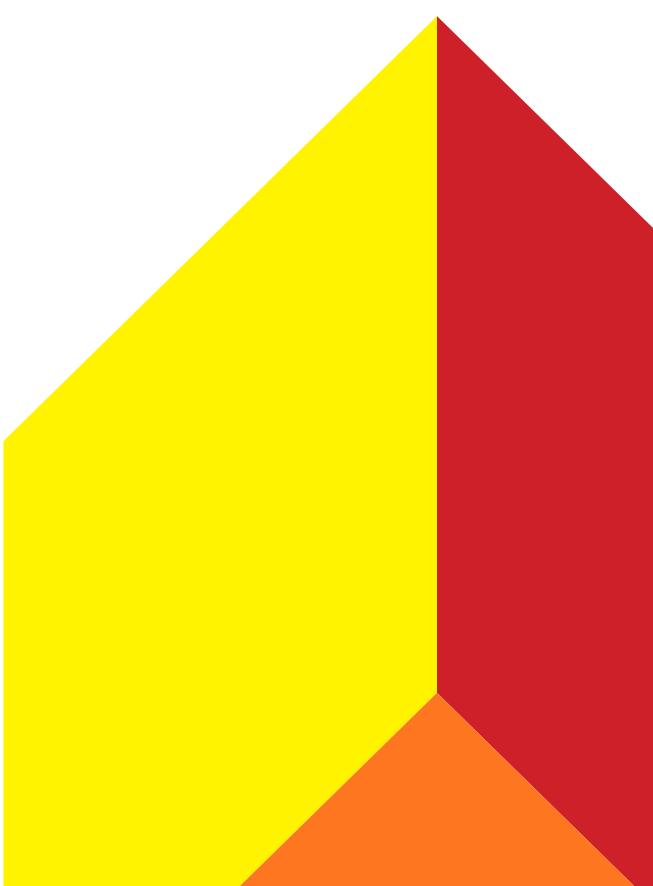
- 1) Lack of awareness
- 2) Non-acceptance of newer technologies by locals

Measures

We can increase awareness among people so they would participate in the development of the country.

 We can promote participation by private companies to more extent to reduce the overall cost.

We can introduce attracting policy to encourage investments.



A photograph of a woman in a white dress kneeling in a field of green plants, possibly corn. She is looking down at something in her hands. The background shows a blue sky and more greenery.

THANK YOU!