

RENEWABLE ENERGY POTENTIAL OF LATIN AMERICA



DECEMBER 2009

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1 ABSTRACT

The focus of this paper is to give an overview of the potential of renewable energy of every country in Latin America. Five different types of renewable energy resources exist: solar power, wind power, hydro power, geothermal and biomass. The purpose of this work is to contribute to the development of the widespread use of these renewable energy sources to counter the increasing concentrations of greenhouse gases, carbon dioxide and several other gases in smaller amounts such as methane and nitrous oxide, whose effects cause global warming. Recent data from the International Energy Agency (IEA) shows that renewable energies amount to almost 29% of the total primary energy supply in Latin America, which seems quite impressive in comparison to the 5.7% share of renewables in the Organization for Economic Co-operation and Development (OECD). However, the situation is not as good as it seems. The Latin American renewable energy sector is almost entirely dominated by hydro energies and biofuels. The problem is that these two forms of energy are not in all cases the most adequate. The dependency of hydro energy causes problems when there are droughts and the water levels fall significantly, as is the result of climate change. Biofuels have come under heavy criticism for a number of reasons. The most common is that industrial biofuels do not contribute to reducing greenhouse gases, as intended, whereas traditional biofuels and the production of charcoal lead to deforestation. Altogether, then, it is clear that the current situation of renewables in Latin America is less optimistic than it initially appears. Therefore, maps which show the total energy supply and the potential of renewable energy sources for each Latin American country have been gathered. The maps show that besides the already mentioned dominant two renewable energy sources, there is enough potential to expand greatly the other renewables in Latin America.

2 WHAT IS RENEWABLE ENERGY?

The non-profit, non-partisan association GoGreenVa defines “renewable energy” as follows:

“Renewable energy generally refers to electricity supplied from renewable energy sources, such as wind and solar power, geothermal, hydropower and various forms of biomass. These energy sources are considered renewable sources because their fuel sources are continuously replenished.”¹

Renewables are distinguished from non regenerable fossil sources of energy (e.g. coal, petroleum, natural gas) whose supplies are limited. Theoretically, fossil energy sources like petroleum or hard coal can be replaced in nature, but their regeneration takes so long that they cannot play a sustainable role for use by human beings.

All of the available renewable resources result primarily from the sun’s activity, the earth’s rotation and heat from the earth’s interior. Much of the research into and application of energy forms which use resources without consuming them is based on these systems and their derivations like sunlight, weather, tides and temperatures below the earth's surface.² Renewable energies are carbon dioxide neutral, i.e. they don't emit either carbon dioxide (CO₂) or any more than the plants can assimilate in their process of growth.³ The nuclear fission/fusion within the sun are the sources of solar energy and most other regenerative energies, with the exception of geothermal energy and tidal power. Since the sun has a remaining lifespan of about five billion years⁴, we avoid the issue of using up our reserves in a few generations.

¹ http://www.gogreenva.org/?/green_glossary

² <http://www.stromversorger-energieversorger.de/erneuerbare-energien.php>

³ <http://dev.umweltamt.dortmund.de/umweltamt/project/assets/template1.jsp?iid=az&smi=12.0&tid=68122&b=R>

⁴ http://www.dlr.de/desktopdefault.aspx/tabid-5089/8554_read-18304/

2.1 RENEWABLE ENERGY SOURCES:

As already mentioned, five different renewable energy sources exist which can be used to generate energy. These are described here more precisely.

2.1.1 SOLAR ENERGY:

“Solar energy is the energy received by the earth from the sun. This energy is in the form of solar radiation, which makes the production of solar electricity possible.”⁵

2.1.2 WIND ENERGY:

“Energy received from the movement of the wind across the earth. This energy is a result of high and low pressures, the heating of our oceans, earth, and atmosphere by the sun.”⁶

2.1.3 HYDROPOWER:

Clean energy technology that uses moving water to produce electricity. Water flows through a hydraulic turbine, which spins and then rotates generators and converts rotational energy into electricity.⁷

2.1.4 BIOMASS:

Biomass is the common name for organic materials used as renewable energy sources such as wood, crops and waste.⁸

2.1.5 GEOTHERMAL:

“The ground beneath our feet, the earth’s crust, contains considerable energy in the form of heat. All of this geothermal energy has the potential to generate geothermal power to provide large amounts of electricity.”⁹

⁵ http://www.clean-energy-ideas.com/energy_definitions/definition_of_solar_energy.html

⁶ http://www.clean-energy-ideas.com/energy_definitions/definition_of_wind_energy.html

⁷ <http://www.egreenideas.com/glossary.php?group=h>

⁸ http://www.clean-energy-ideas.com/energy_definitions/definition_of_biomass.html

⁹ http://www.clean-energy-ideas.com/geothermal_power.html

3 WHY IS IT IMPORTANT TO GENERATE RENEWABLE ENERGY?



Figure 1 Reserves Of Most Fossil Energy Sources¹⁰

In reality, renewable energies are ancient. For thousands of years people have collected wood for cooking and heating; they have used water mills, hot springs and the power of the wind for sailing. Only about 200 years ago did people begin to exploit in a big way the fossil resources: coal, petroleum, natural gas and later, uranium – with the then unknown consequences for climate and world peace. But these sources of energy are now running out: According to the Federal Institute of Earth Science and Raw Materials, worldwide oil reserves will be exhausted in approximately 40 years and the uranium reserves in 45 years. Over the last 20 years, the energy potential of the sun, wind, water, biomass and geothermal energy has been rediscovered. With the help of modern technologies, this energy is being used in the form of electricity, heat and fuels. And their potential will not be exhausted. According to human metrics, renewable energies are infinitely available.¹¹

With levels of fossil fuels steadily decreasing, we need to act now to become less

¹⁰ <http://www.unendlich-viel-energie.de/de/panorama/50-gute-gruende.html>

¹¹ <http://www.unendlich-viel-energie.de/de/panorama/50-gute-gruende.html>

dependant on fossil fuels and more reliant on renewable energy sources. The decreasing levels of fossil fuels isn't the only reason we should begin to use renewable energy. Pollution from fossil fuel burning has become a huge problem in many countries around the world, especially the developing world. With carbon emissions at an all time high, air quality can be very poor in some areas with the consequence of leading to an increase in respiratory diseases and cancers.

The main reason to switch to cleaner energy production methods is the global warming issue. The more carbon dioxide we pump into the atmosphere, the greater the greenhouse effect and subsequent global warming. While we can't simply stop using fossil fuels and thinking that global warming will go away, we can slow down and dilute the effects of global warming through the widespread use of renewable energy resources. There are many natural energy sources available to us, but we must decide which method is best for us, as all of these sources have an impact on our current environment.

The installation of a solar panel or a wind turbine to boost every home's power supply would be an significant step forward. Some governments are in the process of supplying solar panels to hundreds of households to test this method of energy saving.

Geothermal energy is a technology set to be very important in the future. With geothermal energy, heat is extracted from within the earth's crust and transformed either into a hot water system, or if there is plenty of this energy, a geothermal power plant. Huge amounts of money have flowed into research of this method, especially in recent years, to make the current technology more effective.

These are the reasons as listed above that we should turn to renewable energy resources which are more than likely to play a very vital and important role in our future society.

4 THE CURRENT STATE OF RENEWABLES IN THE WORLD

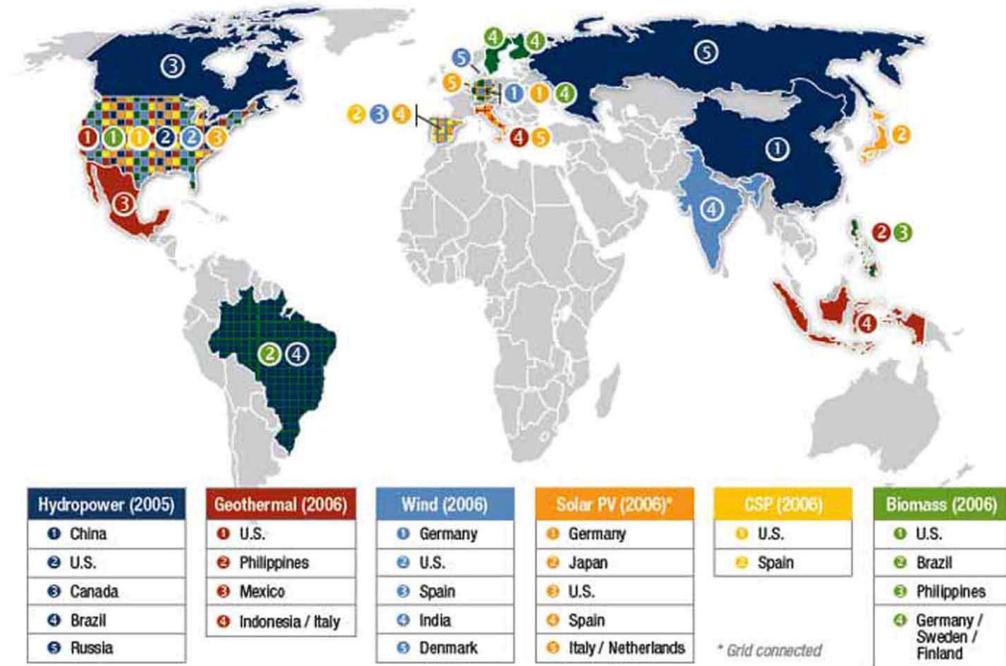


Figure 2 Top Countries with Installed Renewable Electricity by Technology¹²

In 2007, the world Total Primary Energy Supply (TPES) was 12,026 Mtoe (million tons of oil equivalent), of which 12.4%, or 1492 Mtoe, was produced from renewable energy sources. The shares of other energy sources were as follows: 34% oil, 26.4% coal, 20.9% natural gas and 5.9% nuclear energy. By IEA definition, renewable energy sources include renewable combustibles and waste (solid biomass, charcoal, renewable municipal waste, gas from biomass and liquid biomass), hydro, solar, wind and tidal energy. Non-renewable waste sources (nonrenewable industrial waste or non-renewable municipal waste) are not included in renewables.

¹² www.nrel.gov/docs/fy09osti/45654.pdf

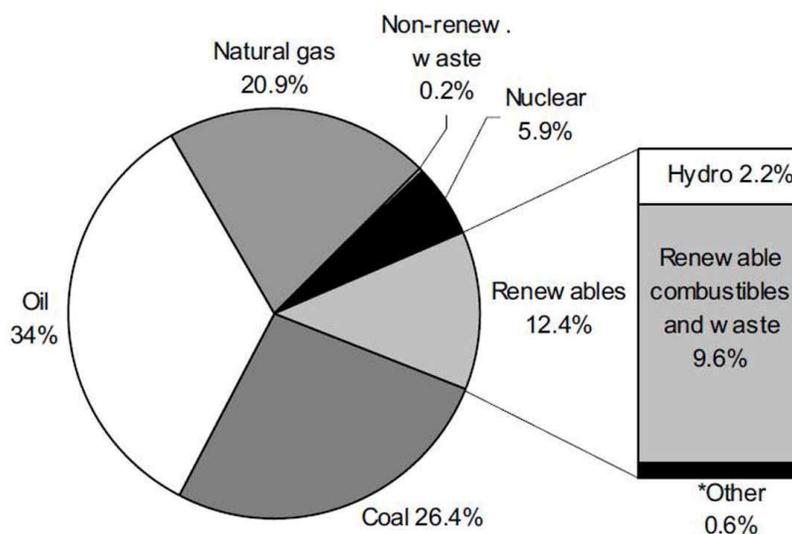


Figure 3 2007 Fuel Shares In World Total Primary Energy Supply¹³

Due to its widespread non-commercial use in developing countries, solid biomass is by far the largest renewable energy source, representing 9.3% of world TPES, or 73% of global renewables supply. The second largest source is hydro power, which provides 2.2% of world TPES, or 17.7% of the renewable share. Geothermal is the third largest renewable source and is much smaller, representing 0.4% of world TPES or 3.3% of renewables supply in the world. The contribution of “new” renewables (solar, wind and tide) to energy supply is still very marginal, representing approximately 0.2% of world TPES, or 1.6% of renewables supply.

¹³ <http://www.iadb.org/intal/intalcdi/PE/2009/03711.pdf>

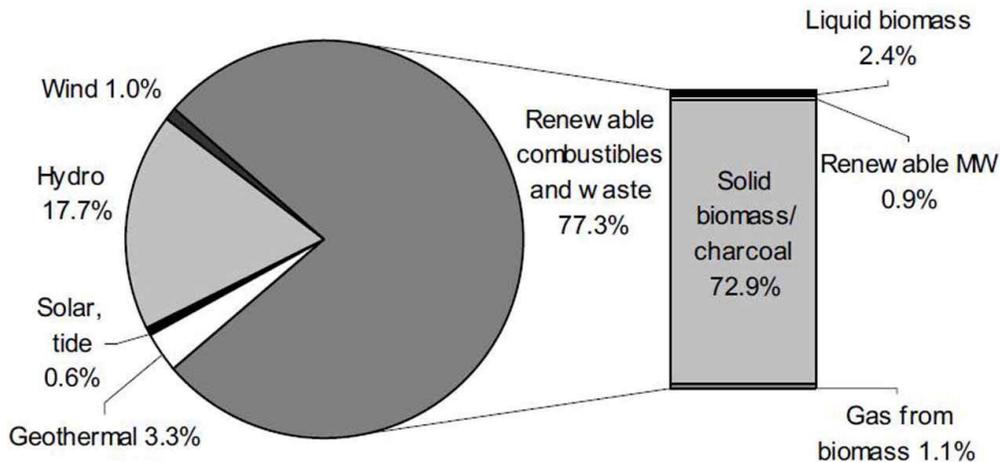


Figure 4 2007 Product Shares In World Renewable Energy Supply¹⁴

Since 1990, renewable energy sources have grown at an average annual rate of 1.7%, which is slightly less than the growth rate of world TPES of 1.9% per annum. Growth has been especially high for wind power, which grew at an average annual rate of 25%. However, this is due to its very low base in 1990, and the production still remains small. OECD countries account for most of the production and growth of solar and wind energy. The second highest growth rate was experienced by renewable municipal waste, biogas and liquid biomass. This segment grew on average at 10.4% annually since 1990, yet primary solid biomass, which is the largest contributor to renewable energy in the world, has experienced the slowest growth among the renewable energy sources, with a growth rate of 1.2% per annum. Non-OECD countries account for most of the production of solid biomass (wood and crop waste) but its growth is comparable for OECD and non- OECD countries. Solar photovoltaics and solar thermal experienced a 9.8% annual growth rate. The average annual growth rate of hydro power in non-OECD countries, 3.7% between 1990 and 2007, was larger than in OECD countries, which was only 0.4%. Growth was particularly strong in Vietnam (10.6%), China (8.2%), and India (3.3%) in the Asia region, in Brazil (3.5%), Argentina (3.2%), and Peru (3.7%) in the Latin American region, and in Mozambique (26.8%) and Angola (9.1%) in the African region.

¹⁴ <http://www.iadb.org/intal/intalcdi/PE/2009/03711.pdf>

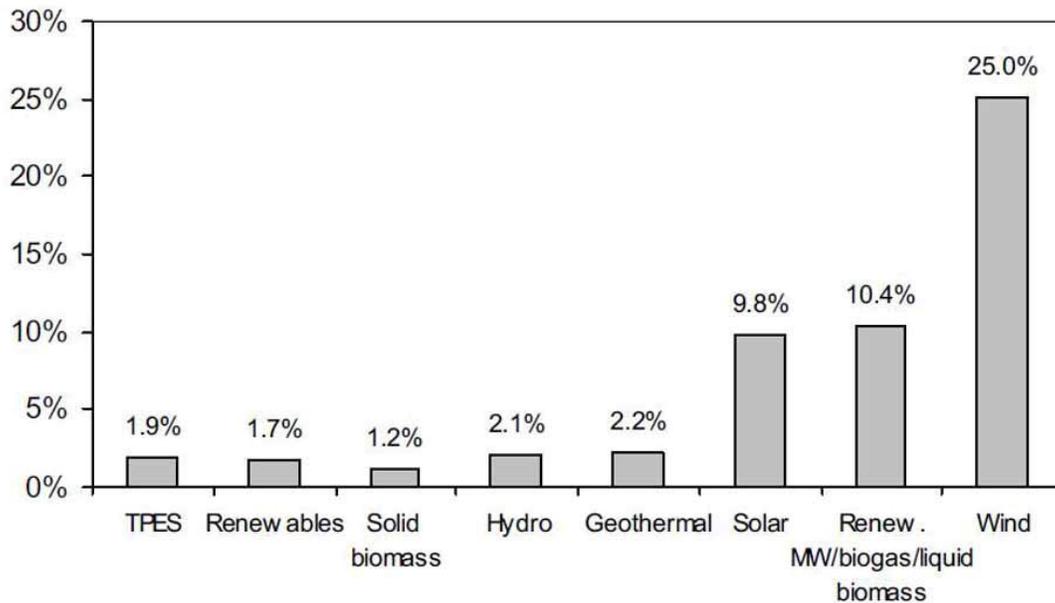


Figure 5 Annual Growth Rates Of World Renewables Supply From 1990 - 2007¹⁵

The hydro electricity generation in non-OECD countries started to exceed that of OECD countries in the year 2001. In 2007, the share of non-OECD countries reached 59.1% and is expected to further increase as most of the remaining hydro potential resides in these developing countries.

The biggest share of solid biomass, 85.9%, is produced and consumed in non-OECD countries, where developing countries, situated mainly in South Asia and sub-Saharan Africa, use non-commercial biomass for residential cooking and heating. Africa, which accounts for only 5.2% of the world's total TPES in 2007, produced 26.2% of the world's solid biomass supply. Energy diversification and a more efficient use of solid biomass are expected to provide mitigation opportunities for sustainability issues regarding the use of biomass in some non-OECD regions. The developing regions who are dependent on wood for cooking and heating are also causing deforestation in those same communities.

¹⁵ <http://www.iadb.org/intal/intalcdi/PE/2009/03711.pdf>

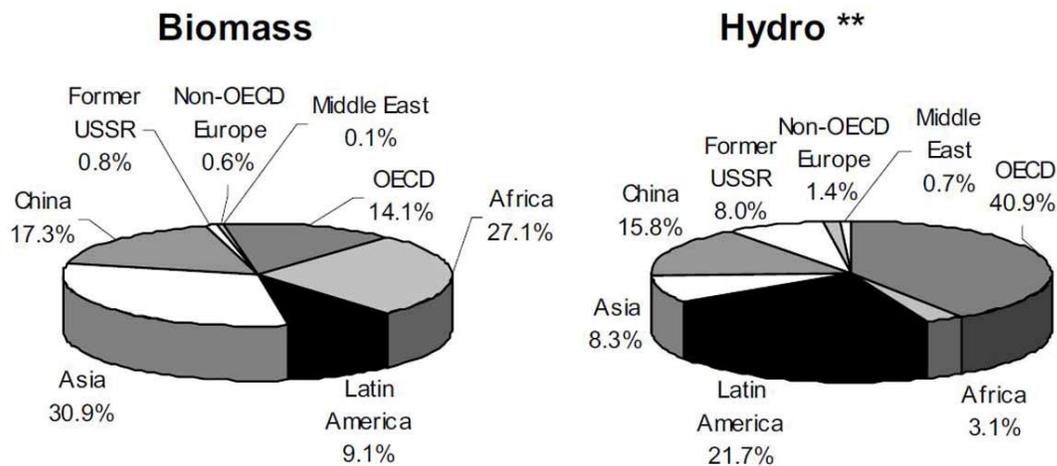


Figure 6 2007 Regional Shares of Renewables Supply¹⁶

Because of their heavy non-commercial use of biomass, non-OECD countries remain the principal renewables users, accounting for 76% of world total renewables supply. On the other hand, while OECD countries supply only 24% of world renewables, they constitute 45.7% of the world TPES. Consequently, in OECD countries the share of renewables in total energy supply is only 6.5%. This share is 18.3% for non-OECD countries. However, the OECD countries play a major role when looking at “new” renewables, with a supply of 68.8% of world energy from wind, solar and tide in 2007.

¹⁶ <http://www.iadb.org/intal/intalcdi/PE/2009/03711.pdf>

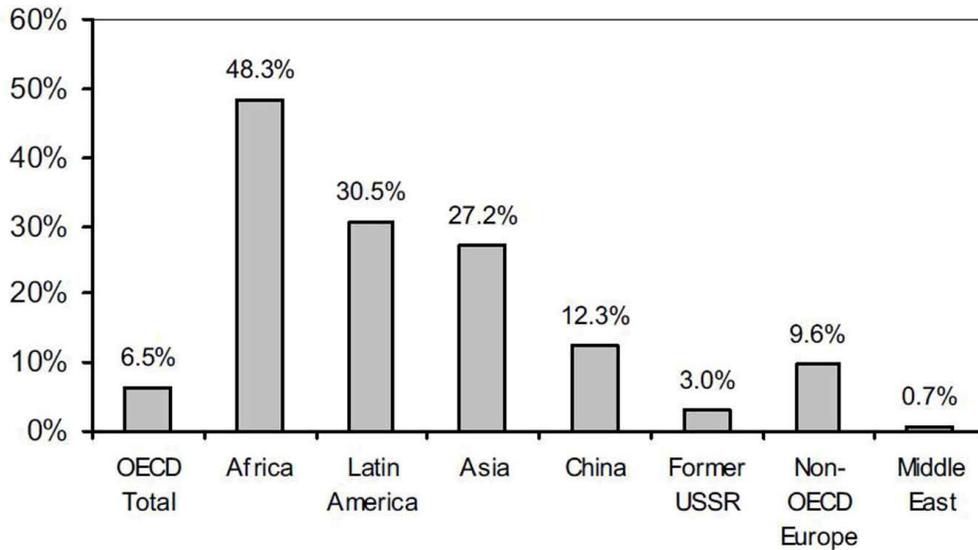


Figure 7 2007 Renewables Supply Shares¹⁷

While more than half of the primary renewable energy supply in OECD countries is used to generate electricity, on a global level, a large part of renewables is consumed in the residential, commercial and public services sectors. Again, this is a consequence of widespread biomass use in the residential sector of developing countries. In fact, only 24.4% of renewables are used for electricity production worldwide, while 52.3% are used in residential, commercial and public sectors.

