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Geopolitics of Energy in Brazil

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Definition

The present world has its attention focused on the energy problem, whose effects are severe within the dynamic coexistence of conflicts of interest and complexity of the energetic matrices involved. The approach of this work will be based on the National Energy Plan - 2030, elaborated by the Brazilian Ministry of Mines and Energy, where the strategies of expansion of energy supply will be approached taking into account the energy efficiency and technological innovation involved, both in the generation as in energy consumption, within the perspective of Energy Geopolitics and sustainability

Introduction

The main objective of this article is to present how energy generation and conflicts of interest are expressed, approaching the geopolitics of energy and indicating how energy and sustainability committee operates in a developing country and the need for a clear and strategic plan for objectives agreed with global committees. In Brazil, this is presented directly through the National Energy Plan (PNE-2030), prepared by the Ministry of Mines and Energy. Similarly, this paper argues that all these energy concepts must be consolidated and treated as a program to be achieved in schools and universities, which should seek an efficient system in energy management and sustainability. In general, higher education institutions (HEI) can and should be treated as green buildings and mini-cities, but this presents itself as a difficulty, mainly in Brazil due basically to organizational and financial barriers. The data presented in this study are results of research carried out at UNIFAAT, HEI, located in the city of Atibaia, São Paulo, Brazil, by students of the Undergraduate Courses in Civil Engineering through the Center for Studies and Research (CEPE) with the objective of fomenting the processes of formation and generation of knowledge in the area of energy and sustainability that is part of UNIFAAT sustainability educational policies.

Geopolitics of Energy

Geopolitics of energy includes relations between countries on energy, economics, and politics,

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and its study and understanding is important for making decisions between governments, companies, and society. In today's increasingly globalized and competitive world, the way each country produces, supplies, and consumes energy directly affects safety, socioeconomic development, and the environment globally. Numerous facts that have occurred in the recent past have led countries to change their energy policy. The Fukushima nuclear accident in Japan; the so-called Arab Spring, which convulsed parts of Middle East and North Africa; and European Union (EU) sanctions against Iran, with possible repercussions on Iranian oil trade to European countries, are facts of great relevance. Within this context, planners should consider all facts and factors such as global geoeconomics, global energy demand behavior, global oil and gas market reactions, prospects of the nuclear industry, development of renewable energy, and efforts and treaties for the global reduction of carbon emissions when assessing the need for changes in strategic plans to mitigate the risk of energy shortages in their countries or companies. The correct analysis of variables influencing the energy industry, with global nuances, tends to focus on events involving two large blocks of countries: United States/European Union and the emerging economies Brazil, Russia, India, China, and South Africa which, although not representing a cohesive economic bloc or that participate mostly in global governance, have a total GDP of over 22% of the world total, according to the World Bank. Named in 2001 by economist Jim O'Neill with the acronym BRIC to designate the economies that were most likely to grow in the future, he warned that emerging economies would grow at rates faster than the world's largest economies. Brazil, Russia, India, and China then gained prominence in the discussions about the global market and came to represent the growth of emerging countries. South Africa only joined the group in 2011, when the acronym was adapted to the current BRICS. Considering the above points and observing the oscillations in financial markets of the United States and Europe, which border recession, and repercussions that this situation brings to the markets of the whole world, it seems that the world energy demand continues in an upward curve, mainly due to the energy needs of emerging economies of Asia and Latin America. The latest publication of the World Energy Outlook (November 14, 2017, International Energy Agency) predicts major changes in the world energy market. Over the next 25 years, a 30% increase in demand is expected, which should be supplied mainly by renewable energy and natural gas. China should boost this market with cleaner and more diversified energy. The shale oil and gas revolution in the United States will make it the world's largest LNG exporter and a net oil exporter by the end of that decade. Wind energy should boost the European energy market. Brazil meets domestic demand with about 42% of energy based on renewable sources and plans to double the use of sustainable energy, double energy efficiency targets, and universalize access to energy by 2030.