¹⁷ <http://www.iadb.org/intal/intalcdi/PE/2009/03711.pdf>

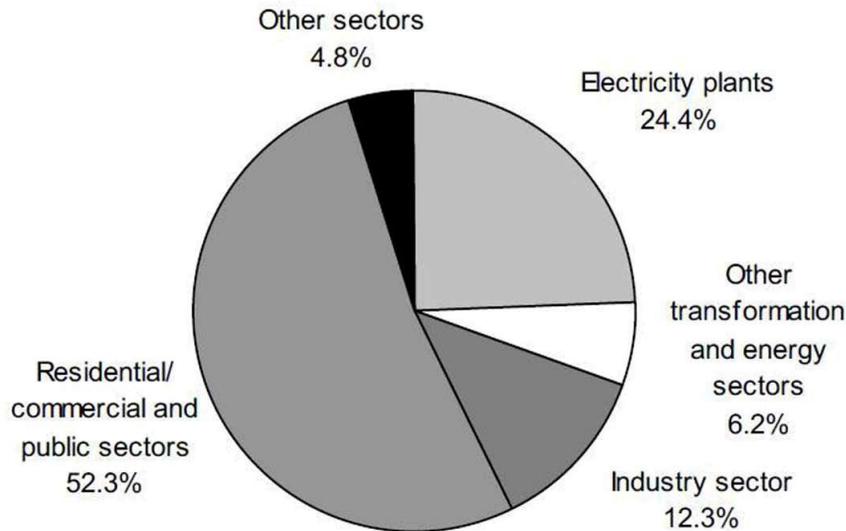


Figure 8 2007 World Sectoral Consumption of Renewables¹⁸

Despite this fact, renewables are the third largest contributor to global electricity production. They accounted for 17.9% of world generation in 2007, after coal (41.6%) and slightly behind gas (20.9%) but ahead of nuclear (13.8%) and oil (5.7%). Hydro supplies the vast majority of renewable energy, generating 15.6% of world electricity and 87% of total renewable electricity. Combustible renewables and waste, including solid biomass, play a minor role in electricity generation, supplying 1.1% of world electricity. Although growing rapidly, geothermal, solar and wind energies accounted for only 1.2% of world electricity production in 2007. Renewable electricity generation has grown worldwide since 1990 on average by 2.6% per annum, which is less than the total electricity generation with an average rate of 3.1%. While 19.5% of global electricity in 1990 was produced from renewable sources, this share fell to 17.9% in 2007. This decrease is mainly the result of slow growth of the main renewable source, hydro power, in OECD countries, which produces about 36% of global renewable electricity.

¹⁸ <http://www.iadb.org/intal/intalcdi/PE/2009/03711.pdf>

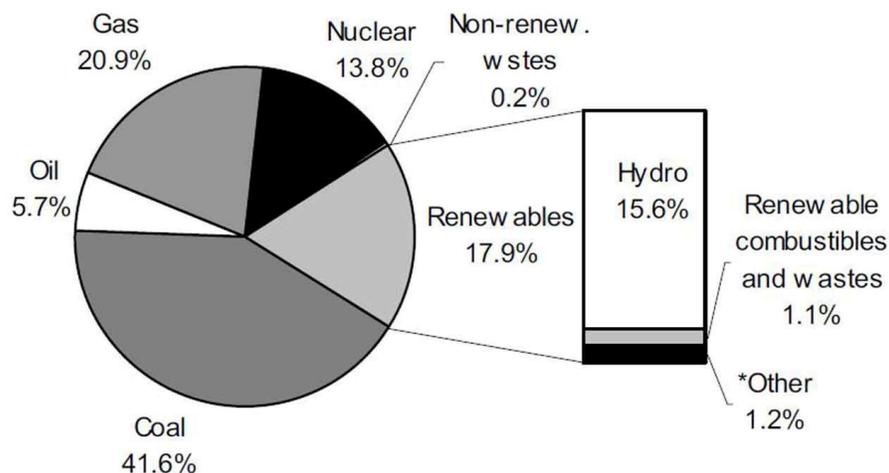


Figure 9 Fuel Shares In World Electricity Production In 2007¹⁹

Since 1990, renewable electricity grew at an annual average rate of only 1.3% in OECD countries, while it grew at 3.9% in non-OECD countries. While renewable electricity in non-OECD regions has been growing at a slightly lower rate than total electricity generation (3.9% versus 4.6%), growth of renewable electricity in OECD countries was relatively lower than total electricity generation growth (1.3% versus 2%). Since 1995, electricity growth has been higher in non-OECD countries, which includes developing economies in Asia and Africa. Population growth is much higher in developing countries than in OECD countries, and as income increases, people switch from fuel wood and charcoal to kerosene and liquefied petroleum for cooking and have better access to electricity through national and rural electrification programs. As a consequence, future electricity growth, including renewable electricity growth, is expected to remain higher in non-OECD countries than in OECD countries.²⁰

¹⁹ <http://www.iadb.org/intal/intalcdi/PE/2009/03711.pdf>

²⁰ <http://www.iadb.org/intal/intalcdi/PE/2009/03711.pdf>

5 THE CURRENT STATE OF RENEWABLES IN LATIN AMERICA

According to recent data from the International Energy Agency (IEA), renewable energies amount to almost 29% of the total primary energy supply (TPES) in Latin America. At first, this figure looks relatively high and somewhat impressive, especially if we compare it to the 5.7% share of renewables of OECD countries and the 0.7% share in the Middle East. These numbers, however, can be very misleading.

In reality the situation of renewable energies in Latin America is not as positive or optimistic as we might want to think, or as certain statistical data lead us to believe. There are many problems associated with the implementation of renewables as well as their impact on the environment and society. In this context, the main problem for renewable energies in Latin America is in the way energy and development policies have been constructed. In most cases, energy policies and strategies in Latin America have excluded renewables and other alternatives as being too costly and technologically unfeasible, or by arguing that the country does not have the capabilities to implement them. The easiest explanation for this, and one which is usually mentioned, is the lack of incentive and foresight. Since the region has an abundance of resources such as oil, gas, and hydro, it is in general easier, cheaper and more technically feasible to keep exploiting conventional energy resources than to invest in renewable energies or create appropriate renewable energy policies. Another common explanation is that the development of renewable energies clash with the interest of powerful players, particularly large energy companies, and, therefore, there are few incentives to promote them.

The Latin American renewable energy sector is almost entirely dominated by only two forms of renewables: hydro and biofuels, which make up respectively 36% and 62% share of the total of renewables. Other forms of renewable energies represent only an insignificant fraction of total energy production (1.4%). The

problem itself is that these two forms of energy are not in all cases the most adequate and in fact questionable to the extent of being renewable and sustainable.

First of all, the hydroelectricity sector has been dominated by large hydro plants which produce almost the entire share of renewable energy to produce electricity. Large hydro plants have been constructed in Latin America for several decades now, as countries have embraced and promoted them as a means of reducing dependency on fossil fuels, especially given the large hydro potential of the region. Hydro plants have been particularly important in the production of electricity, as it represents 60% of total electrical production in Latin America. In countries like Brazil, Paraguay, and almost all Central American nations, this figure rises to more than 90% of the total. Hence, several Latin American countries have come to depend almost completely on the hydro sector for electricity. This has created problems for them on several occasions, particularly when there are extended dry periods and water levels fall down significantly. Moreover, apart from creating energy security concerns, large hydro has caused serious environmental and social problems, particularly in sensitive regions like the Amazon rainforest. The construction, for example, of the Tucuruí hydro plant in the Brazilian rainforest flooded around 2400 square kilometres of rainforest and displaced around 30,000 indigenous people from their traditional territories. In this context, large hydro cannot be properly considered a form of clean, sustainable energy, particularly if viewed from the context of sustainable development.

In the case of biofuels, its percentage share among renewables has been decreasing considerably at the regional level for the simple reason that statistical data does not distinguish between traditional and industrial/modern biofuels. Traditional biofuels are those associated with subsistence energy consumption (firewood, grass), whereas industrial/modern forms concern mainly the production of biofuels such as ethanol and sugarcane. Since the 1970's,

traditional biomass has decreased from 30% of total TPES to currently 15%, whereas modern biofuels have only increased slightly. Thus, as there is more urbanization and expansion of the electric grid, the percentage of biomass will keep shrinking as people turn from traditional biofuels to other sources of energy. Also, both traditional and industrial biofuels have come under heavy criticism from a number of NGO's, civil groups and certain government authorities for a number of reasons. The most common opposition is that industrial biofuels do not contribute to reducing greenhouse gases, and they provoke a series of environmental and social problems, whereas traditional biofuels can lead to deforestation and other unsustainable practices. Although it is debatable to what extent all these criticisms are true, it is clear that biofuels are not seen as the most optimal solution by some, and that it can, as big hydro, have negative consequences.

Altogether, then, it is clear that the current situation of renewables in Latin America is worse than what appears at first sight. In fact, if we would take away large hydro and unsustainable biofuels production, the region will not be much better than other parts of the world.²¹

²¹http://www.flacsoandes.org/web/imagesFTP/9408.Renewable_Energy_Policies_in_Latin_America___The_role_of_the_State_1_.pdf

6 POTENTIAL OF RENEWABLE ENERGIES IN LATIN AMERICA

All countries in the region are endowed with abundant renewable energy sources. Solar, wind, biomass, small hydro and other energy resources from the ocean are available in the region in larger or smaller quantities, depending on the geographical location and topography of the individual countries.

The force of winds can be used to produce mechanical power and electricity by means of commercially available and cost-competitive technologies. Southeast Mexico and most Central American and Caribbean countries are subject to the influence of the Trade Winds, while Southern Mexico and Central America are exposed to strong and almost constant thermally driven winds, which in the case of Mexico are known as *Tehuantepecer* [9], produced by the temperature difference between the waters of the Atlantic and the Pacific oceans. Windy places can also be found in the southern hemisphere. Low winds cannot be effectively used to produce power while excessively strong winds may cause damage to wind generators. However, when properly located and sized, wind has proven to be a reliable energy resource. A few countries (basically Brazil and Argentina) in the Latin American region have developed wind maps to guide project developers. A low resolution wind map of the region was developed over a decade ago by the Latin American Energy Organization (OLADE).

Solar energy is more evenly distributed, as good portions of the region lie within the Sun Belt Region of highest solar radiation. Thus, except for site specific adverse microclimates, solar energy is a predictable and reliable resource, capable of being transformed to heat and electricity by means of several technologies in different stages of development and are commercial availability. Solar irradiance maps are available for Mexico, Colombia, Brazil, Argentina and a few other countries.

As a natural consequence of the solar radiation available, photosynthetic activity in most of the region of study is rather high, and hence the high production of biomass fuels. In addition, many countries in the region have an economy based on agriculture, so that agricultural waste, forest residues and other residues from raising animals (e.g. manure or methane from decomposing waste) is also abundant. These resources are difficult to evaluate, so that information in a compiled and analyzed form is difficult to find.

Most countries in the region already use a good portion of their hydraulic potential to generate electricity. Most operations are in the multi-megawatt range, seeking economies of scale characteristic of large hydroelectric technologies. This practice has left a large portion of the small hydroelectric potential yet to be exploited. Given the high rainfall indices and the rough topography of many countries, small hydropower offers a good alternative to supply electricity, especially in remote sites.

Wave and tidal power, along with other forms of energy available in the ocean, represent an enormous energy potential for coastal countries in the region, especially when one considers the large coastline to inland ratio of most countries in Latin America. Unfortunately, technologies to tap such energy resources are still far from commercialization.

The challenge of renewable energy resource development in the region is the fact that little has been done to properly measure and characterize these resources. In the case of project development, available information on the local renewable resource is often limited, if not unreliable. In most cases, information is non-existent, which represents a major barrier to the incorporation of this alternative as part of the national energy inventories and planning exercises.²²

²² <http://www.iea.org/work/2003/budapest/mexico.pdf>

6.1 Argentina

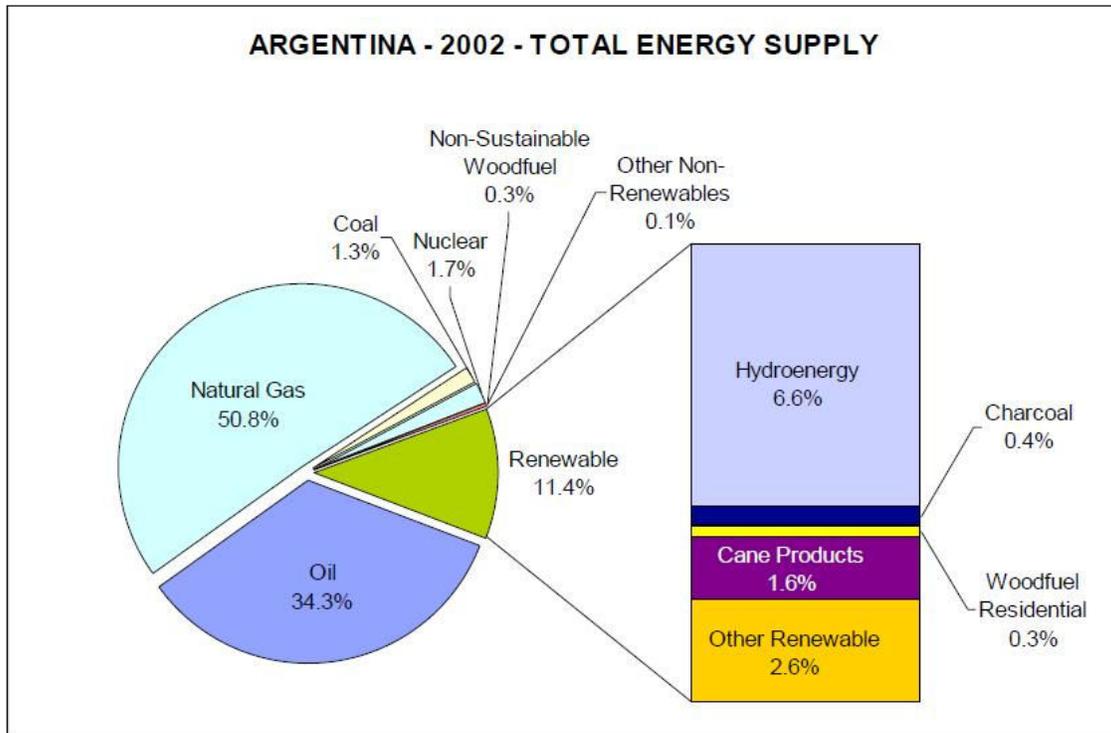


Figure 10 Argentina – 2002 – Total Energy Supply²³

Natural gas with 50.8%, followed by 34.3% from oil, has the highest percentage of the total energy supply of Argentina.

In 2002, the share of all renewable energy supply, with 11.4 % of the total energy supply, is not insignificant. The main renewable source is hydro energy with 6.6%. Other renewable technologies, such as cane products with 1.6%, charcoal with 0.4%, woodfuel with 0.3 % and other renewables, such as wind and solar, do not play an important role.

²³ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.1.1 Wind Power

The potential for wind power is large in the Argentina. The greatest potential is concentrated to the south of the country where the winds are strong and constant year round.

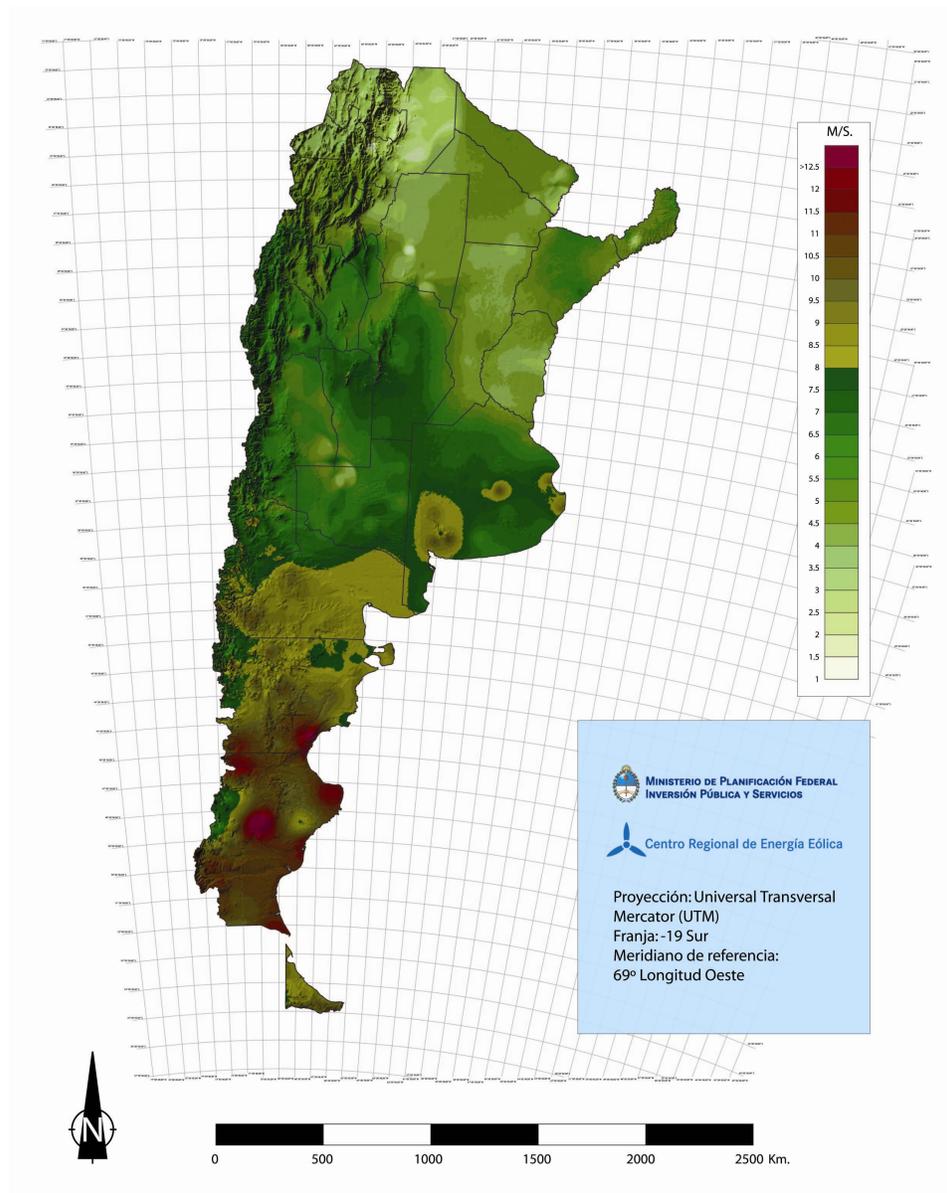


Figure 11 Argentina: Wind Power Potential²⁴

²⁴ Regional Wind Power Center, Ministry of Federal Planification, Public Investment and Services

6.1.2 HYDRO

The hydropower potential is located mainly in the Andes Mountain because of the great currents generated by the snow thaws in spring and summer. The other premier location is the Iguazú Falls.



Figure 12 Argentina: Hydro Potential²⁵

²⁵ Cámara Argentina de Energías Renovables 2009

6.1.3 BIOMASS

The potential for bioenergy is again very large in the country. The greatest potential is concentrated to the north as well as in the center of the country where the timber and agricultural sectors can provide waste fuels.

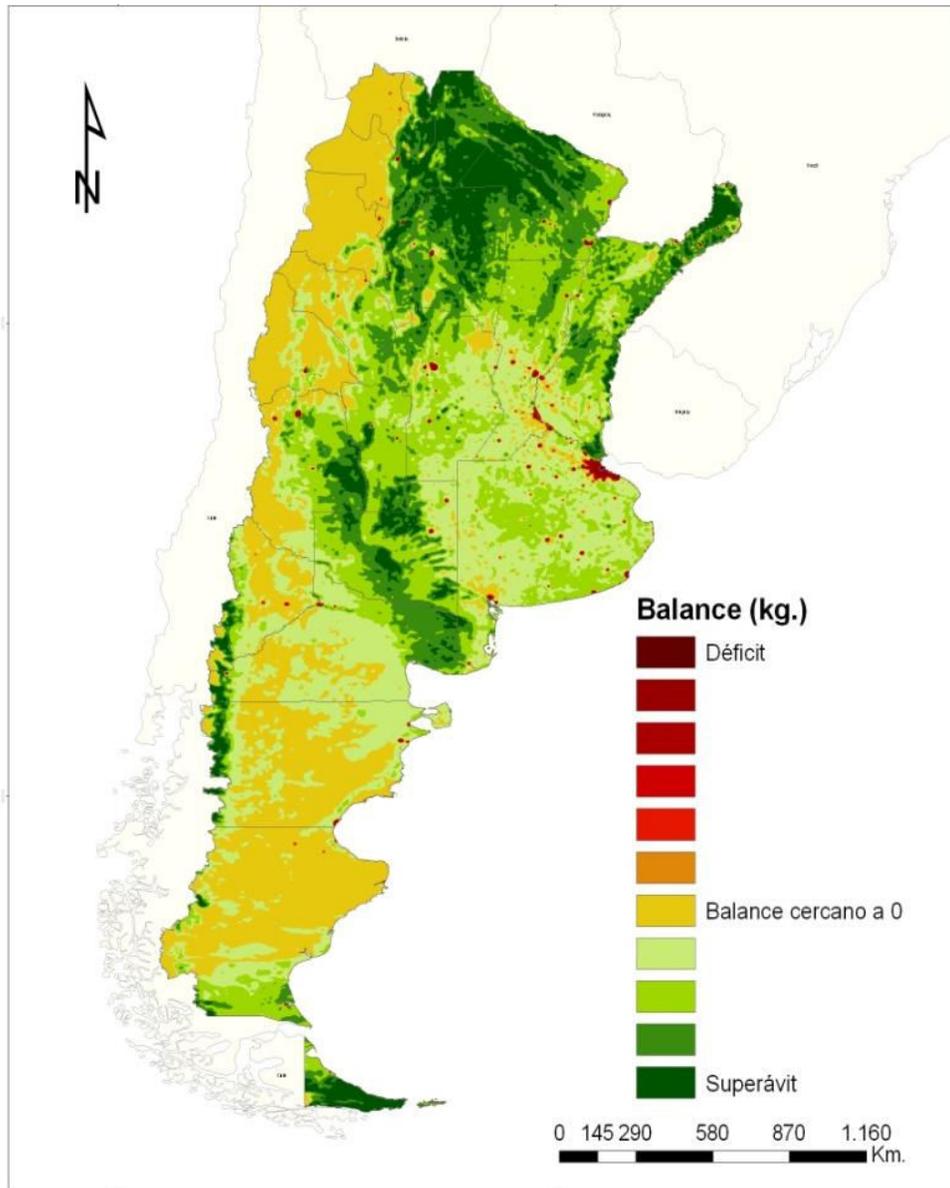


Figure 13 Argentina: Bio-Energy Potential²⁶

²⁶ Cámara Argentina de Energías Renovables 2009

6.1.4 SOLAR POWER

The potential for solar power is abundant in Argentina. The greatest potential is concentrated to the north of the country and could be harnessed for peak loads.

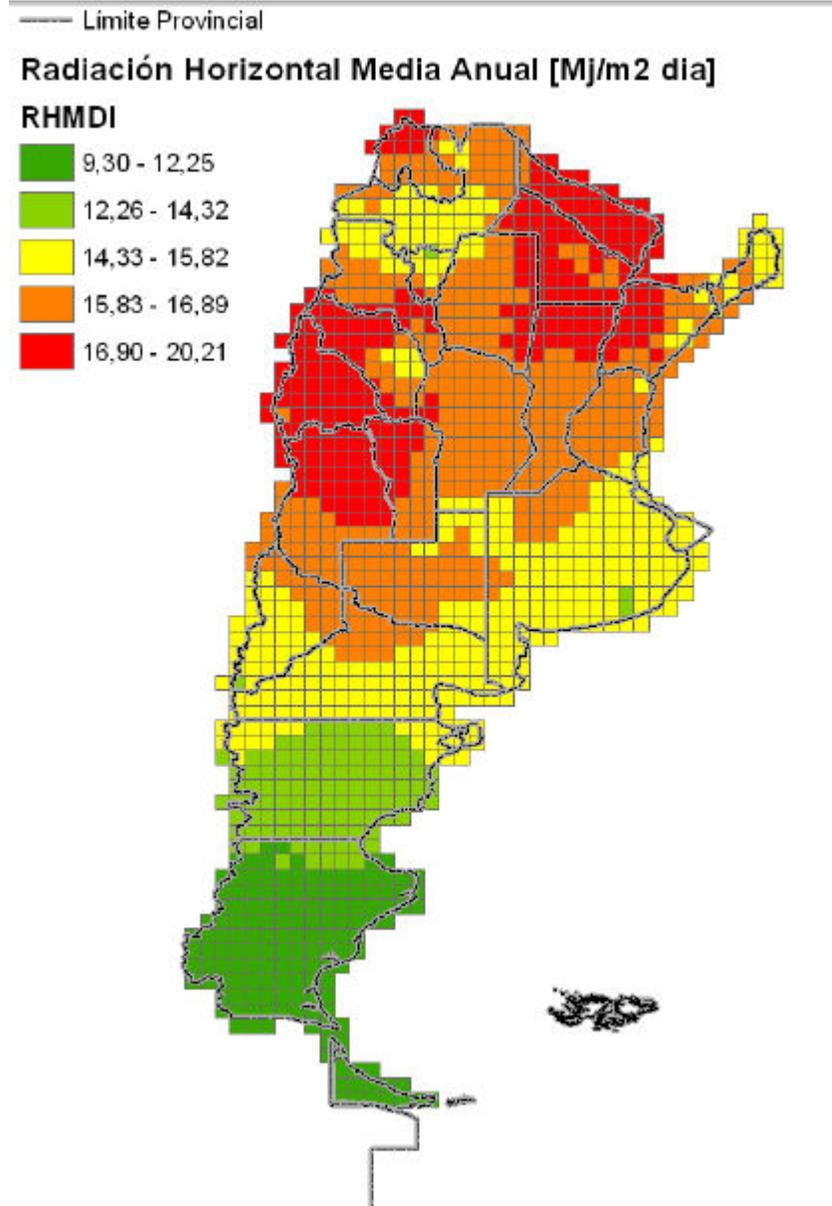


Figure 14 Argentina: Solar power potential²⁷

²⁷ <http://www.developingrenewables.org/energyrecipes/reports/reports/061127%20Recipes%20-%20Argentina%20RE%20potential%20report.pdf>

6.1.5 GEOTHERMAL

The greatest potential is concentrated to the western mountains. The potential of geothermal energy is tremendous as evidenced by presence of volcanoes in the Andes. Harvesting this heat can provide quality base-load power for the country.



Figure 15 Argentina: Geothermal potential²⁸

²⁸ <http://www.developingrenewables.org/energyrecipes/reports/reports/Argentina%20-%20Part%20C%20-%20Country%20Maps%20060209.pdf>

6.2 BOLIVIA

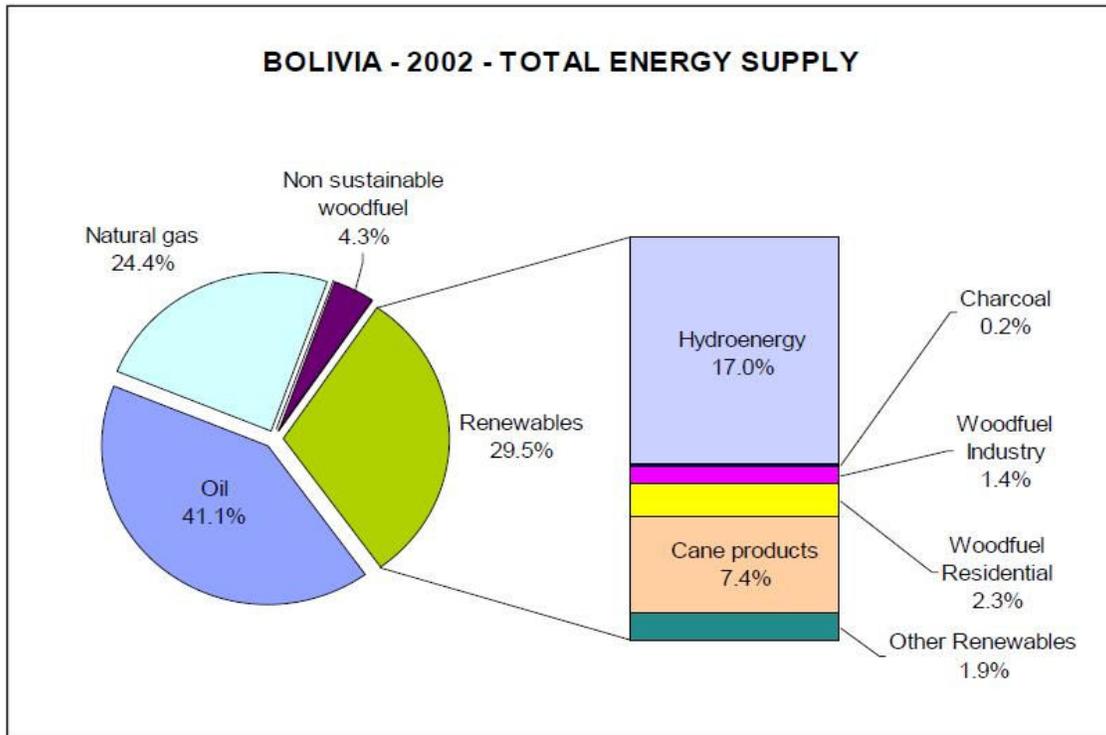


Figure 16 Bolivia – 2002 – Total Energy Supply²⁹

The main energy supply in 2002 is oil with 41.1%, followed by renewables and natural gas.

The supply of renewable energies represents around 29.5% of total energy supply. Hydro energy with 17% has the largest proportion of renewable energies, followed by cane products with 7.4%. Woodfuel, charcoal and other renewables are subordinated.

²⁹ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.3 BRAZIL

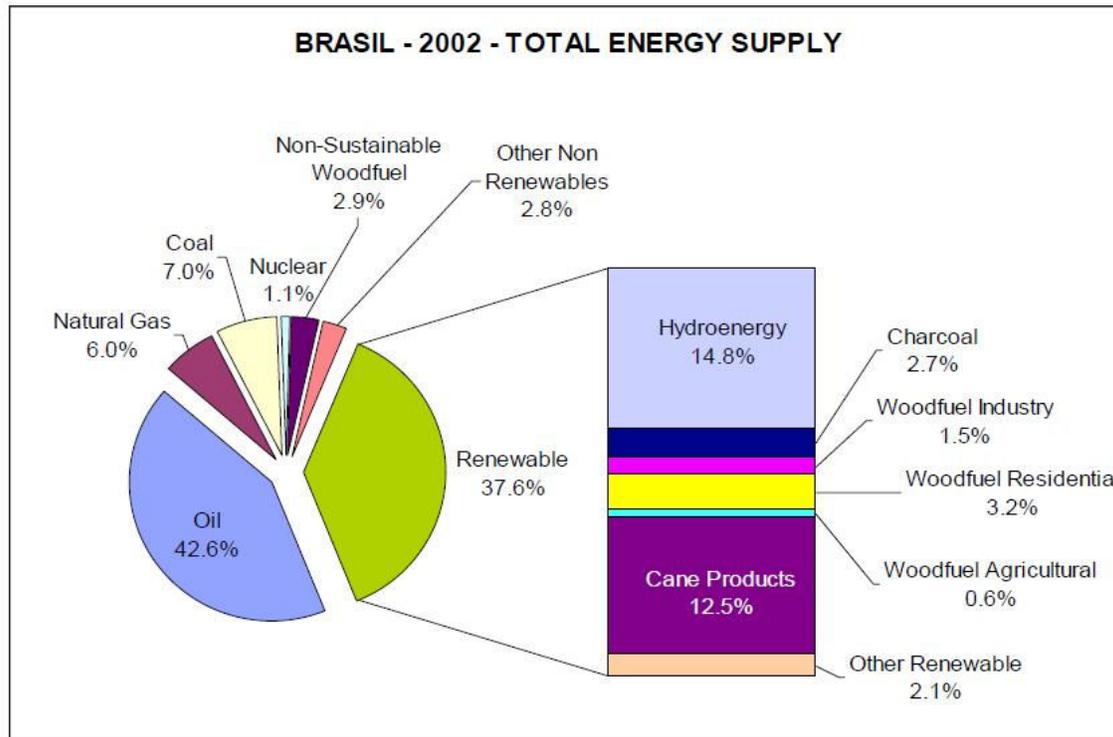


Figure 17 Brazil – 2002 –Total Energy Supply³⁰

In Brazil, as in many other countries, oil also represents the main part of the total energy supply with 42.6%.

The share of all renewable energy supply as a whole is significant, exceeding 37% of total energy supply. There are two main renewable sources: hydro energy (14.8%), with the largest share, and sugarcane products, with a very sizeable percentage (12.5%). The renewable fuelwood portion and charcoal also play an important role (together representing 8%). The share of other renewable technologies, such as wind and solar, is very low.

³⁰ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.3.1 WINDPOWER

The potential for wind power is large in the country. The greatest potential is concentrated along the northeast coast where the winds are constant year round. This is true for many continental coastlines and there are offshore wind developments that Brazil could emulate in Europe.

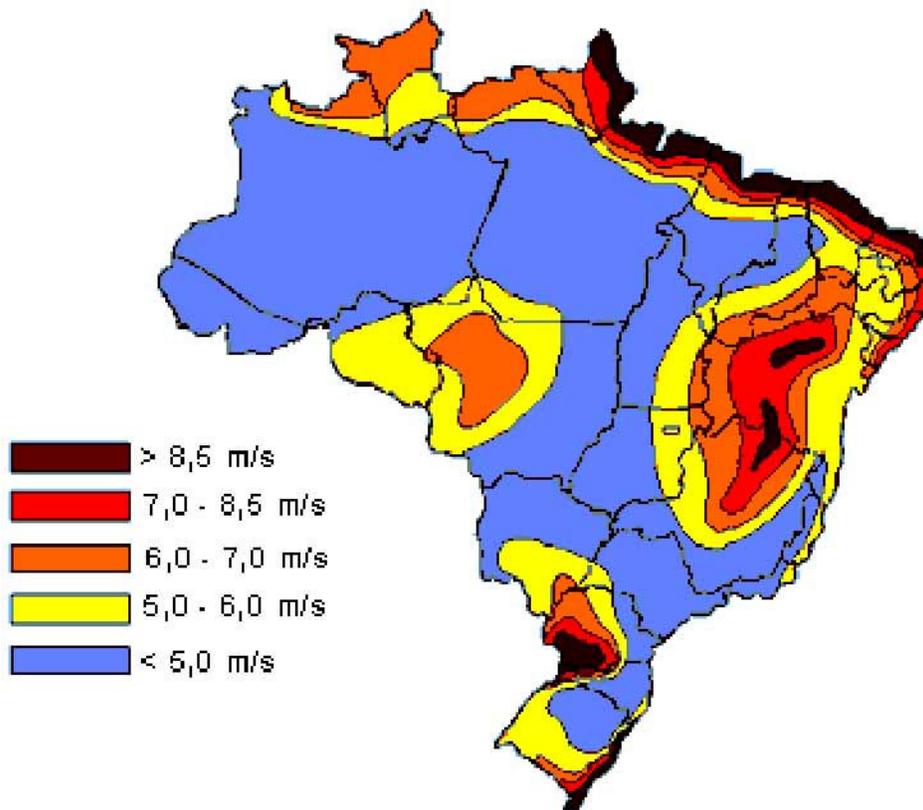


Figure 18 Brazil: Wind Power Potential³¹

³¹ <http://www.matternetwork.com/2009/5/>

6.3.2 Geothermal

Brazil is blessed with abundant geothermal hot spots which increases the potential of geothermal energy, especially along the northern-east coast and in the south.

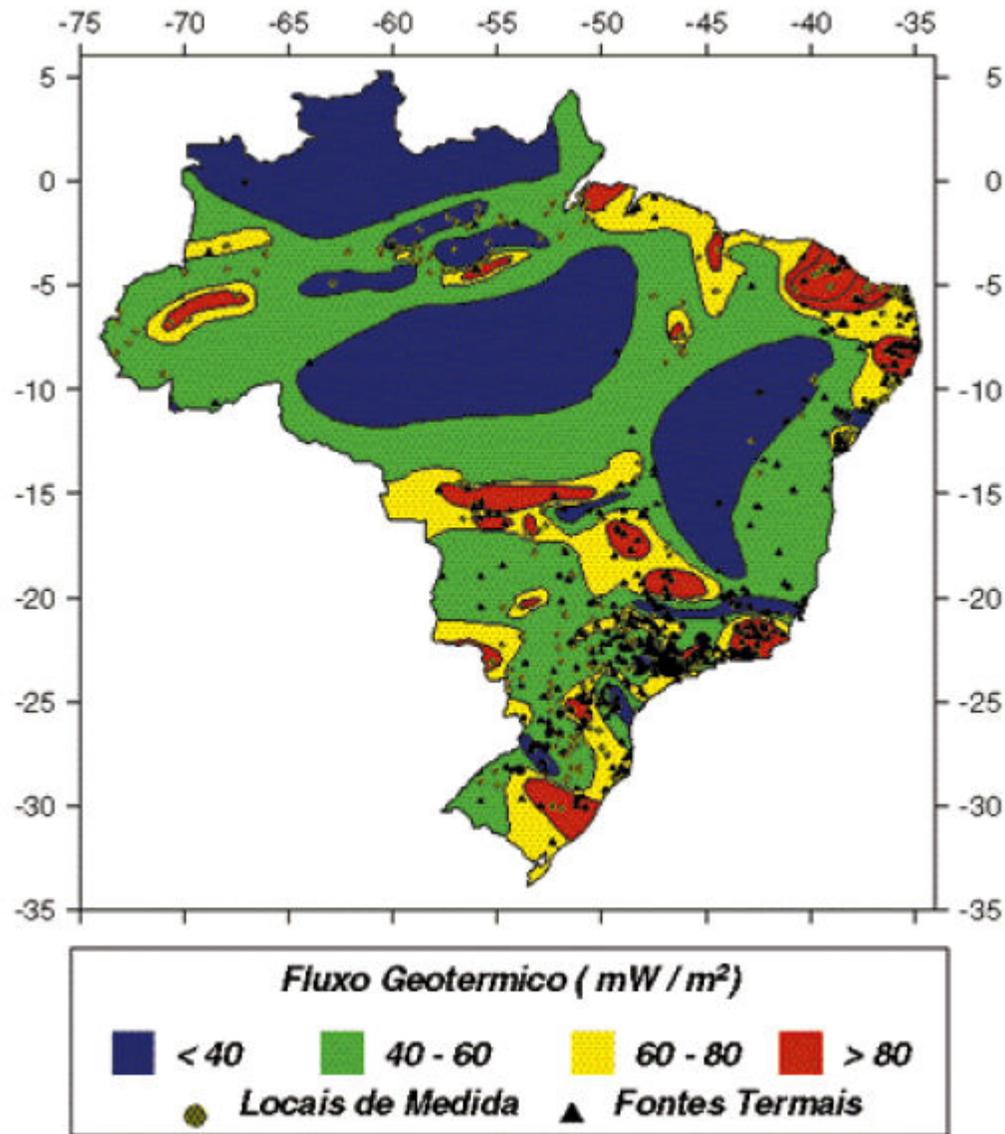


Figure 19 Brazil: Geothermal potential³²

³² <http://www.energyrecipes.org/reports/reports/Brazil%20-%20Part%20C%20-%20Country%20Maps%20060209.pdf>

6.3.3 HYDRO POWER

Brazil has already specialized on hydro energy generation, but there are still areas with high potential, like in the north-west and the south.

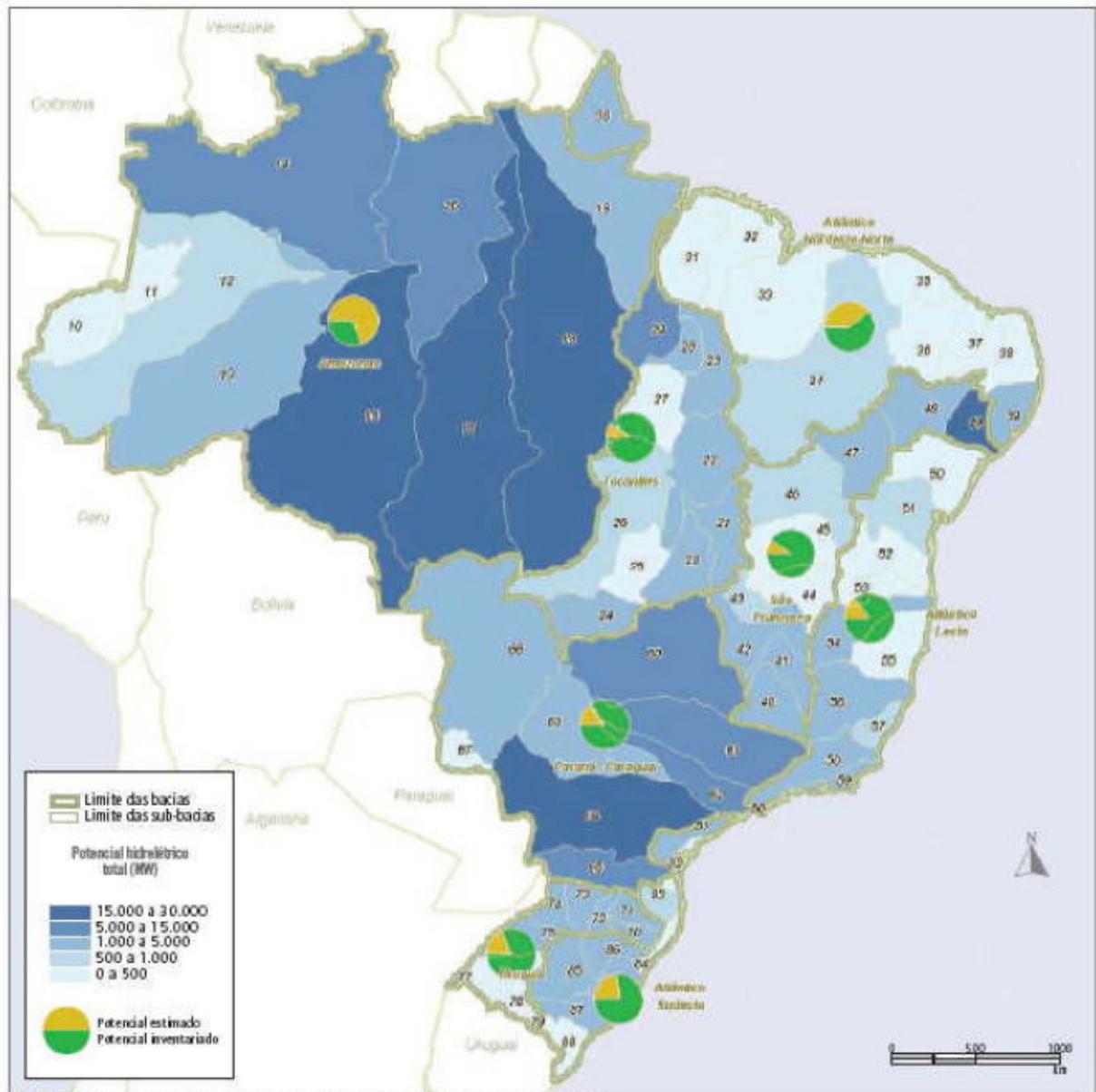


Figure 20 Brazil: Hydro Power Potential³³

³³ <http://www.energyrecipes.org/reports/reports/Brazil%20-%20Part%20C%20-%20Country%20Maps%20060209.pdf>

6.3.4 SOLAR POWER

The potential of solar power in Brazil is very high. In almost every part of the country, it would be possible to develop new solar plants. Especially in the east where the solar radiation is ideal to marry production and load demand.

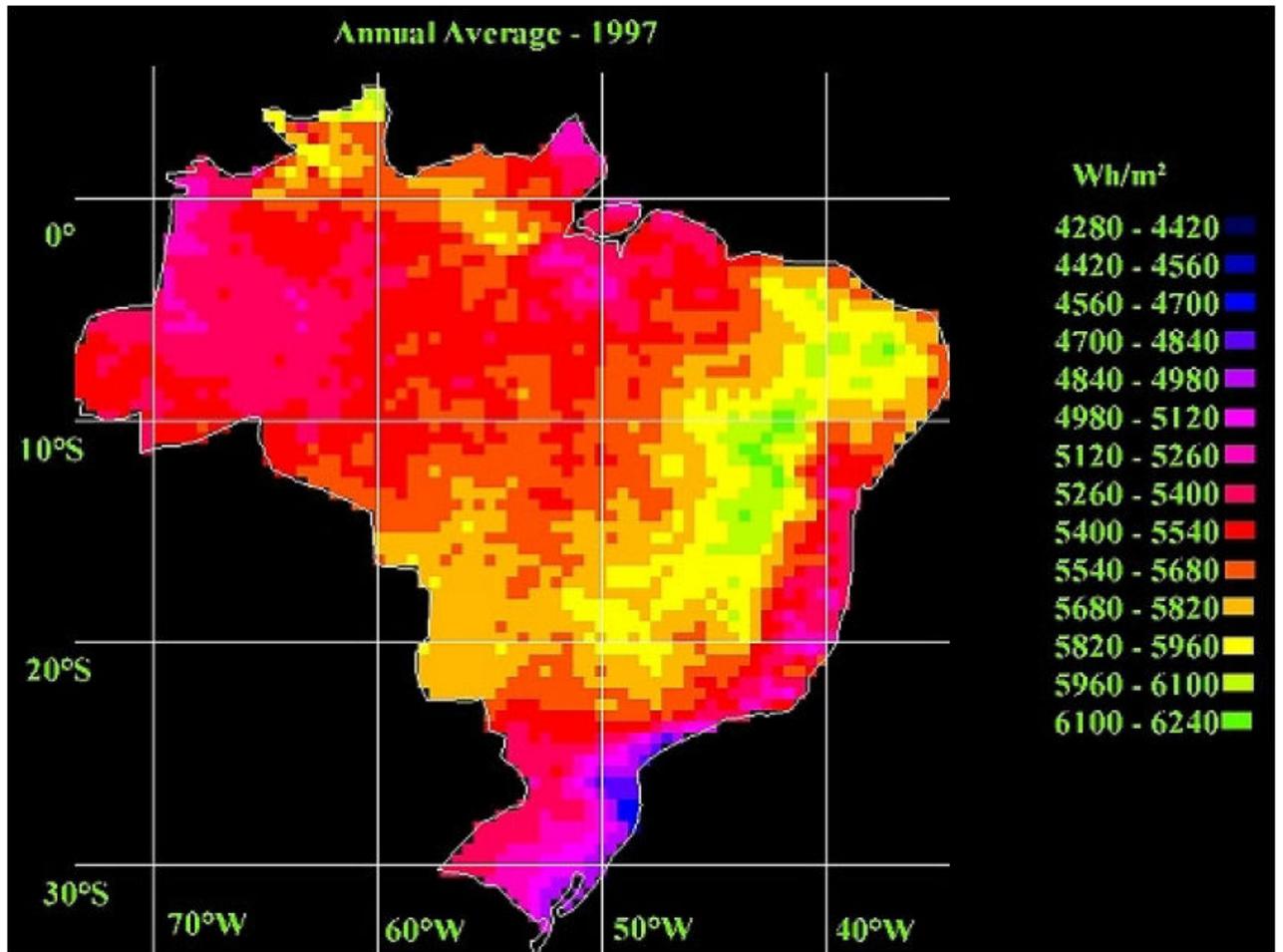


Figure 21 Brazil: Solar Power Potential³⁴

³⁴ <http://www.energyrecipes.org/reports/reports/Brazil%20-%20Part%20C%20-%20Country%20Maps%20060209.pdf>

6.4 CHILE

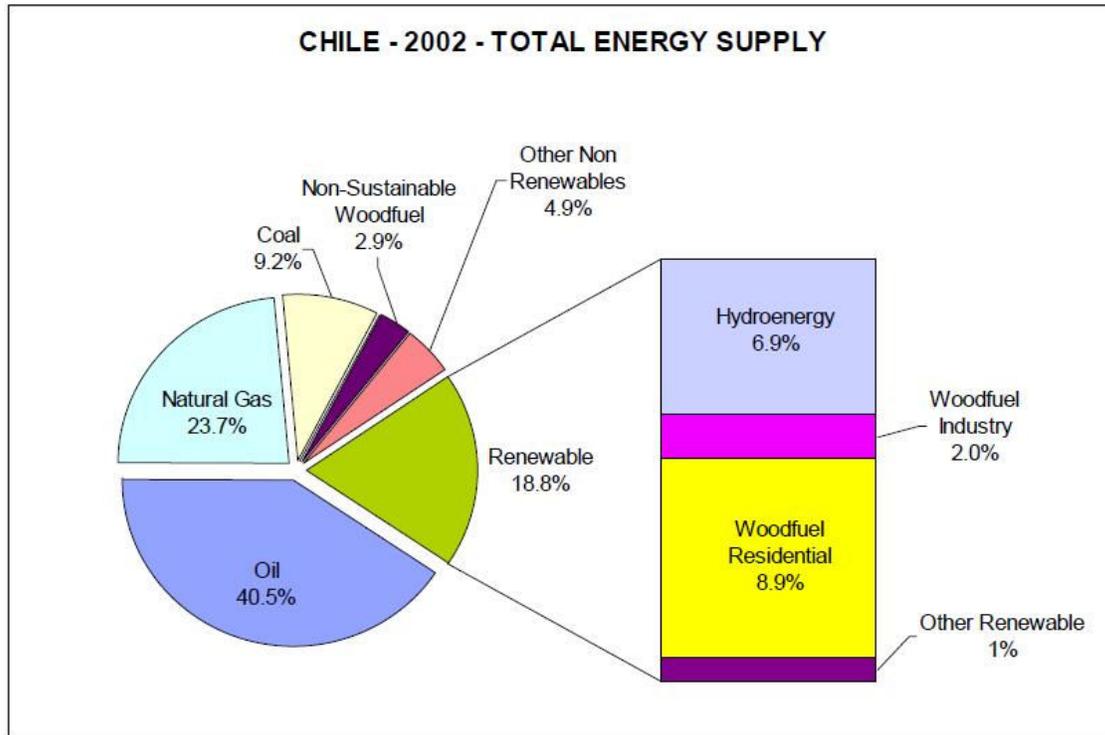


Figure 22 Chile – 2002 – Total energy supply³⁵

With 40.5%, oil plays the most important part of the total energy supply in Chile. The second highest part is represented by natural gas (23.7%) followed by renewable energies (18.8%).