Energy Policy

Energy policy reflects the guidelines established by the government of a country aimed at managing and exploiting energy resources, in order to feed the industrial park, commerce, and population in general. Energy resources can be available by exploiting existing sources or by importing them. Restructuring the energy sector is one of the key issues for securing investments in the industry, accumulating enough to meet the ever-increasing need for fuel and electricity. At the same time, it is important that government actions be carried out from a sustainable perspective, ensuring availability of resources to future generations. This can be done by taking into account coherent implementation strategies, avoiding waste, and considering financial, human, technological, and natural resources. Therefore, as energy policy is of vital importance for the economic sustainability of the nations, we will describe and further compare the energy policies of Brazil, the USA, China, European Community, and Russia.

(a) **Brazilian Energy Policy**: Brazilian energy policy is based on Law 9478/1997, which highlights the importance of sustainability of recommended solutions, use of renewable energies, efficient use of energy, diversification of the energy matrix, and environment preservation. As a UN member, Brazil has been making efforts to restructure its energy matrix in order to increase the share of renewable energy, in accordance with the provisions set out in Agenda 2030 (document assumed at the United Nations Summit on Sustainable Development in 2015).

(b) **US Energy Policy**: In March, 2017 President Trump issued an executive order (President Trump's Energy Independence Policy) with criticism of the Obama administration, which had created a clean energy agenda centered on the climate change agenda. With this order, the United States cancels any measure that makes energy more expensive, seeking energy self-sufficiency. This way it resumes the projects of massive exploitation of shale gas and the construction of gas and oil pipelines, and that will cover federal lands and indigenous territories. It also resumes the possibility of mining coal in these territories. American energy independence, then, becomes the main energy policy.

(c) **China's Energy Policy**: As described by Fuser (2013) in "Energy and International Relations," the Chinese government has adopted three strategic priorities:

1. Diversify external energy suppliers;
2. To use petroleum and natural gas transported by land (oil and gas pipelines) rather than seafarers, in order to reduce their vulnerability before a naval blockade or to sanctions.
3. Launch state or semi-state oil companies aiming to obtain control of hydrocarbon reserves around the world.

(d) **European Community Energy Policy**: As described in European Union website in the section "EU energy targets, 2018," the European Union's energy policy has three main objectives: security of supply, competitiveness, and sustainability. The EU has laid the foundations for energy that guarantees EU citizens and businesses a secure, affordable, and environmentally friendly energy supply, setting objectives:

Objectives for 2020:

20% reduction of at least greenhouse gas emissions as compared to 1990 levels

20% of energy from renewable sources

20% improvement in energy efficiency

Objectives for 2030:

40% reduction of greenhouse gas emissions

At least 27% of energy from renewable sources

27–30% increase in energy efficiency

15% of electricity interconnection (i.e., 15% of electricity produced in the EU can be transferred to other EU countries)

Objectives for 2050:

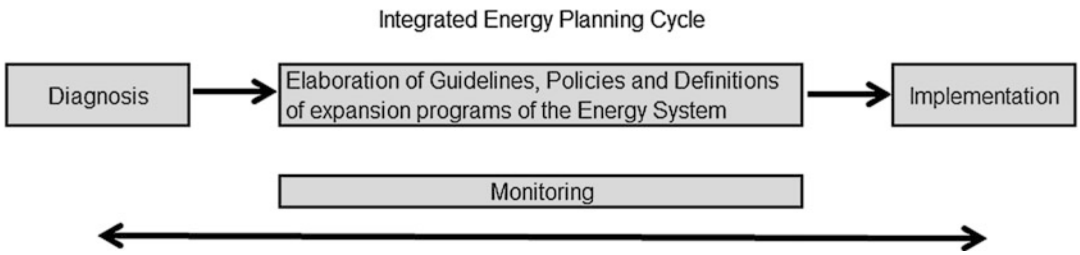
An 80–95% cut in greenhouse gases compared with 1990 levels

(e) **Russia's Energy Policy**: As described by Fuser (2013) in "Energy and International Relations," Russia seeks to consolidate the position as an energy supplier because of its enormous potential. Under the leadership of Vladimir Putin, Russia hopes to review its status as a major power, using a policy of insertion with the supply of energy to the EU. Much of Russia's hydrocarbon reserves are in eastern Siberia, thus facilitating exports to the Asian market. The accelerated economic growth of China, India, and other Asian countries should, in medium term, consolidate the goals of Russia's foreign policy of providing energy supplies.