Woodfuel (10.9%) and hydro energy (6.9%) are the two main renewable energy sources. The use of other renewables like wind, solar or geothermal remains nominal.

³⁵ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.5 COLOMBIA

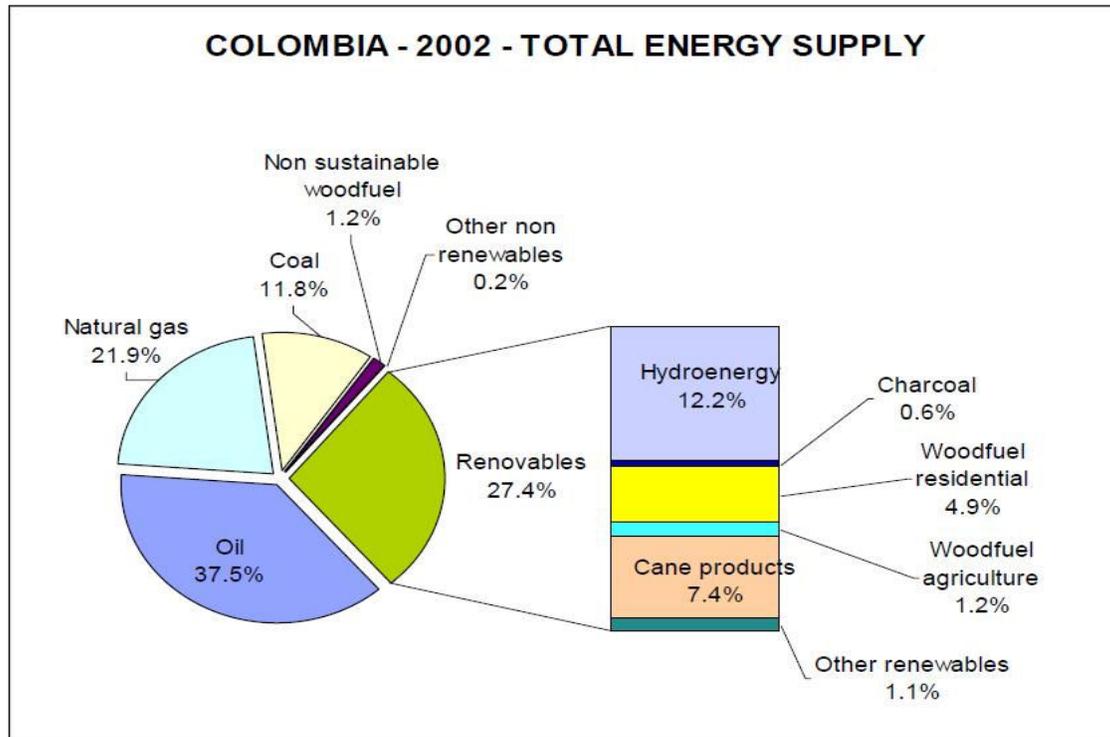


Figure 23 Colombia – 2002 – Total Energy Supply³⁶

Colombia has, as many other countries, a high dependency on oil (37.5%). However, in this case, renewables account for quite a large share, exceeding 27% of total energy supply.

Hydro energy (12.2%) and cane products (7.4%) represent the most important renewable energy sources in this country. Woodfuel with 6.1% plays an important role too. Charcoal and other renewables are generated only in a very small quantities.

³⁶ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.5.1 WIND POWER

The potential for wind power is not so large in the country. The best potential is concentrated along the northern coast and mountaintops in the highlands.

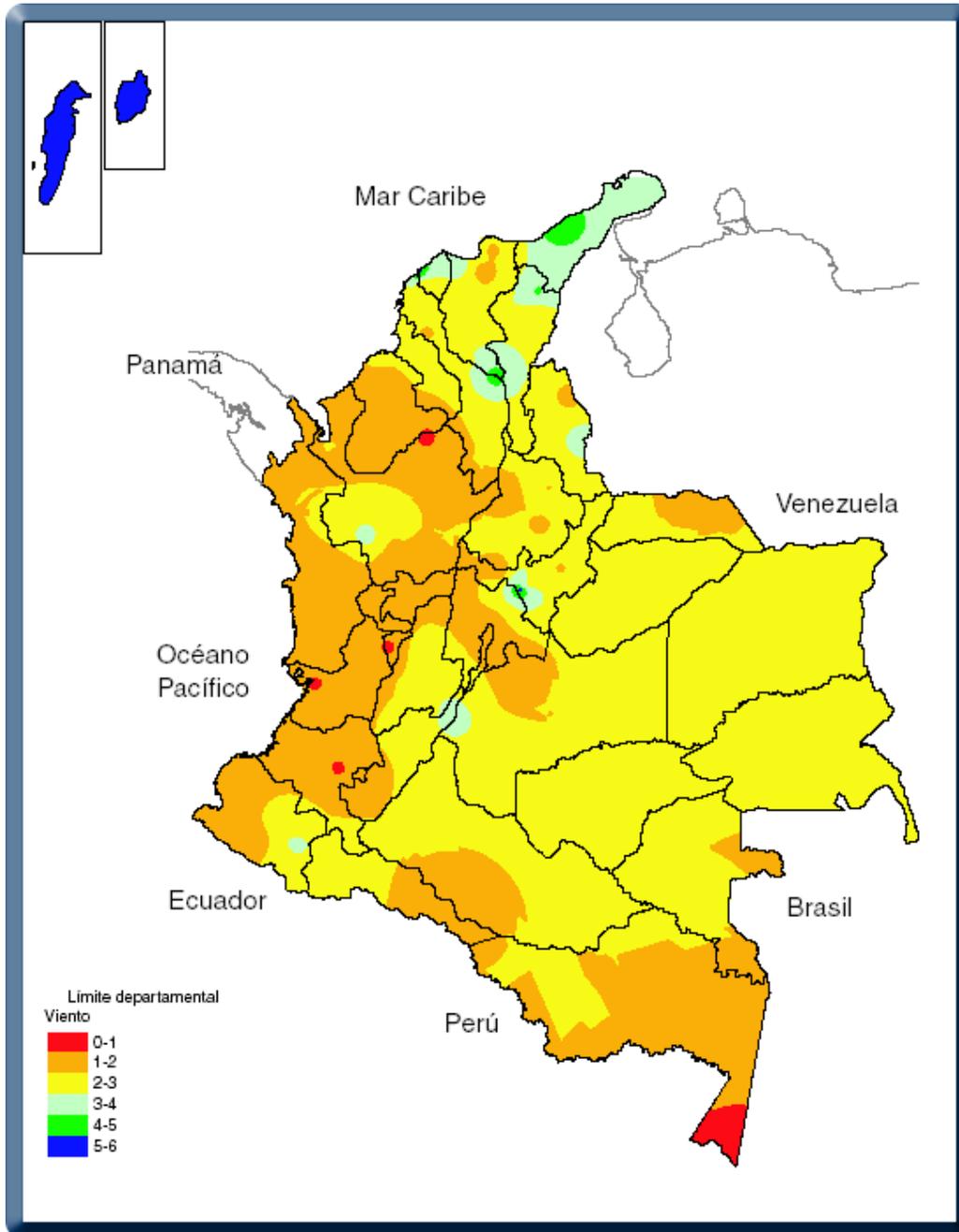


Figure 24 Colombia: Wind Power Potential³⁷

³⁷ <http://www.todacolombia.com/geografia/mapas/mapavientoscolombia.gif>

6.5.2 GEOTHERMAL

There are many geothermal areas in Colombia. The greatest potential is concentrated along the northern coast and the western part of the country.



Figure 25 Colombia: Geothermal Potential³⁸

³⁸ <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/geo-latin-america/geo-colombia.shtml>

6.5.3 HYDRO POWER

Colombia already has discovered its great potential for hydro energy. The country is already tapping much of this river flow. As you can see on the map, the greatest potential is concentrated to the west, flowing from the Andes range.

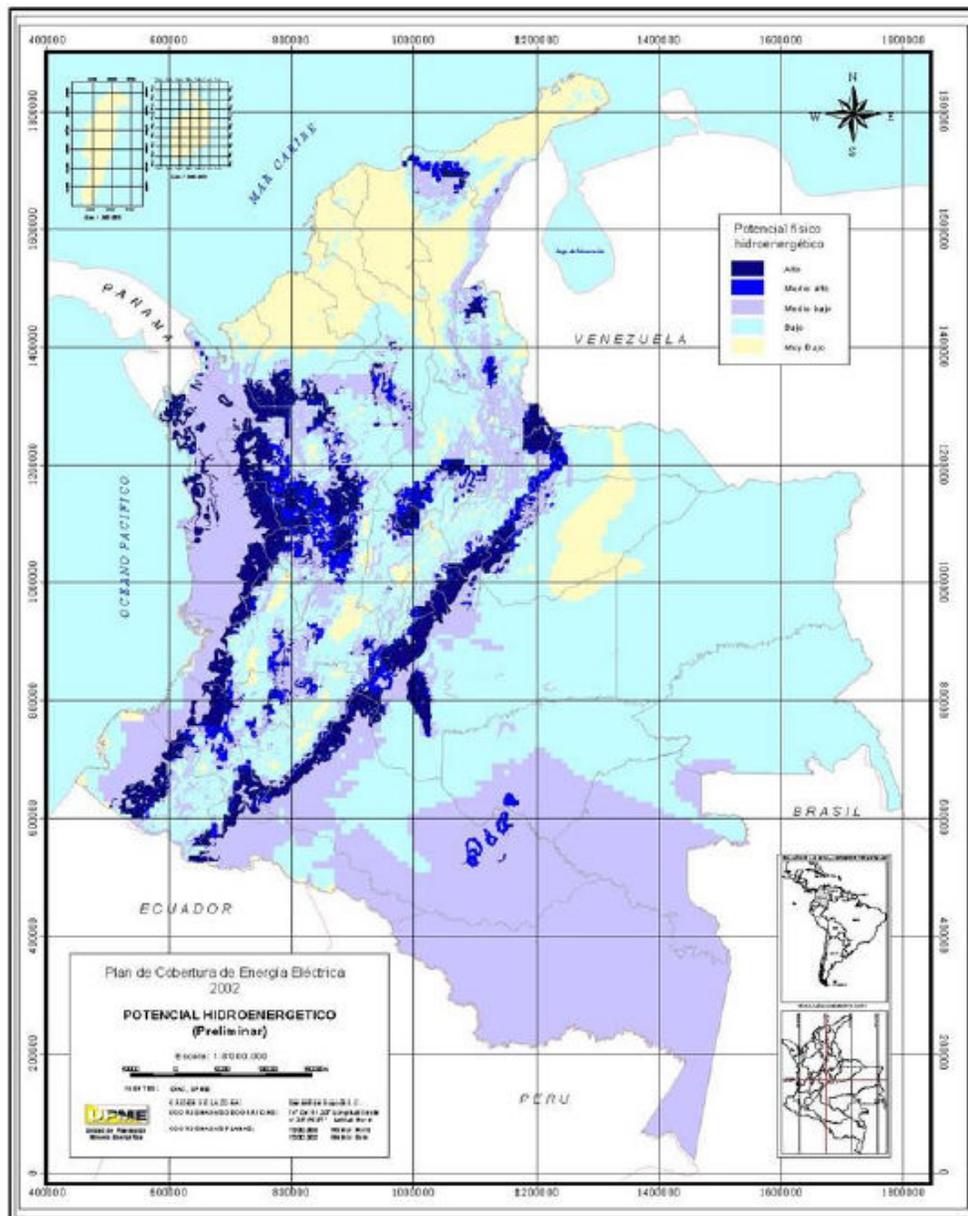


Figure 26 Colombia: Hydro Power Potential³⁹

³⁹ <http://www.developingrenewables.org/energyrecipes/reports/reports/Colombia%20-%20Part%20C%20-%20Country%20Maps%20060209.pdf>

6.5.4 SOLAR POWER

As you can see on the following two maps, the highest solar power potential is concentrated to the north, which could serve peak energy to those population centers.

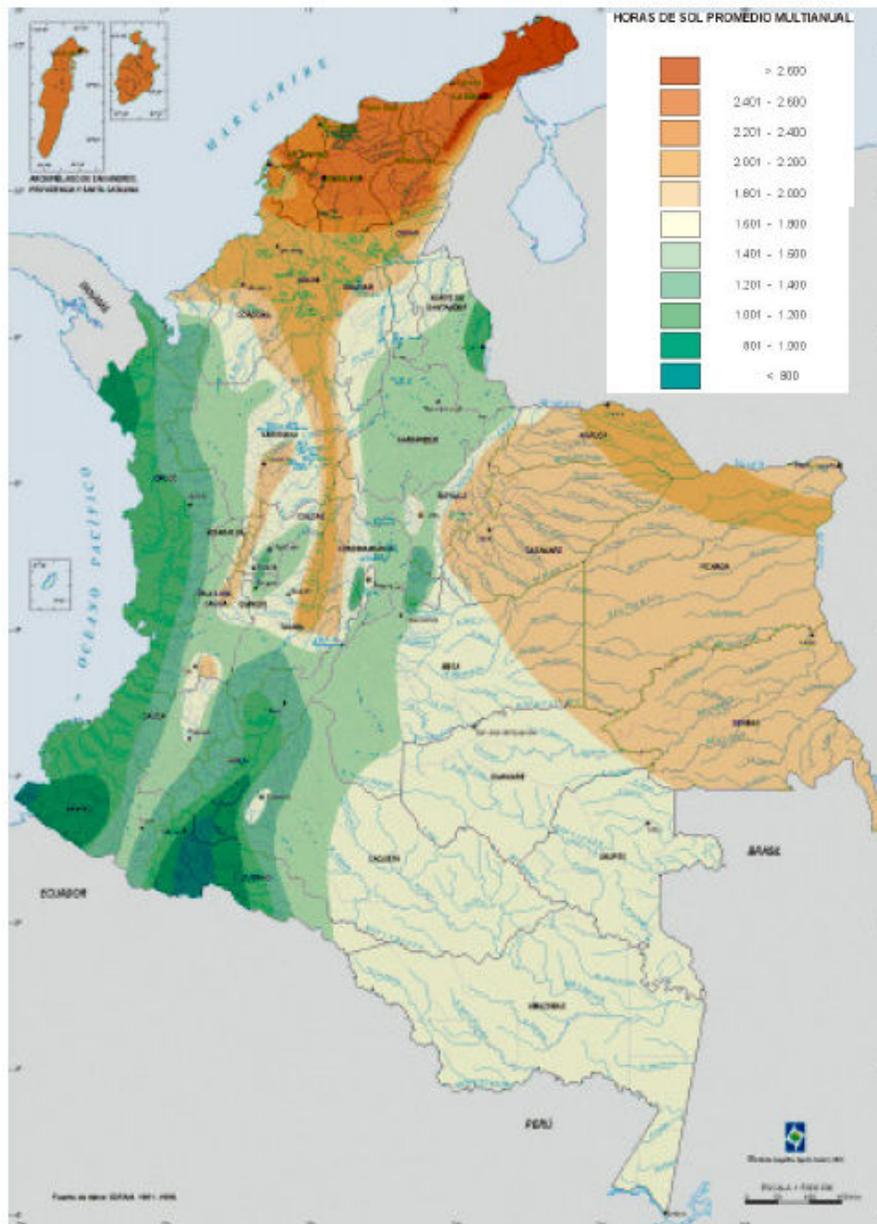


Figure 27 Colombia: Solar Power Potential⁴⁰

⁴⁰ <http://www.developingrenewables.org/energyrecipes/reports/reports/Colombia%20-%20Part%20C%20->

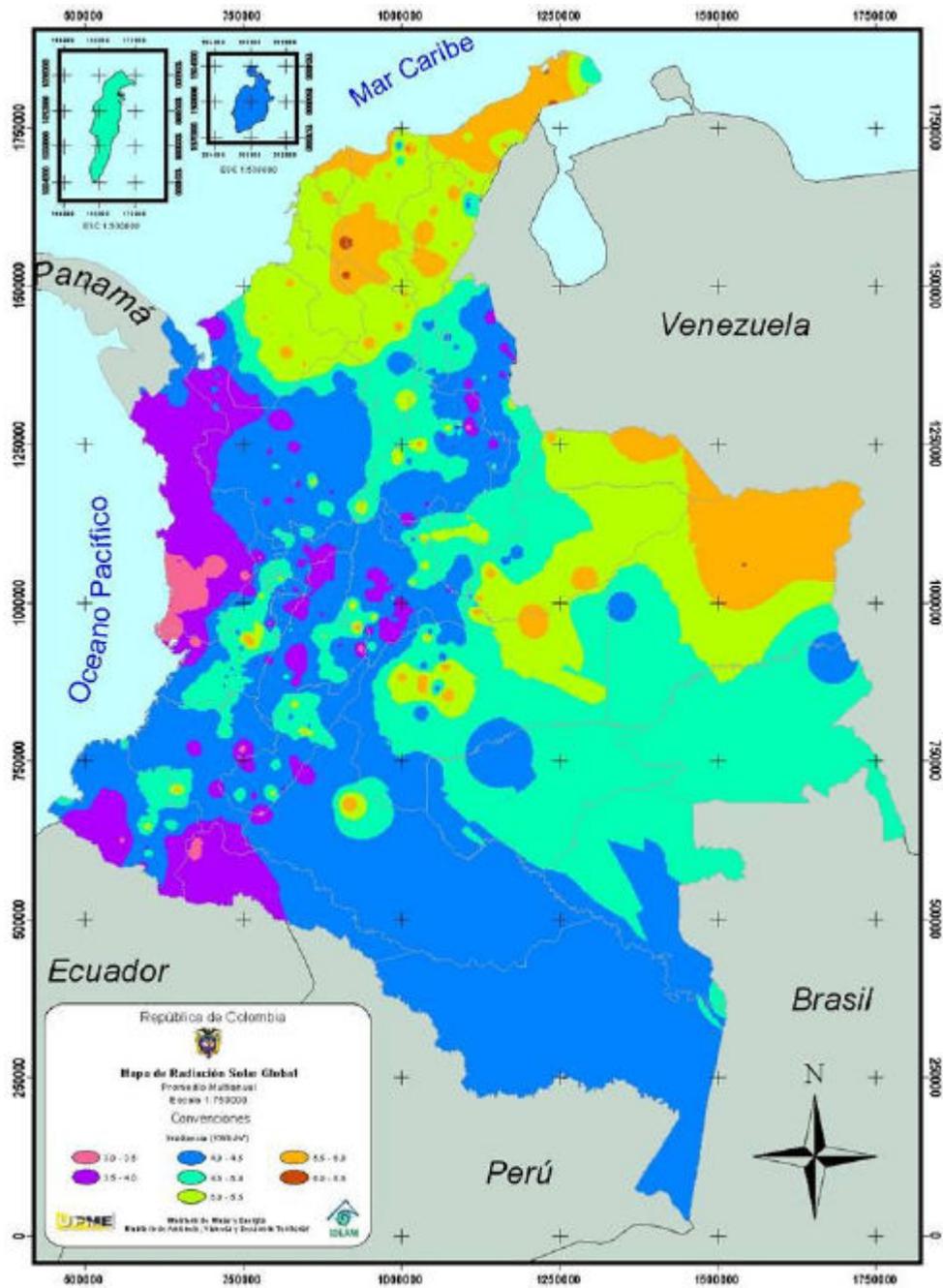


Figure 28 Colombia: Solar Power Potential⁴¹

⁴¹ <http://www.developingrenewables.org/energyrecipes/reports/reports/Colombia%20-%20Part%20C%20-%20Country%20Maps%20060209.pdf>

6.6 COSTA RICA

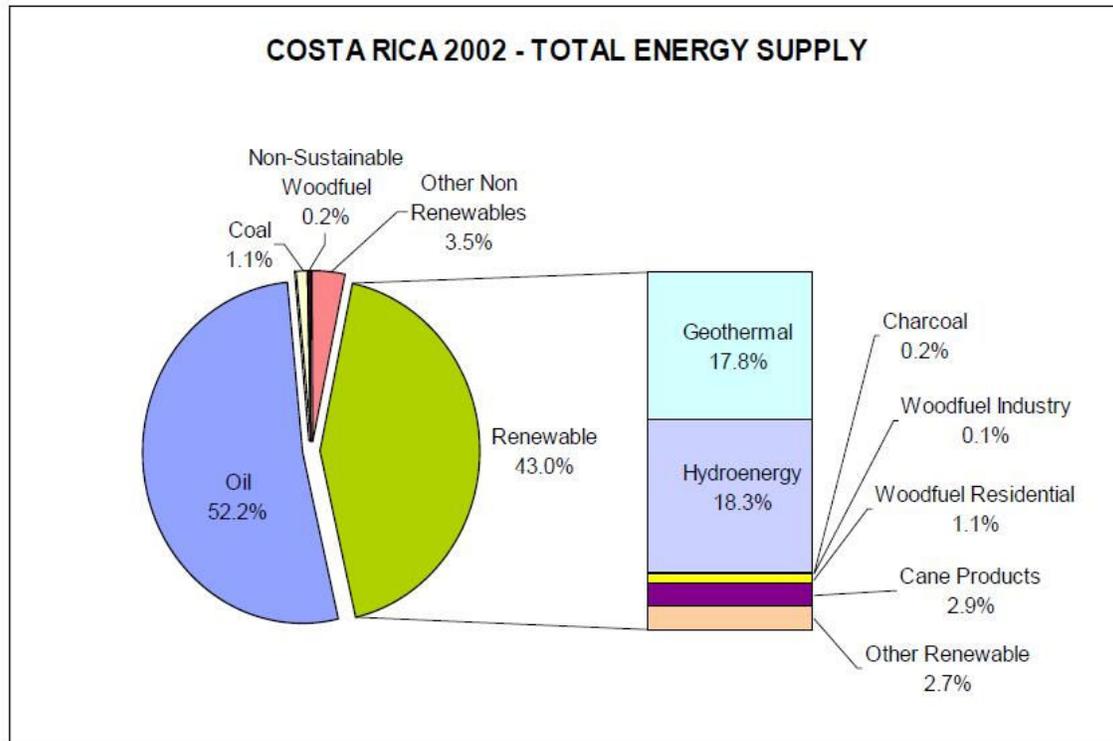


Figure 29 Costa Rica – 2002 – Total Energy Supply⁴²

With 52.2%, oil has the highest percentage of the total energy supply of Costa Rica. This is followed by renewables (43%).