Comparison of Energy Policies

By comparing the energy policies of Brazil, the USA, China, European Union, and Russia, it can be noticed that three factors can be highlighted: natural resources, technology, and organization of industries and markets.

Natural Resources: They are of decisive importance in quantity, quality, and location. The dispute between holders of large reserves and their consumers arises economic and political pressure, leading to a search for and discovery of new reserves outside traditional regions, such as of oil and gas. New sources of energy continue to be studied, thus reducing dependence on



Geopolitics of Energy in Brazil, Fig. 1 Integrated energy planning cycle

"unreliable" countries and, finally, having as a premise effective action in view of problems related to global climate change.

Technology: This is linked directly to natural resources factor. Technological advancement makes it possible to search for and access new or unconventional sources of energy. In case of oil and gas, two issues stand out: (1) the technological advance that allows exploration in deep and ultra-deep waters and (2) the technological challenge in the area of unconventional resources, such as bituminous sands, ultra-heavy oil, and synthetic fuels and shale gas. In both cases, technology is essential for maintenance of the oil/gas chain, incorporating new resources. Still in the field of gas, it is important to emphasize its transformation into liquefied natural gas (LNG), allowing distribution in a logistics more similar to petroleum. Technological efforts are also aimed at reducing the energy dependence of the traditional fossil fuel matrix, with three main fronts: (1) improving the efficiency of traditional energy generation; (2) development of energy generation by renewable fuels, wind, photovoltaic, geothermal, and biomass; and (3) improving the energy efficiency of consumer goods that use electricity.

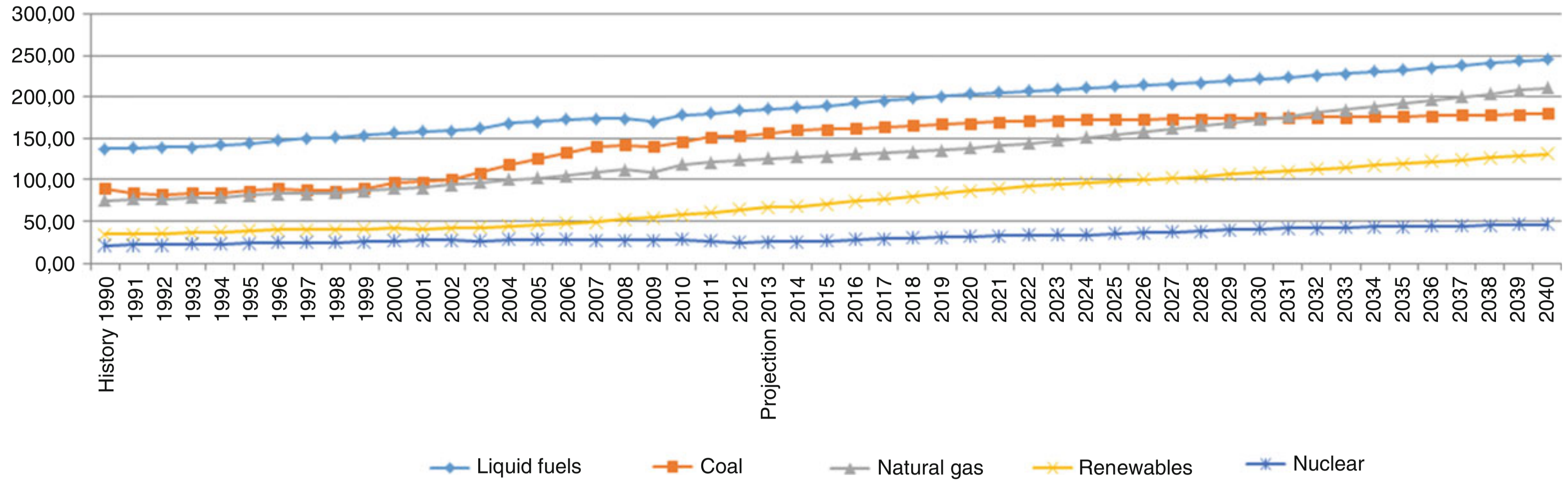
Organization of Industries and Market: In the oil sector, expansion of non-OPEC oil supply is not enough to meet demand growth. There is also the issue of refining capacity, as lower-quality resources and greater environmental requirements, coupled with the need to produce lighter derivatives, create another bottleneck and demand modernization of refining plants in order to reduce pressure on market prices. In case of natural gas, we see a market with a high concentration of mergers and acquisitions of gas and electricity companies, together with a vertical integration of the production chain, its transportation, and distribution. In the biofuels sector, Brazil's role in case of ethanol is evident, and it can become a major exporter depending on the absorption of technologies and opportunities for market diversification. Regarding biodiesel, competitive raw materials are also under study to enable the tripod: technology, production scale, and business model.