Therefore, the share of all renewable energy of the total energy supply in 2002 is very significant. The main renewable sources are 18.3% from hydro energy and 17.8% from geothermal.

Other renewable technologies, such as cane products with 2.9%, charcoal with 0.2%, woodfuel with 1.2% and other renewables with 2.7%, do not play an important role.

⁴² http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.7 ECUADOR

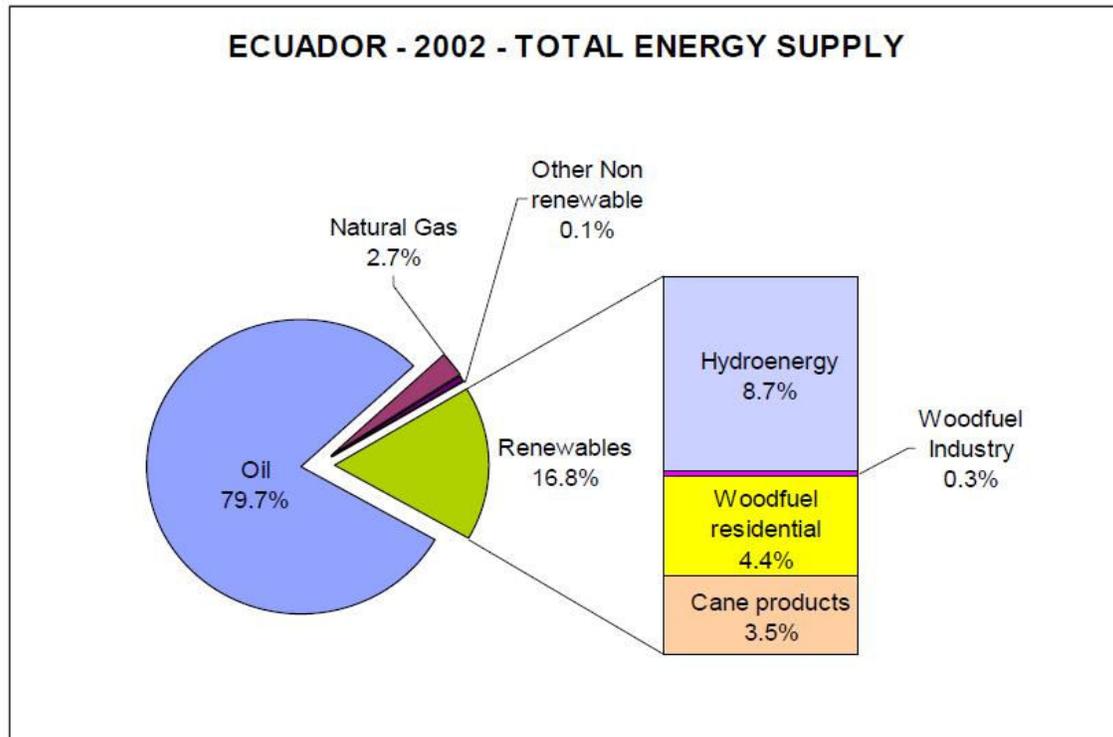


Figure 30 Ecuador – 2002 – Total Energy Supply⁴³

In Ecuador, oil represents the main portion of the total energy supply with a very high percentage of 79.7%.

The share of all renewable energy supply as a whole is not very significant, although it is the second most utilized kind of energy, exceeding 16% of total energy supply. There are three main renewable sources: hydro energy (8.7%), with the largest share, woodfuels (4.7%) and cane products with a percentage of 3.5%.

The other renewable technologies, such as wind and solar, do not exist as yet.

⁴³ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.8 EL SALVADOR

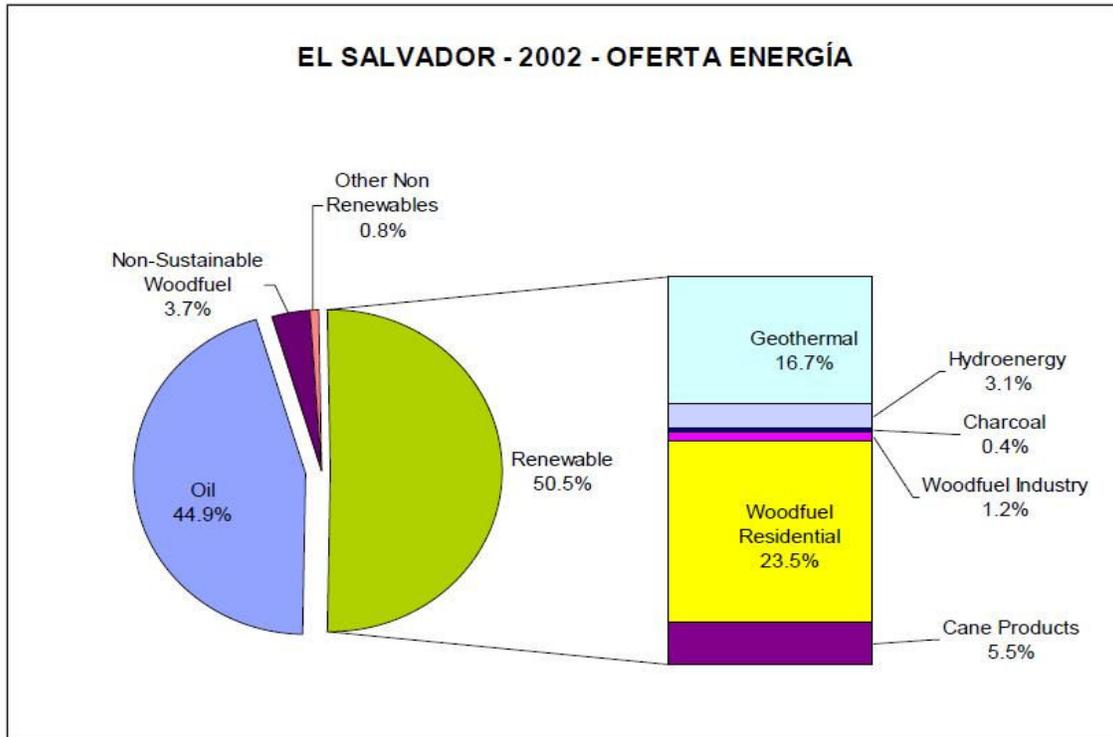


Figure 31 El Salvador – 2002 – Total energy supply⁴⁴

The main energy supply, in 2002, lies with 50.5% from renewable energies, followed by oil with 44.9%.

The supply of renewable energies represents one of the highest in all of Latin America. Woodfuels with 24.7% have the largest proportion of renewable energies, followed by geothermal with 16.7%. Cane products, hydro energy and charcoal are subordinated. Other renewables are missing in El Salvador entirely.

⁴⁴ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.8.1 WIND POWER

The potential for wind power is not so large in El Salvador. Only in the mountainous north and in the west of the country is there high resource potential.

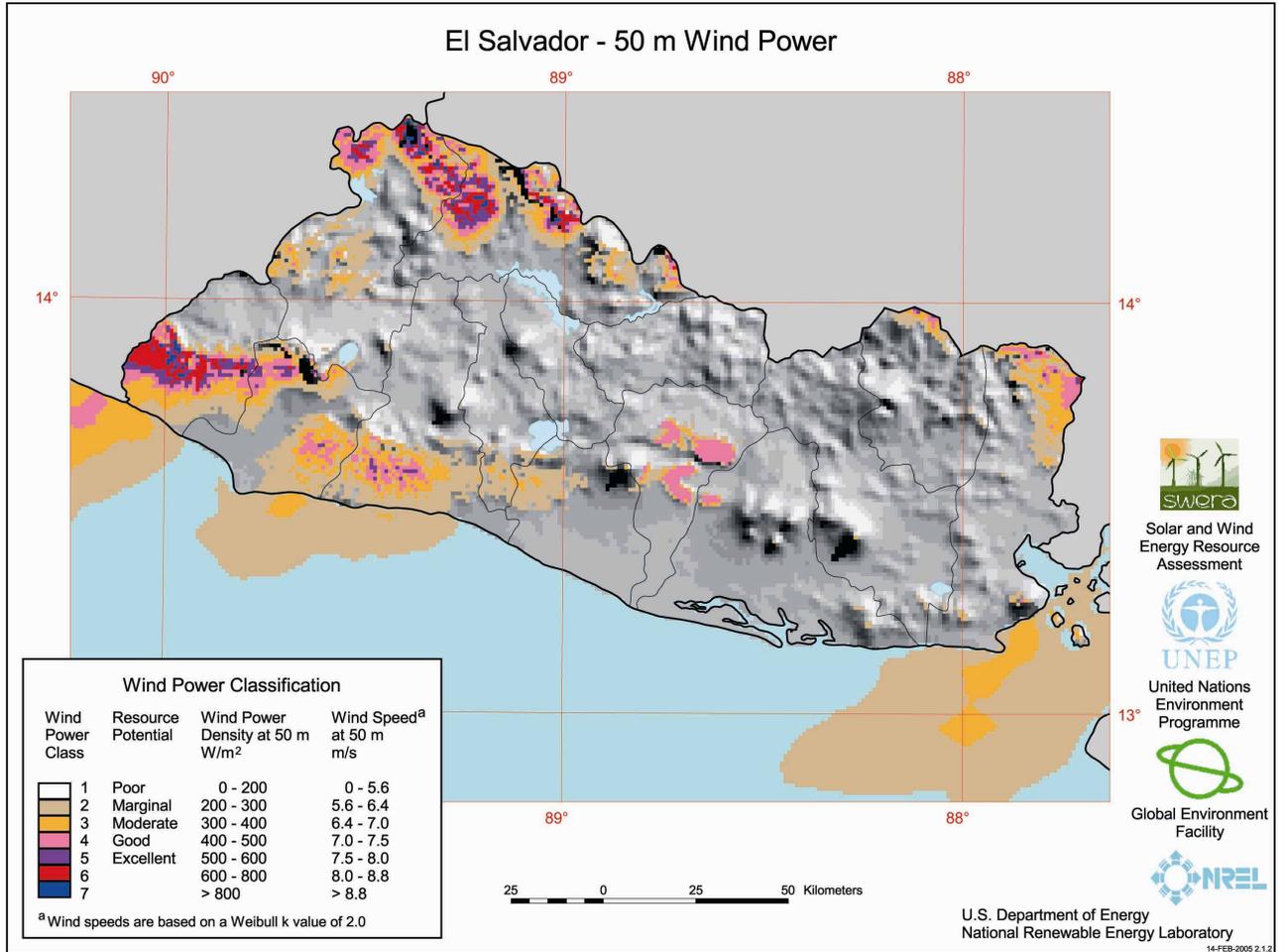


Figure 32 El Salvador: Wind power potential⁴⁵

⁴⁵ http://www.nrel.gov/wind/pdfs/el_salvador.pdf

6.8.2 SOLAR POWER

The solar radiation in El Salvador is significant and constant all over the country. Only in the northern mountains are there areas where the solar intensity decreases.

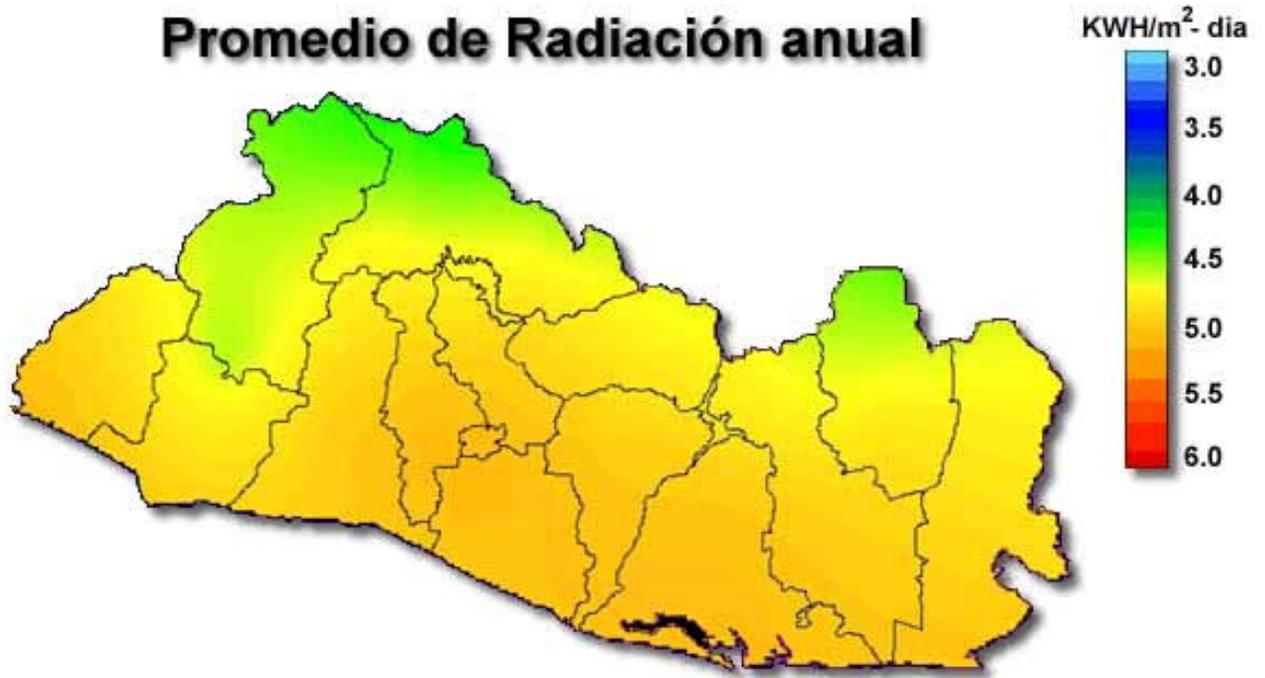


Figure 33 El Salvador: Solar Power Potential⁴⁶

⁴⁶ <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/solar-latin-america/solar-el-salvador.shtml>

6.8.3 GEOTHERMAL

The country is already generating a lot of geothermal energy. Due to the presence of many volcanoes along the Pacific Rim, the potential is very high. As the map shows, El Salvador is already studying other geothermal fields near Chinameca, San Vicente and Cuyanausul.

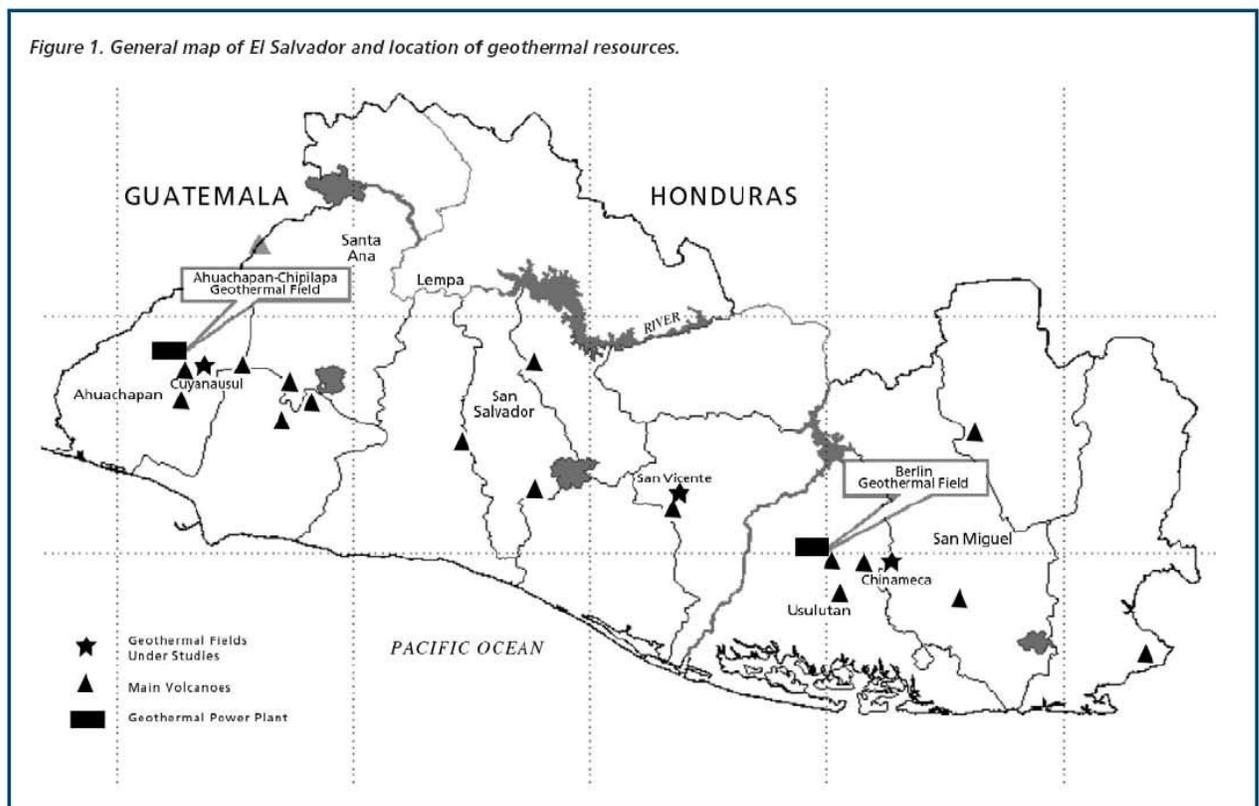


Figure 34 El Salvador: Geothermal Potential⁴⁷

⁴⁷ <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/geo-latin-america/geo-el-salvador.shtml>

6.9 GUATEMALA

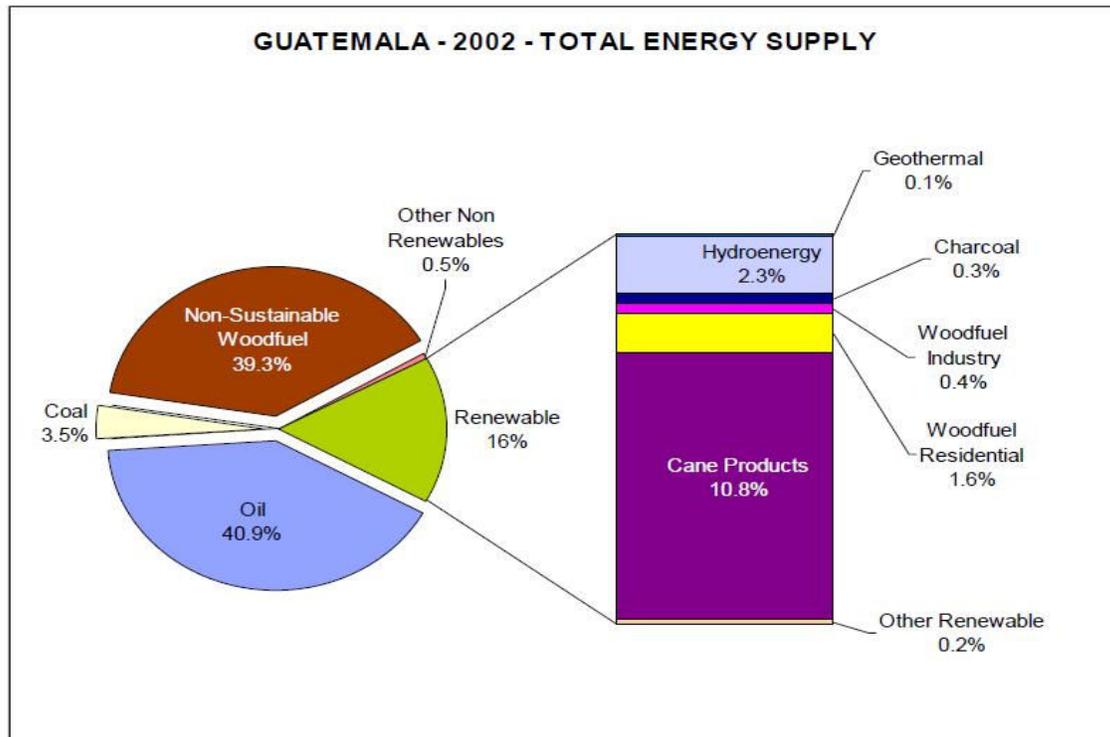


Figure 36 Guatemala – 2002 – Total energy supply⁴⁹

Oil, with 40.5%, and non-sustainable woodfuel, with 39.3%, play the most important parts of the total energy supply in Guatemala.

The third part represents renewable energies with 16%. The main renewable energy sources are cane products with a proportion of 10.8% of the total energy supply. Hydro energy (2.3%), woodfuels (2%) and charcoal (0.3%) play secondary roles. The use of other renewables like wind, solar or geothermal is insignificant at this time.

⁴⁹ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.9.1 WIND POWER

In Guatemala, there are only a few locations where wind development would be worthwhile. The greatest potential is concentrated in the southern mountain peaks.

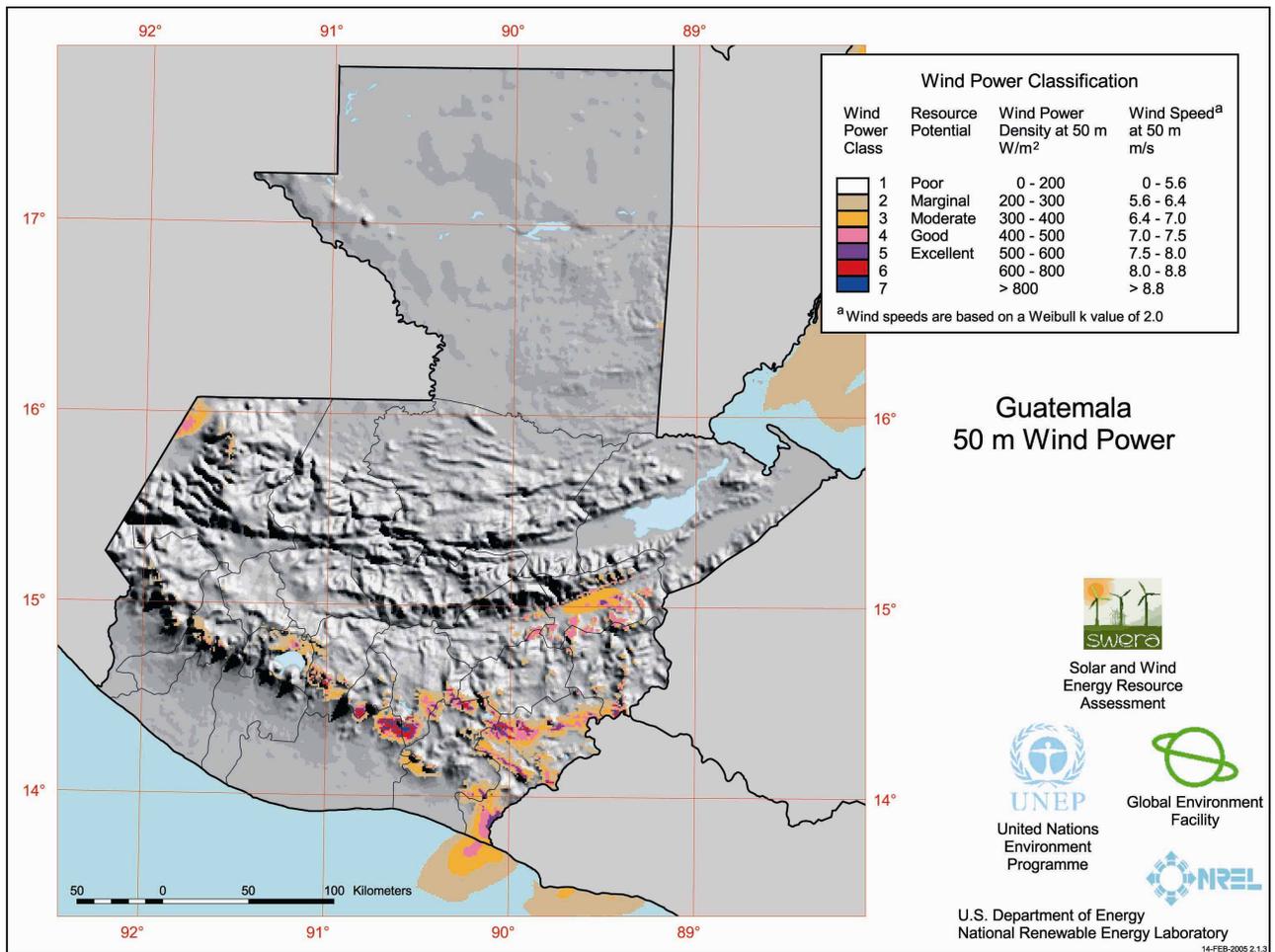


Figure 37 Guatemala: Wind Power Potential⁵⁰

⁵⁰ <http://www.nrel.gov/wind/pdfs/guatemala.pdf>

6.9.2 SOLAR POWER

The potential for solar power is quite large in Guatemala. The greatest potential is concentrated to the southern region of the country, but strong radiation exists in every state.

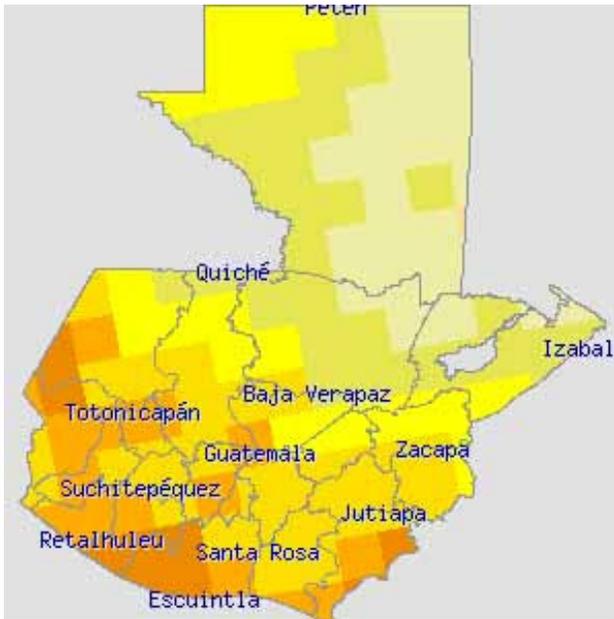


Figure 38 Guatemala: Solar Power Potential⁵¹

⁵¹ <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/solar-latin-america/solar-guatemala.shtml>

6.9.3 GEOTHERMAL

Guatemala has already discovered several geothermal areas. The greatest potential is concentrated to the southern mountains. This is the same range as El Salvador, which taps a significant portion of its needs from geothermal heat.

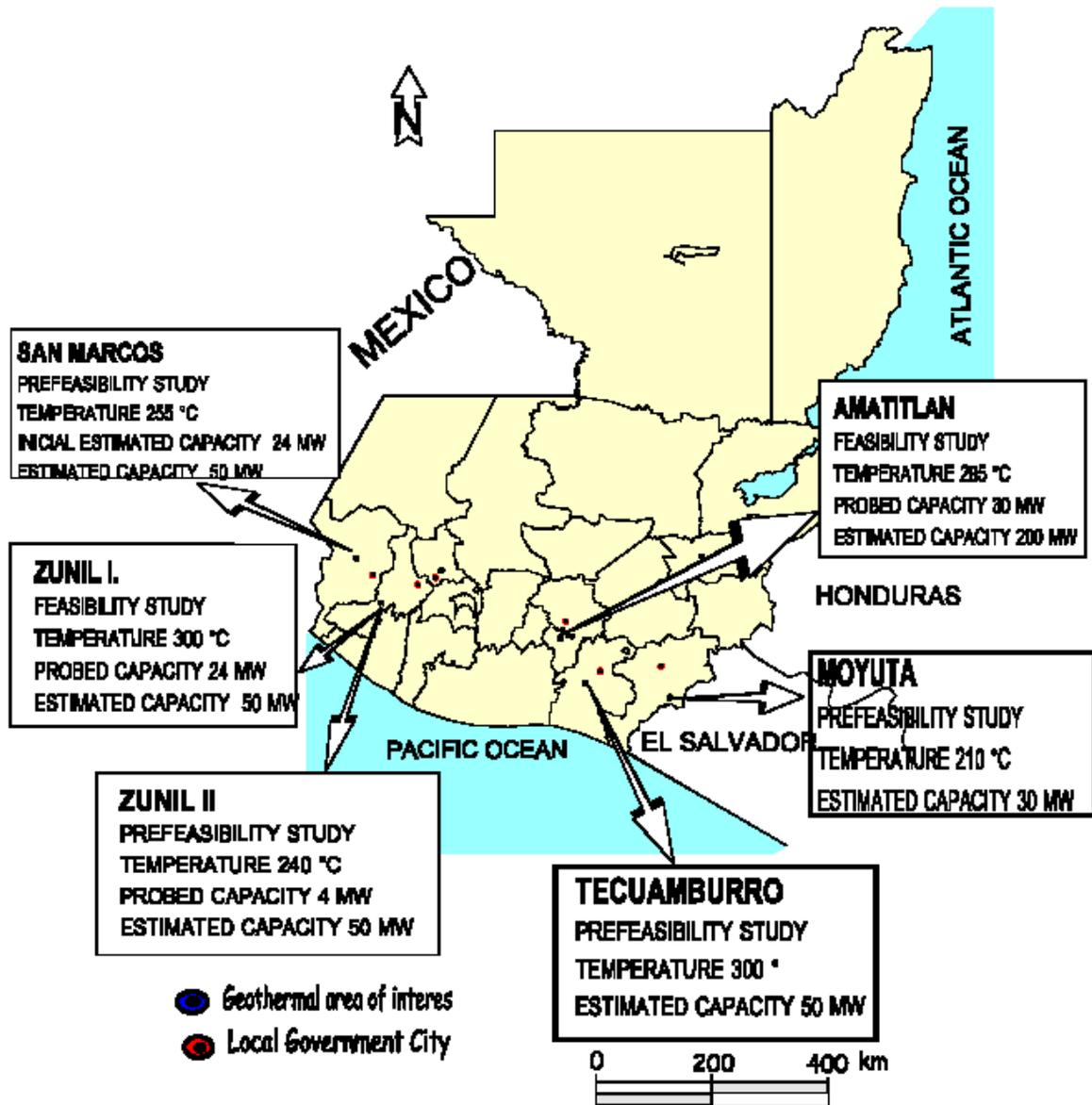


Figure 39 Guatemala: Geothermal Potential⁵²

⁵² <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/geo-latin-america/geo-guatemala.shtml>

6.10 GUYANA

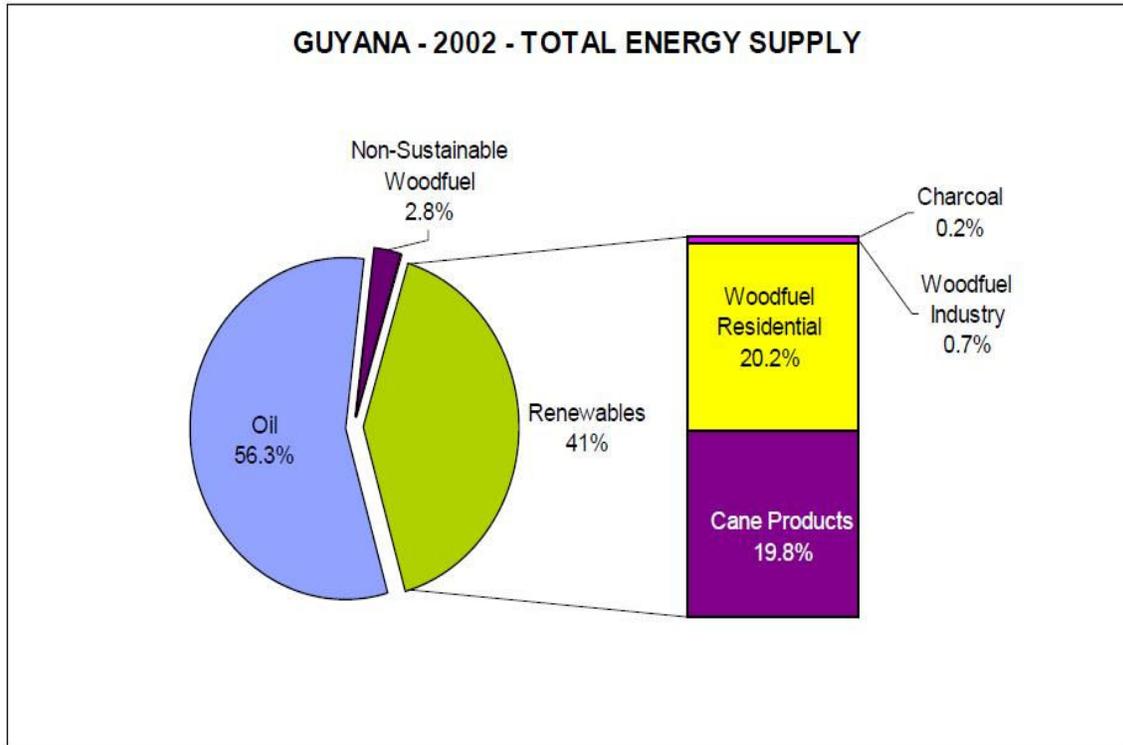


Figure 40 Guyana – 2002 – Total Energy Supply⁵³

Guyana has, as many other countries, a high dependency on oil (56.3%), but in this case renewables also account for a very large share with a percentage of 41% of total energy supply.

Woodfuels (20.9%) and cane products (19.8%) represent the most important renewable energy sources in this country. Charcoal is generated only in a very small quantity and other renewables are not harnessed at this time.

⁵³ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.11 HONDURAS

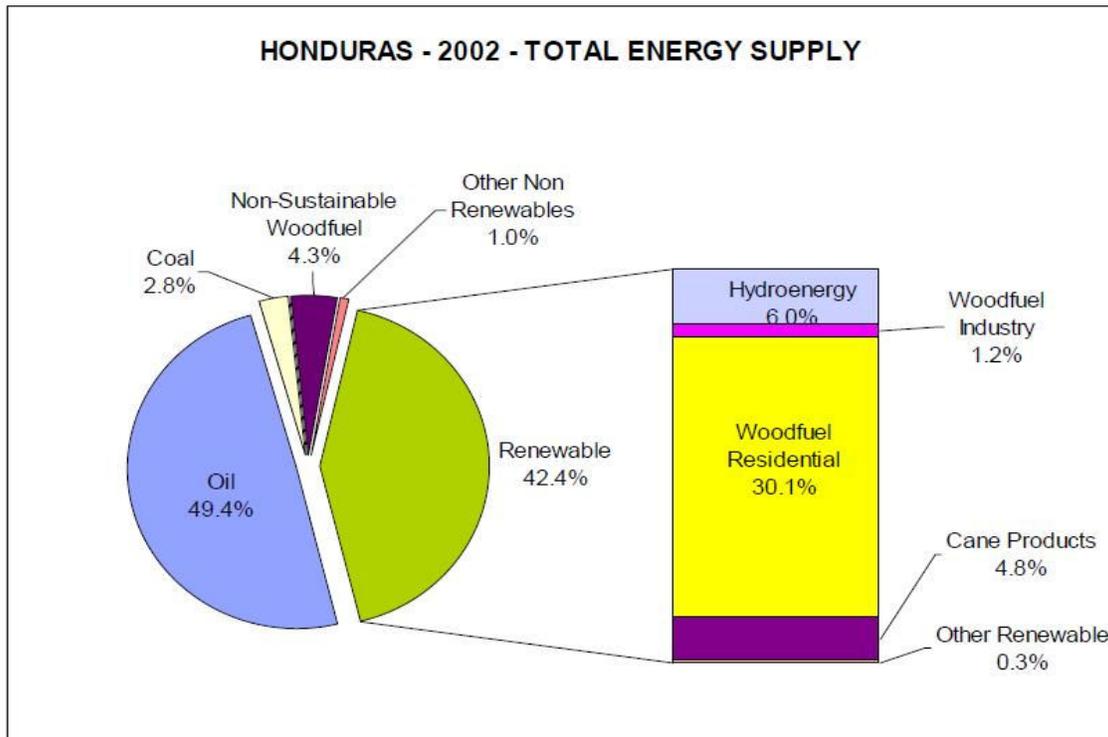


Figure 41 Honduras – 2002 – Total Energy Supply⁵⁴

With 42.4% renewable energies, only exceeded by oil at 49.4%, Honduras has one of the highest percentages of renewable energy supply of Latin America in 2002.

The main renewable sources are woodfuels with 31.3%, followed by hydro energy (6.0%) and cane products (4.8%).

Other renewable technologies, such as wind and solar, do not play an important role.

⁵⁴ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.11.1 WIND POWER

The potential for wind power is small in the country with the exception of the southern mountains where you can find good conditions.

In the offshore north, around the three islands (beginning at the right: Isla de Guanaja, Isla de Roatán and Isla de Utila) there is good potential.

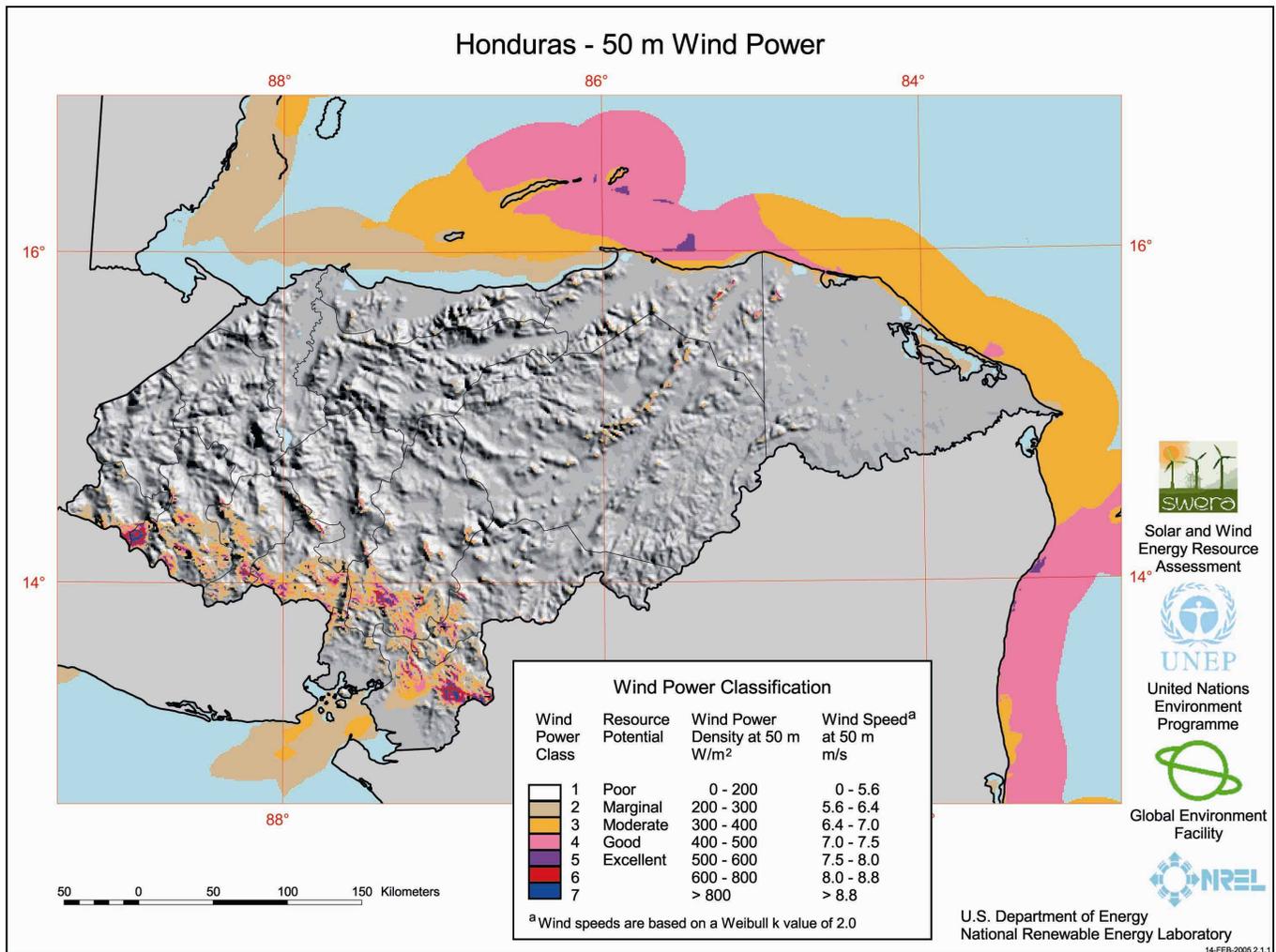


Figure 42 Honduras: Wind Power Potential⁵⁵

⁵⁵ <http://www.nrel.gov/wind/pdfs/honduras.pdf>

6.11.2 SOLAR POWER

The potential of solar power is quite significant in Honduras. The greatest potential is concentrated to the south, but all states have good solar radiation. This is true for all the Central American nations.

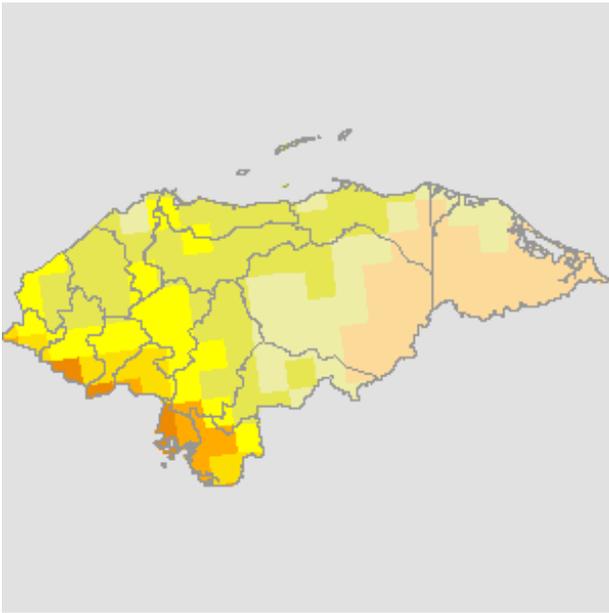


Figure 43 Honduras: Solar Power Potential⁵⁶

⁵⁶ <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/solar-latin-america/solar-honduras.shtml>

6.12 MEXICO

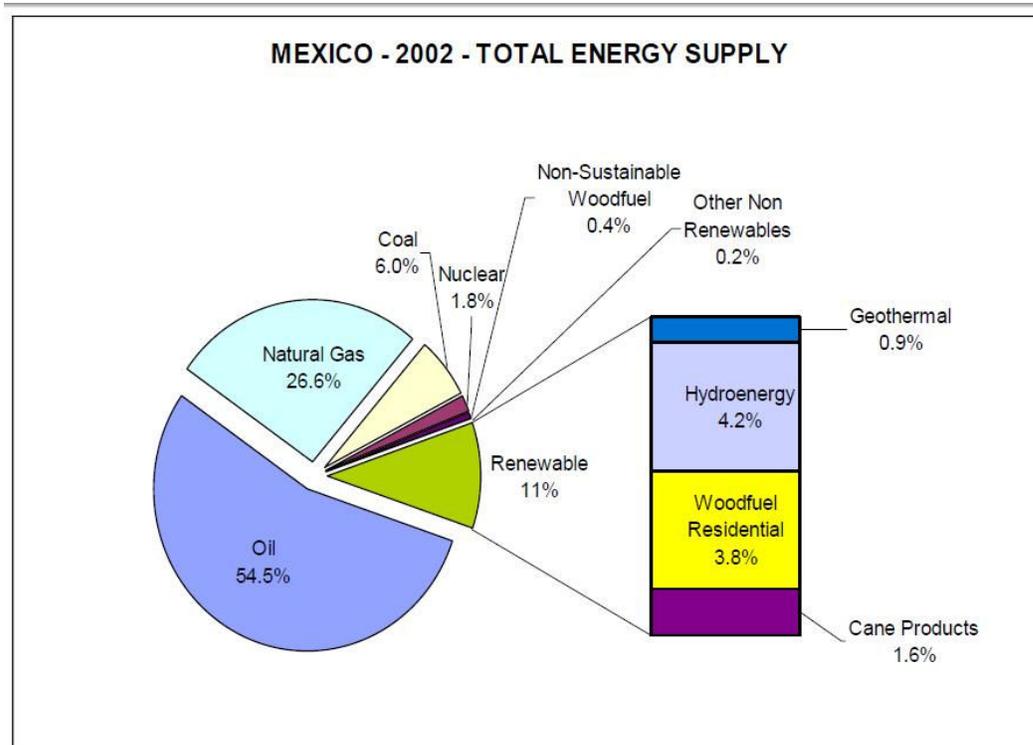


Figure 44 Mexico – 2002 – Total Energy Supply⁵⁷

The main energy supply of 2002 lies with oil at 54.5%, followed by natural gas with 26.6%.

The supply of renewable energies represents around 11% of total energy supply. Hydro energy has 4.2%, the largest proportion of renewable energies, followed by woodfuels with 3.8%. Cane products and geothermal are nominally developed, while solar and wind provide no market share as yet

⁵⁷ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.12.1 GEOTHERMAL

Mexico is rich in geothermal areas; especially in the south and Baja California where the volcano belt is situated, the potential for geothermal energy is great. This resource has tremendous potential for future development.