National Energy Plan 2030 (PNE 2030)

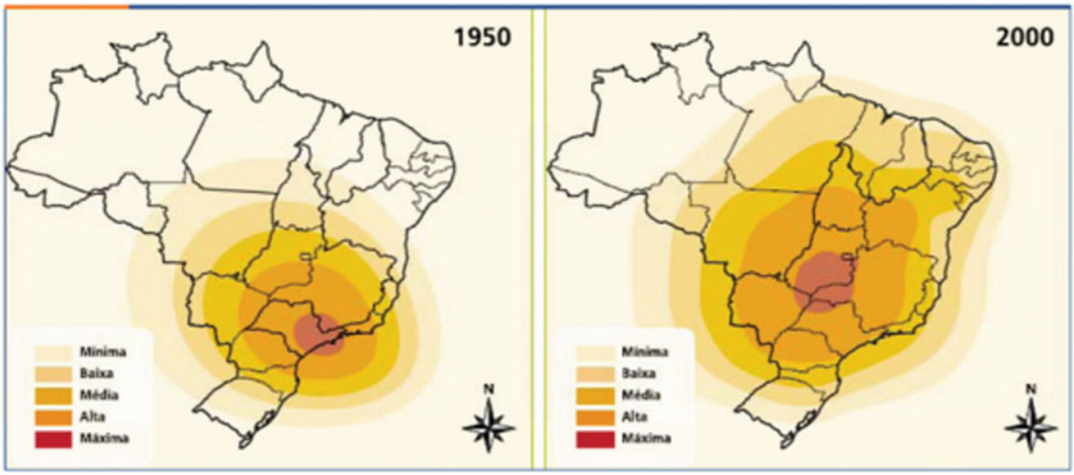
The first study of energy resources integrated planning, within the scope of the Brazilian government, came to cover the need of a strategy to supply the growth of demand. This study covers all types of energy, from oil to nuclear, from wind to thermoelectric, and from natural gas to biomass, among others. Together with another document, called National Energy Matrix 2030, PNE 2030, it is the main planning tool available to public and private sector managers; therefore, we understand energy planning as a cycle with four stages that are continuously completing themselves, as shown in Fig. 1.

Energy Resources and Reserves

Energy resources are the reserves or flows of energy available in nature, which can be used to meet human needs and are classified as fossil resources or renewable resources. Fossil fuels have been generated by partial decomposition of organic matter, millions of years ago: coal, petroleum, natural gas, peat, and bituminous shale.



Geopolitics of Energy in Brazil, Fig. 2 Total world energy consumption per energy source, 1990–2040 (quadrillion Btu). (Source: Data collection and direct translation from INTERNATIONAL ENERGY OUTLOOK 2017 – EXECUTIVE SUMMARY)



Geopolitics of Energy in Brazil, Fig. 3 Territorial evolution of the use of the Brazilian hydroelectric potential. (Source: Atlas of Brazilian Electric Energy 2002)

In addition, we still have fissile material, such as uranium and thorium. Renewable resources are developed by natural streams such as solar, hydro, wind, sea waves, and biomass. The energy resources referred to in this item will be presented in a comparative way, showing a global perspective in relation to Brazil. According to Fig. 2, we can see world consumption per energy source from 1990 up to a forecast in 2040.

Hydroelectric

Among the renewable matrixes, the hydroelectric plant represents a significant part of world production, with about 19% of the world's electricity supply.

The 2007 edition of the US International Energy Outlook reports that hydroelectric generation and other renewable sources will grow by 56% by 2030 and that 33% of the technically viable potential has already been explored, with Europe and North America already having developed their potential and about 70% in South America has to be developed. Asia and Africa also have potential to be explored, and within this scenario, China and Brazil stand out. Figure 3, reproduced from the Brazilian Electric Energy Atlas (ANEEL 2002), shows the historical evolution of the use of Brazilian hydroelectric potential.

Parallel to the hydroelectric potential, there are pressures on a global scale against the emergence of new plants due to socio-environmental issues. In Brazil, these issues have been arising difficulties for the expansion of the hydroelectric sector, requiring more elaborate impact studies aimed at the well-being of affected communities and environmental impact. According to data from the Brazilian Energy Matrix 2030, as shown in Fig. 4, there is a great potential to be explored around the world.

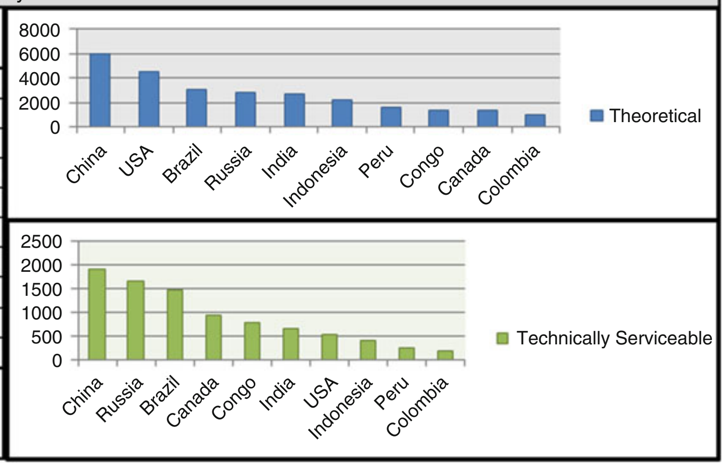
In Brazil, electricity production is generated mostly by hydroelectric plants, corresponding to 75% of installed capacity in the country which generated, in 2005, 93% of the electricity required in the National Interconnected System – SIN. The Brazilian hydroelectric potential is estimated at 261.4 GW (Plan 2105), with only 30% being exploited. Of this total, 32% correspond to a little known estimated potential, and 43% are located inthe North region. The hydroelectric potential and its use by region are illustrated in Fig. 5. In Fig. 6 we see a comparison between the main hydroelectric plants in Brazil and in the world.

Petroleum

According to data from the International Energy Agency, oil accounted for 45% of the world's primary energy supply in 1973. Environmental

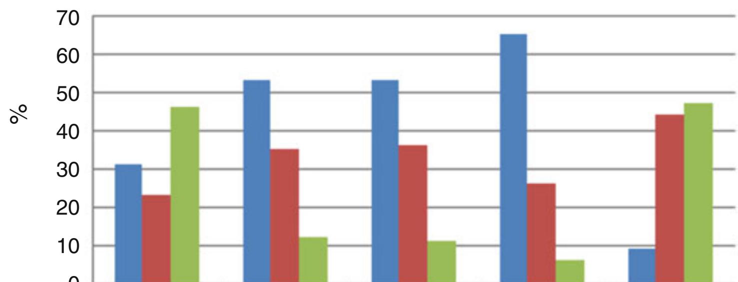
Hydroelectric Potential in the World - TWh/ano

	Theoretical	Technically serviceable
China	5920	1920
USA	4485	529
Brazil	3040	1488
Russia	2800	1670
India	2638	660
Indonesia	2147	402
Peru	1578	260
Congo	1397	774
Canada	1289	951
Colombia	1000	200



Geopolitics of Energy in Brazil, Fig. 4 Hydroelectric potential in the world: theoretically and technically useful (TWh/year). (Source: Brazilian Energy Matrix 2030)

Hydroelectric Utilization of Brazil by Region in %



	Midwest	South	Southeast	Northeast	North
Operation / Construction / Concession	31	53	53	65	9
Unreclaimed / Stocktaking	23	35	36	26	44
Unreclaimed / Estimated	46	12	11	6	47