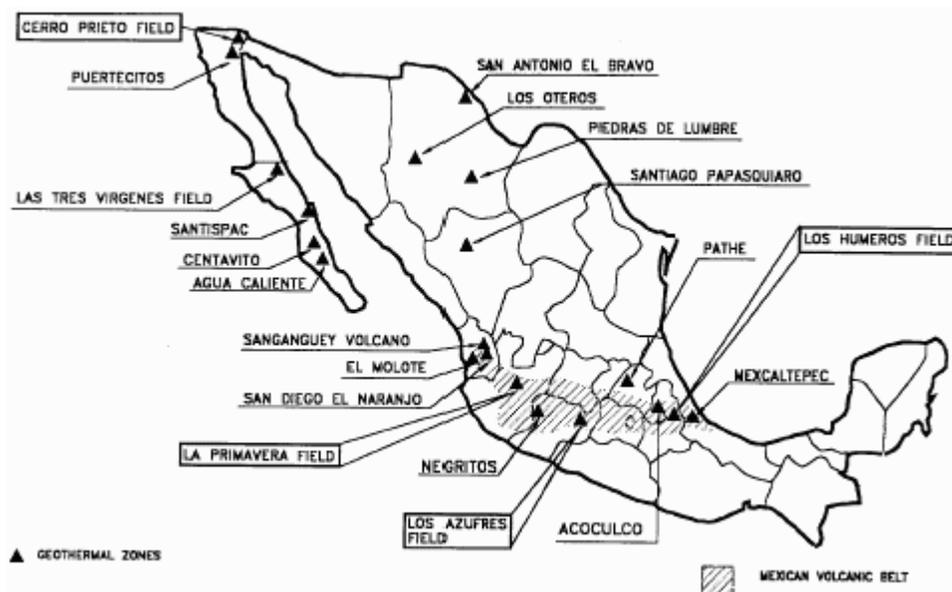


Figure 45 Mexico: Geothermal Potential⁵⁸

⁵⁸ <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/geo-latin-america/geo-mexico.shtml>

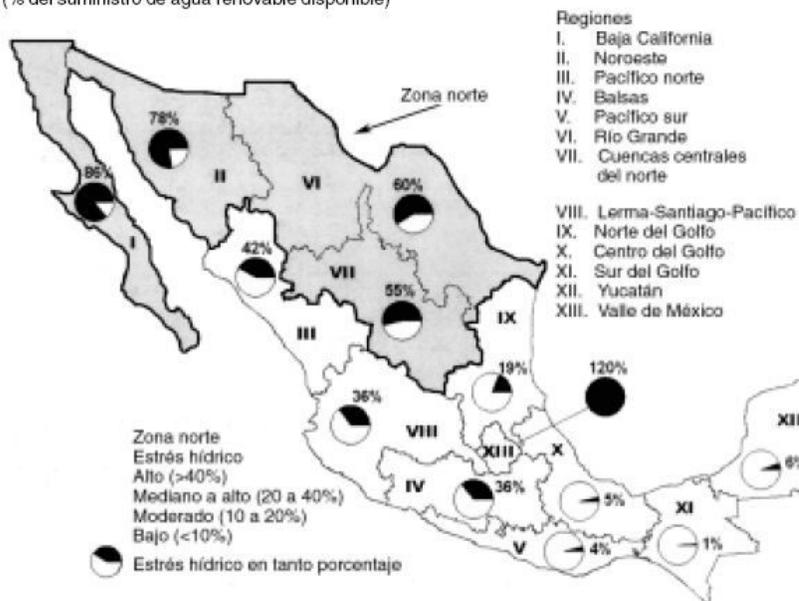
6.12.2 HYDRO POWER

In the north, Mexico already is generating a high percentage of hydro energy, but in the south, there is still a large percentage of untapped potential.

MAPA 1

Estrés hídrico de México: Retiro anual de agua (2004)

(% del suministro de agua renovable disponible)



Fuentes: CNA de México; EIR.

Figure 46 Mexico: Hydro Power Potential⁵⁹

⁵⁹ http://www.larouchepub.com/spanish/other_articles/2006/energia.htm

6.12.3 SOLAR POWER

The potential for solar power is enormous in the country. The greatest potential is concentrated to the northwest desert where the solar irradiation is very high.



Figure 47 Mexico: Solar Power Potential⁶⁰

⁶⁰ <http://www.altestore.com/howto/Tools-Calculators-Reference/Reference-Materials/Solar-Insolation-Map-Caribbean-Mexico-Central-America/a67/>

6.12.4 WIND POWER

The potential for wind power is large in the country. The coastal winds of Baja California and the central highlands offer great potential. This resource is presently untapped in Mexico. The greatest potential is concentrated to the east in the state Tamaulipas.

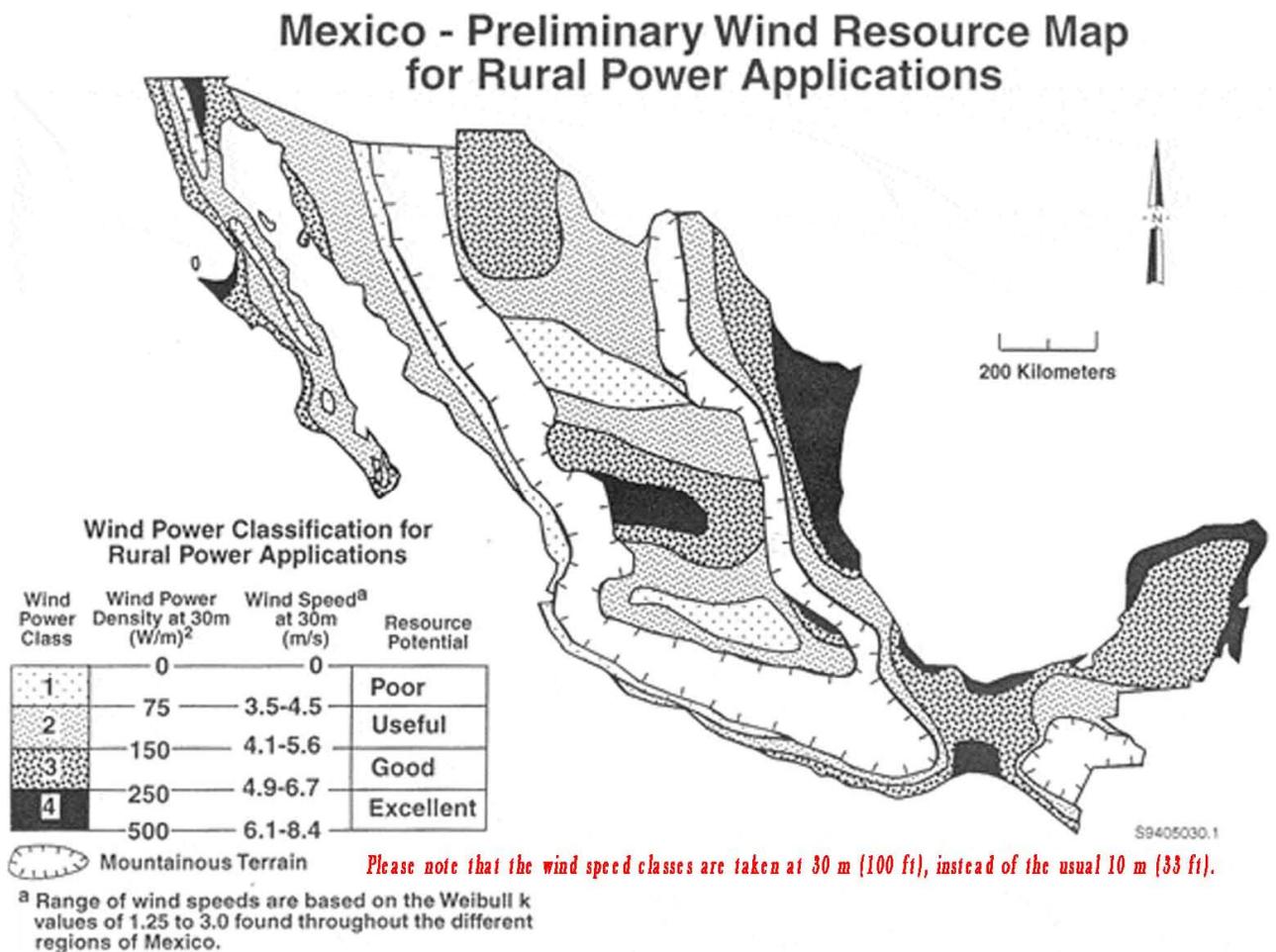


Figure 48 Mexico: Wind Power Potential⁶¹

⁶¹ <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/wind-latin-america/wind-mexico.shtml>

6.13 NICARAGUA

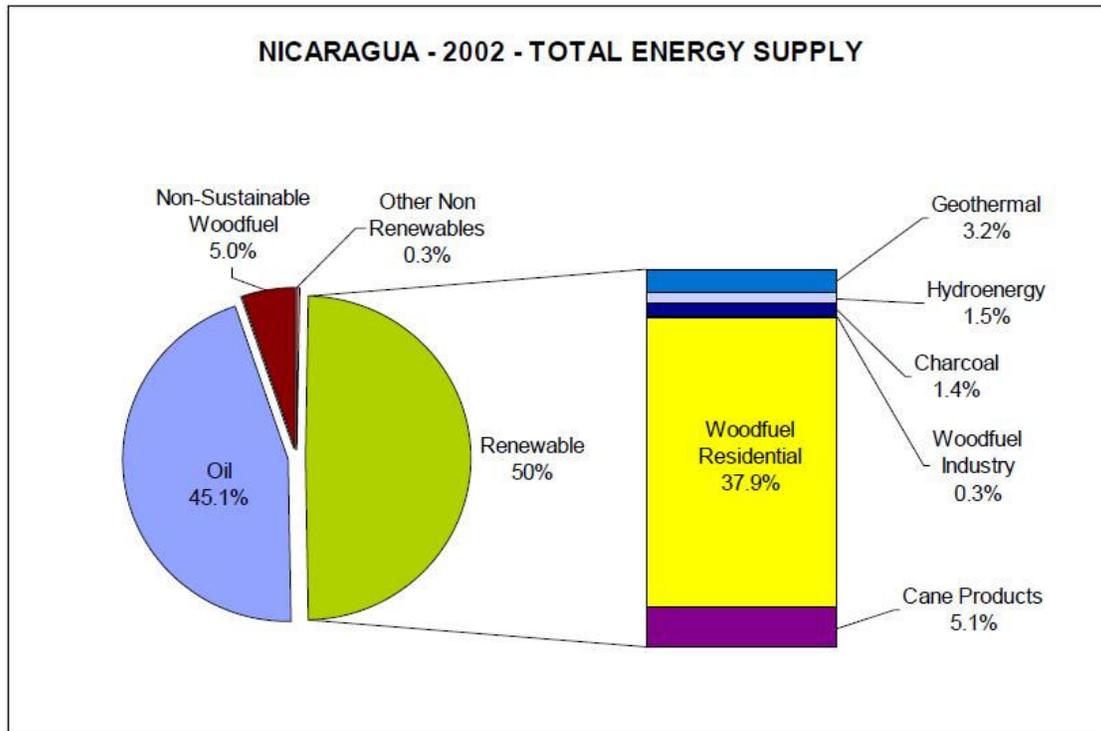


Figure 49 Nicaragua – 2002 – Total Energy Supply⁶²

In Nicaragua, renewable energies play the main role with a 50% proportion of total energy supply. Oil is represented as secondary part with 45.1%. There is one main renewable source, namely woodfuels for residential use (38.2%).

The percentage of renewables from cane products, hydro energy, geothermal and charcoal total 11.2%. Other renewables, such as wind and solar, are non-existent.

⁶² http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.13.1 SOLAR POWER

The solar power potential of Nicaragua is not so large. It's only in the west that you have great conditions to develop solar power plants.



Figure 50 Nicaragua: Solar Power Potential⁶³

⁶³ <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/solar-latin-america/solar-nicaragua.shtml>

6.13.2 GEOTHERMAL

Nicaragua has excellent geothermal resources. The greatest potential for geothermal energy is concentrated to the mountains along the west coast.



Figure 51 Nicaragua: Geothermal Potential⁶⁴

⁶⁴ <http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/geo-latin-america/geo-nicaragua.shtml>

6.13.3 WIND POWER

The potential for wind power in the country is very good. The greatest potential is concentrated in the mountain range and along the east and southwest coast. In the south-west at the coast of Nicaragua, the offshore wind resource is first class.

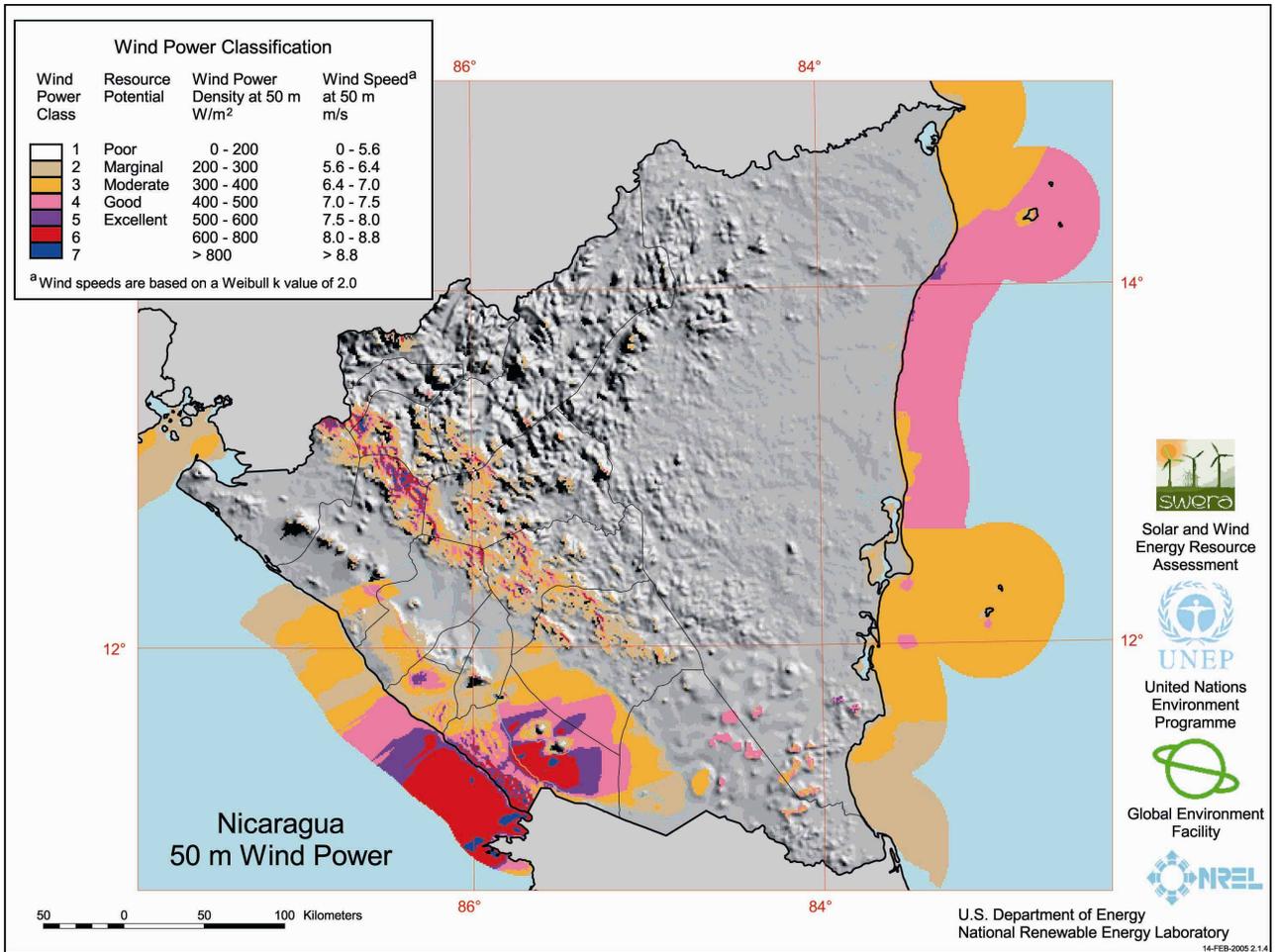


Figure 52 Nicaragua: Wind Power Potential⁶⁵

⁶⁵ <http://www.nrel.gov/wind/pdfs/nicaragua.pdf>

6.14 PANAMA

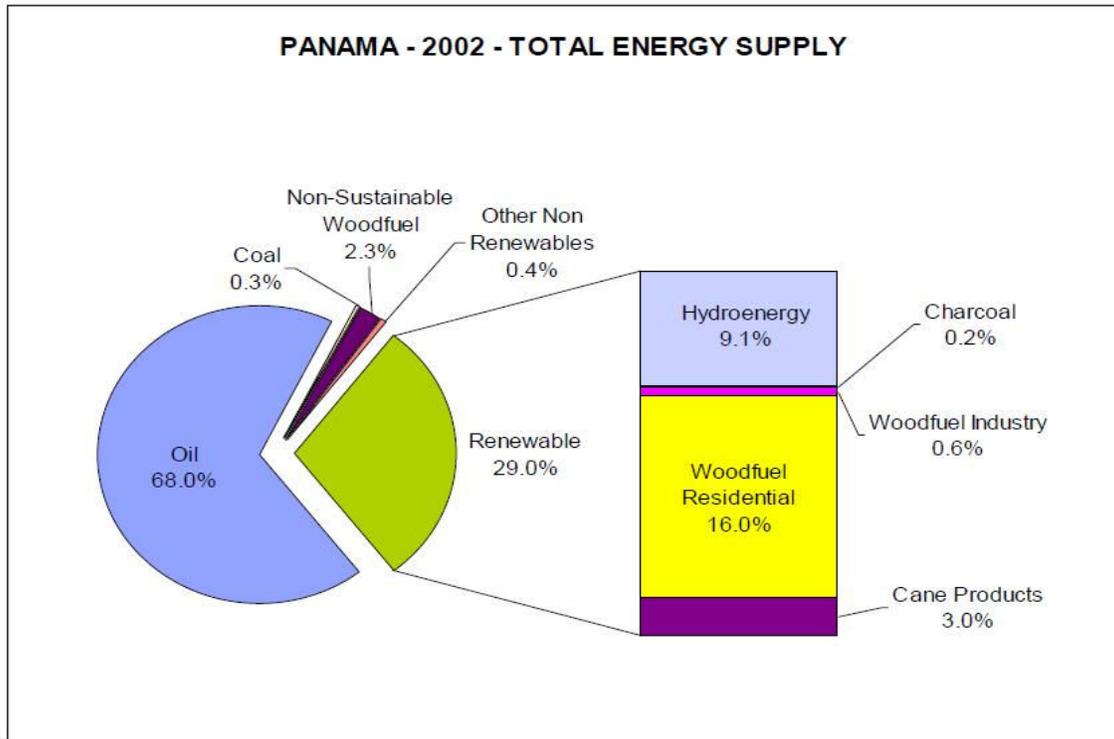


Figure 53 Panama – 2002 – Total Energy Supply⁶⁶

With 68% market share, oil plays the most important part of the total energy supply in Panama. The second largest is represented by renewable energies with 29%.

Woodfuel (16.6%) and hydro energy (9.1%) are the two main renewable energy sources.

Charcoal (0.2%) and cane products (3.0%) are minimal. The use of other renewables like wind, solar or geothermal is non-existent.

⁶⁶ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.15 PARAGUAY

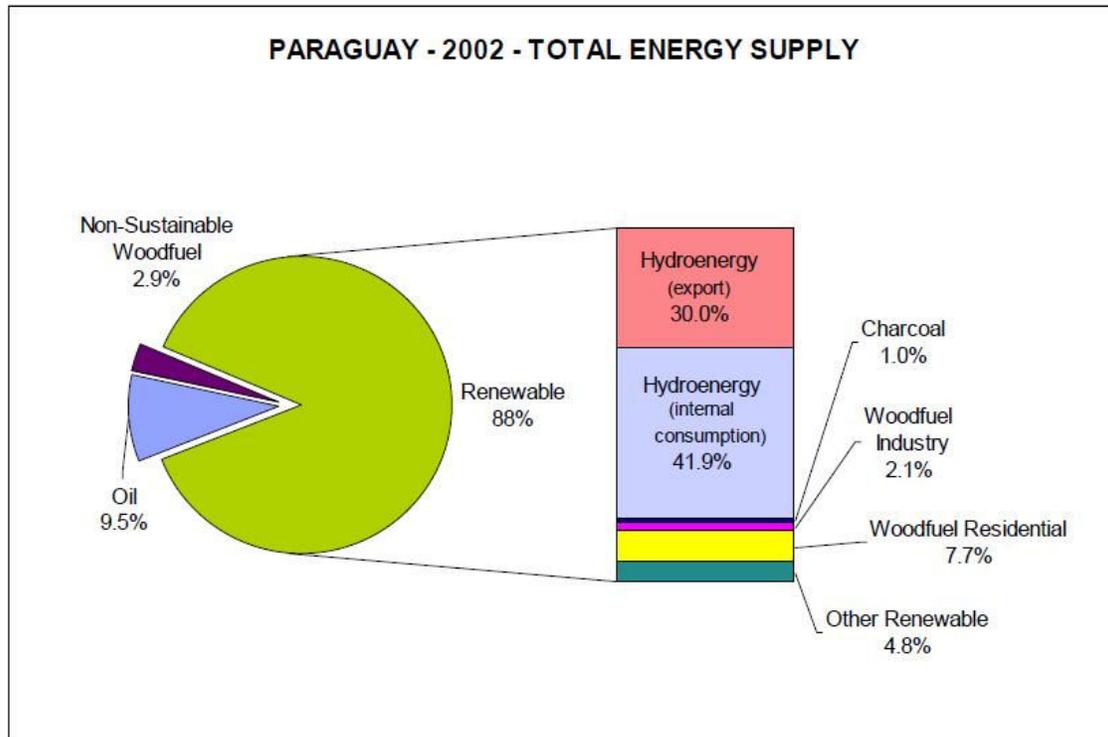


Figure 54 Paraguay – 2002 – Total Energy Supply⁶⁷

Paraguay depends substantially on the use of renewables, with 88%, the highest percentage of renewable energy supply in all of Latin America. On the Parana River, Brazil and Paraguay have built the Itaipu Dam, the 2nd largest hydropower facility in the world. The installed capacity of 14 Gigawatts.

Hydro energy (71.9%) represents by far the most important renewable energy source in this country to the extent that they are able to export 30% of hydro energy. Woodfuels (9.8%), charcoal (1%) and other renewables (4.8%) are generated only in a relative small quantity.

⁶⁷ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.16 PERU

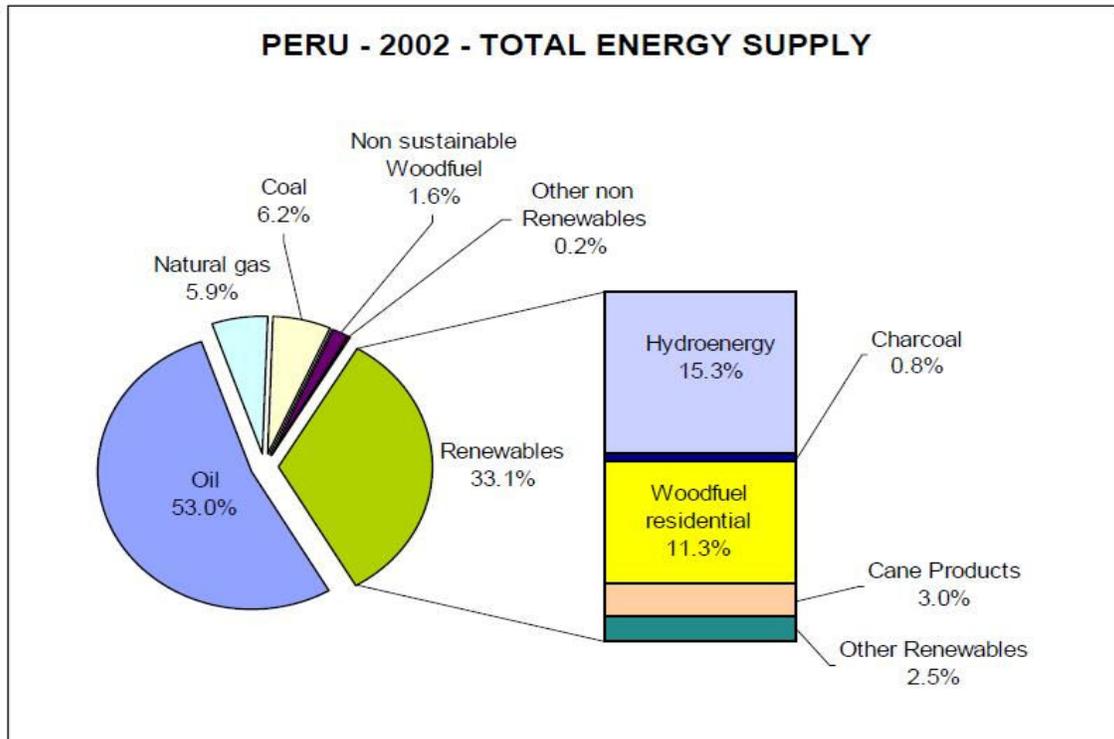


Figure 55 Peru – 2002 – Total Energy Supply⁶⁸

With 53%, followed by renewables at 33.1%, oil has the highest percentage of the total energy supply of Argentina.

The main renewable source is with 15.3% hydro energy. Also woodfuel has a large proportion with 11.3%.

Other renewable technologies, such as cane products with 3%, charcoal with 0.8% and other renewables, such as wind and solar, do not play an important role.

⁶⁸ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.16.1 WIND POWER

The potential for wind power is large in the country. The greatest potential is concentrated along the west coast of the country where the prevailing ocean winds blow on-shore year round.

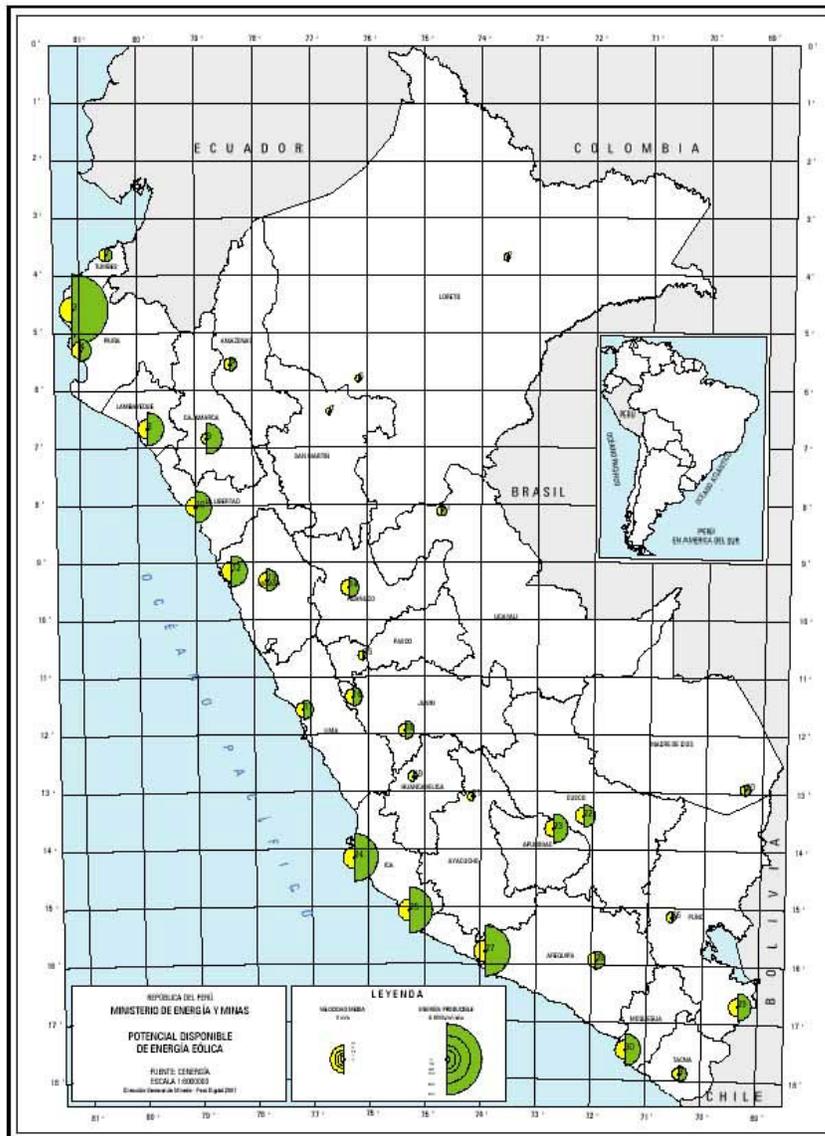


Figure 56 Peru: Wind Power Potential⁶⁹

⁶⁹ [http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/wind-latin-](http://www.geni.org/globalenergy/library/renewable-energy-resources/world/latin-america/wind-latin-america/)

6.16.2 SOLAR POWER

The potential for solar power is excellent in Peru with the greatest potential is found year-round along all western states the country.



Figure 57 Peru: Solar Power Potential⁷⁰

⁷⁰ <http://www.developingrenewables.org/energyrecipes/reports/reports/Peru%20-%20Part%20C%20-%20Country%20Maps%20060209.pdf>

6.16.3 GEOTHERMAL

Especially in the southern region of the country, there is good resource potential for generating geothermal energy.

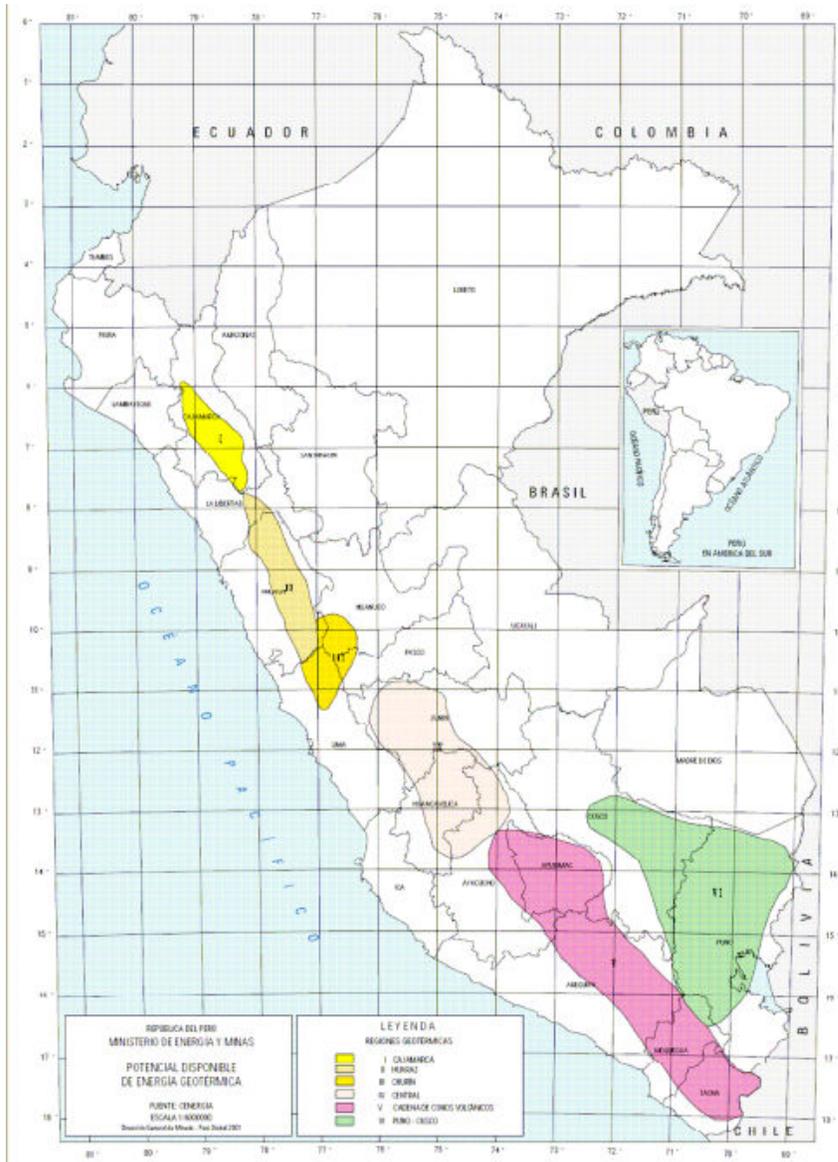


Figure 58 Peru: Geothermal Potential⁷¹

⁷¹ <http://www.developingrenewables.org/energyrecipes/reports/reports/Peru%20-%20Part%20C%20-%20Country%20Maps%20060209.pdf>

6.17 SURINAME

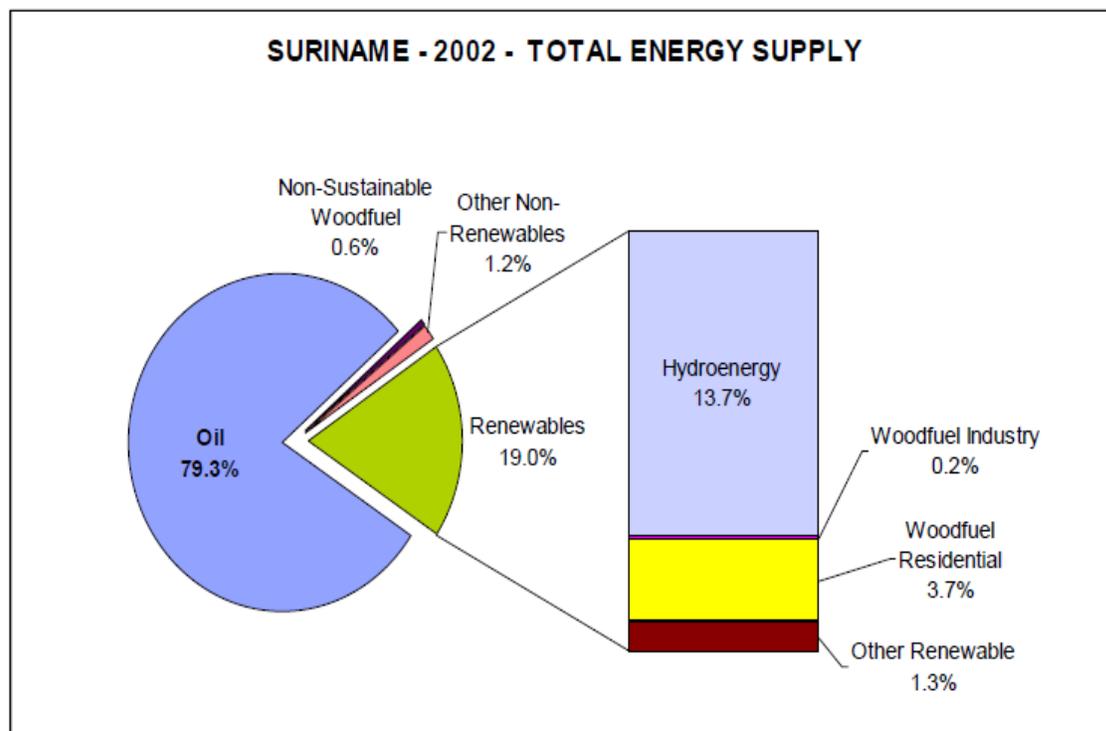


Figure 59 Suriname – 2002 – Total Energy Supply⁷²

The main energy supply in 2002 lies with oil at 79.3%.

The supply of renewable energies represents around 19% of total energy supply. Hydro energy with 13.7% has the largest proportion of renewable energies, followed by woodfuels with 3.9%. Other renewables play a minor role.

⁷² http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.18 URUGUAY

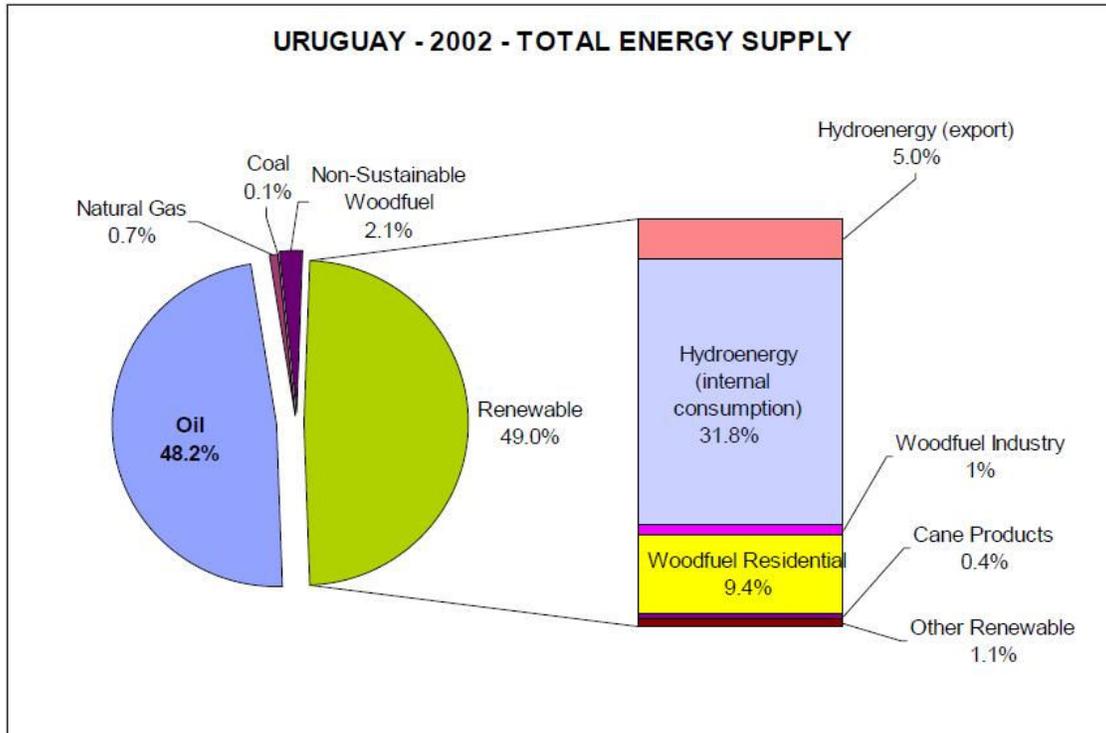


Figure 60 Uruguay – 2002 – Total energy supply⁷³

In Uruguay, renewables represent the main part of the total energy supply with 49%, but it is followed very closely by oil with 48.2%.

The main renewable source is hydro energy with 36.8%. The renewable fuelwood portion with 10.4% also plays an important role. The share of cane products and other renewable technologies, such as wind and solar, is very low.

⁷³ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.19 VENEZUELA

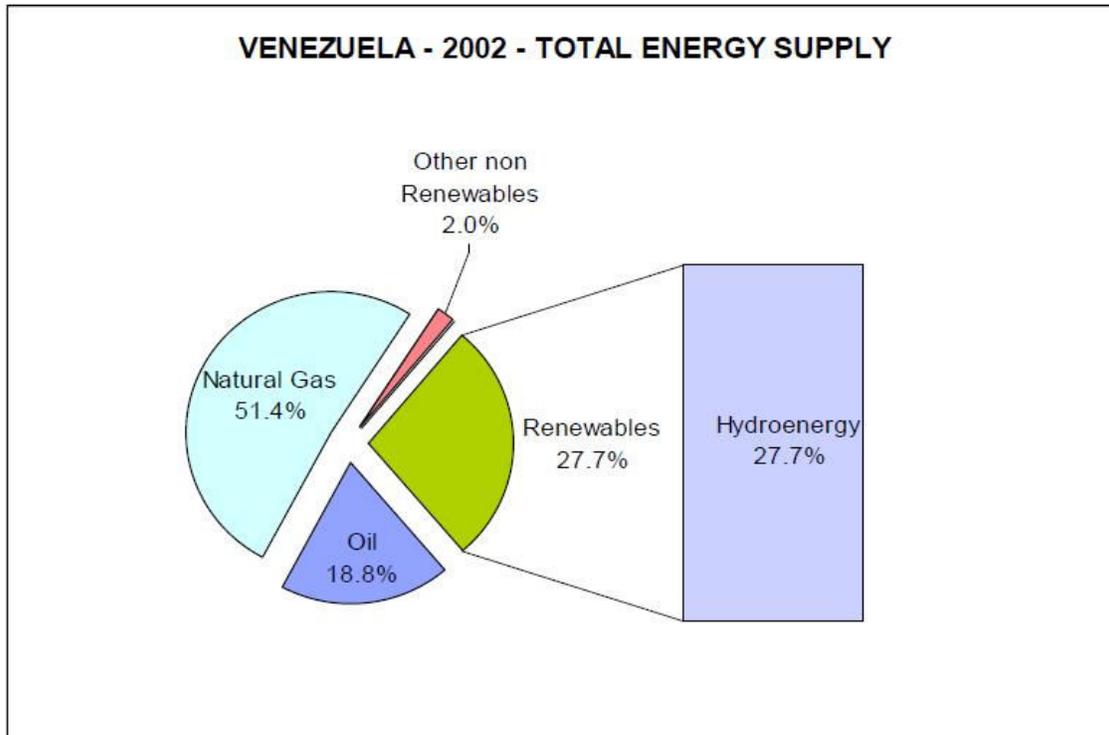


Figure 61 Venezuela – 2002 – Total energy supply⁷⁴

With 51.4% of energy supply, natural gas plays the most important part of the total energy supply in Venezuela.

The second highest parts are represented by renewables (27.7%) and oil (18.8%). Hydro energy is the only renewable energy source used of this country.

⁷⁴ http://www.eclac.org/publicaciones/xml/1/14981/Lcl2132i_s.pdf

6.19.1 SOLAR POWER

Venezuela does have great solar power potential. Especially in the north of the country where the solar radiation is very high.

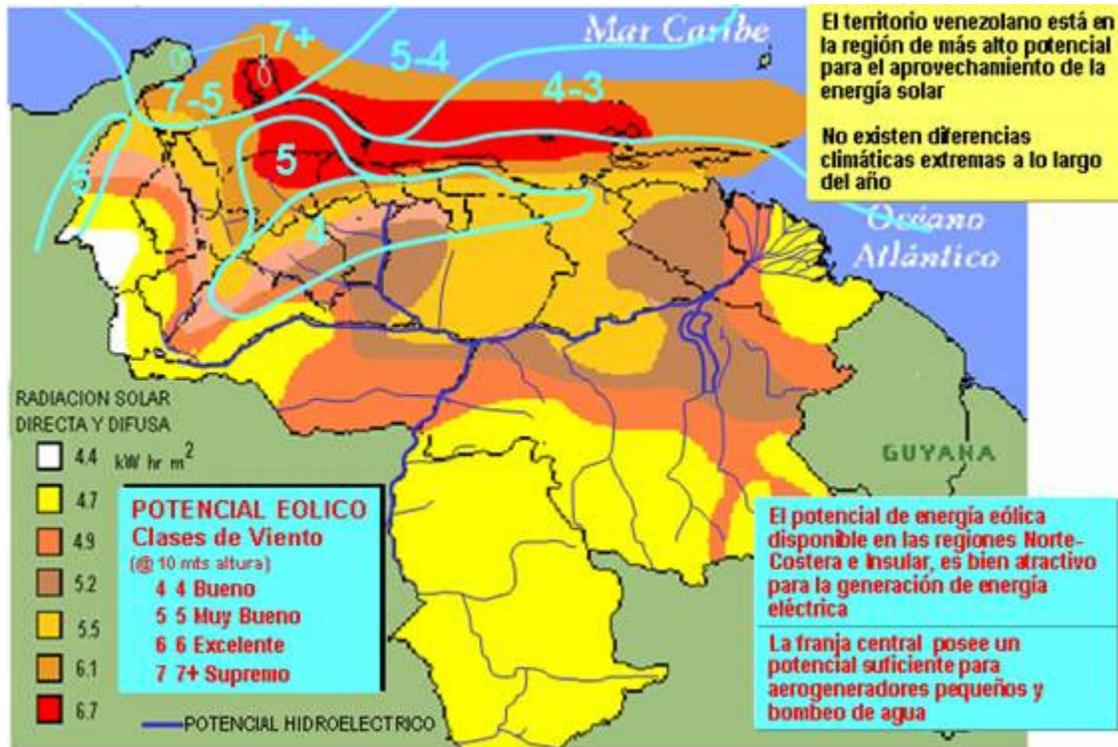


Figure 62 Venezuela: Solar Power Potential⁷⁵

⁷⁵ http://www.soberania.org/Articulos/articulo_1651.htm

7 MAPS OVERVIEW

Countries	Total Energy Supply	Solar	Wind	Biomass	Geothermal	Hydropower
Argentina	✓	✓	✓	✓	✓	✓
Bolivia	✓					
Brazil	✓	✓	✓		✓	✓
Chile	✓		✓			
Colombia	✓	✓	✓		✓	✓
Costa Rica	✓					
Ecuador	✓					
El Salvador	✓	✓	✓		✓	✓
Guatemala	✓	✓	✓		✓	
Guayana	✓					
Honduras	✓	✓	✓			
Mexico	✓	✓	✓		✓	✓
Nicaragua	✓	✓	✓		✓	
Panama	✓					
Paraguay	✓					
Peru	✓	✓	✓		✓	
Suriname	✓					
Uruguay	✓					
Venezuela	✓	✓				

8 Conclusion

The use of hydro energies and biofuels in Latin America has made considerable progress over the previous decades. In fact, in many countries, hydropower is often the dominant power source for generating electricity. This overdependence on hydro has caused supply problems for some nations in when prolonged droughts depleted the flow of water into dams. Unfortunately, the tremendous potential of other renewables such as wind, solar and geothermal is vastly underutilized.

The resource maps show that there is enough potential to greatly expand these other renewables in Latin America. Transmission grid maps should be developed and matched to these renewable resource maps so as to show how this clean energy can get to markets. Transmission access is critical to renewable development at scale.

In spite of this immense potential, it seems that a substantial Latin American renewable energy industry does not yet exist. For most of the countries in Latin America there are few or no resources maps available, or they are of such a poor quality that an analysis is not possible. Argentina is a leader in providing quality renewable resources maps, and we hope its work inspires the development of new renewable resource maps in other Latin America nations.

With cooperation between nations, these renewable energies could be developed for internal use as well as for export – supplying clean energy throughout Latin America. Organizations such as OLADE, MERCOSUR and SIEPAC could provide the cooperative framework for their members, and accelerate clean energy for economic growth and poverty reduction.

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