Geopolitics of Energy in Brazil, Fig. 5 Utilization of the hydroelectric potential of Brazil, by region, in %. (Source: Brazilian Energy Matrix 2030)

impacts, price shock in the 1970s, and technological advances that allowed changes in the energy matrix reduced participation to 34% in 2004. Still, it should account for 35% of the world's primary energy demand by 2030. Consumption for the transportation sector is expected to remain around 58% of oil production, with the main demand for medium and light derivatives (gasoline, diesel, and aviation kerosene). Fig. 7 shows the main flows of oil in the world and defined routes. In energy generation it has been gradually replaced by natural gas. Although maintaining a leadership position among the sources, in 2030, petroleum and its derivatives will account for about 30% of the Brazilian energy matrix, losing 8.9% in relation to 2005, accentuating the trend observed in recent years. Global use of oil and other liquid fuels grows from 95 million barrels per day in 2015 to 104 million barrels per day by 2030. In 2016, Brazil produced 3.24 million barrels per day of oil and other liquids. The increase in

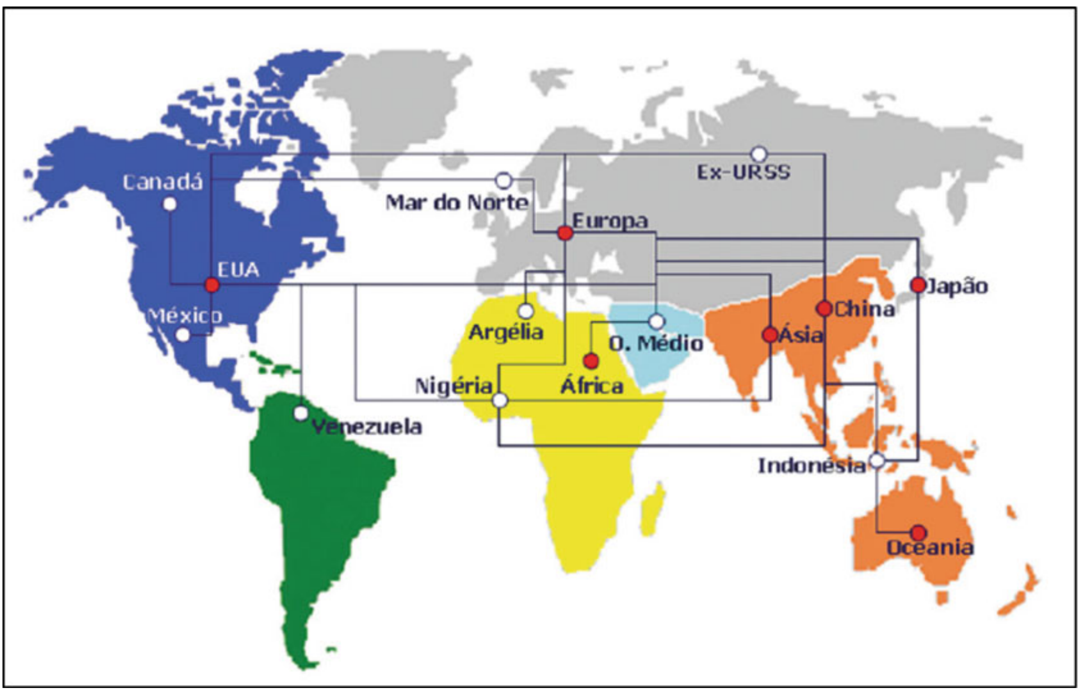
Main Hydropower Plants in Brazil

Nº	Hydropower Plants	River	State of Brazil	Capacity
1	Itaipu Binacional	Paraná	Paraná	14 000 MW
2	Belo Monte	Xingú	Pará	11 233 MW
3	Tucuruí	Tocantins	Pará	8 370 MW
4	Jirau	Madeira	Rondonia	3 750 MW
5	Santo Antônio	Madeira	Rondonia	3 568 MW
6	Ilha Solteira	Paraná	São Paulo e Mato Grosso do Sul	3 444 MW
7	Xingó	São Francisco	Alagoas e Sergipe	3 162 MW
8	Paulo Afonso IV	São Francisco	Bahia	2 850 MW
9	Itumbiara	Paranaíba	Goiás e Minas Gerais	2 082 MW
10	Teles Pires	Teles Pires	Mato Grosso e Pará	1 820 MW

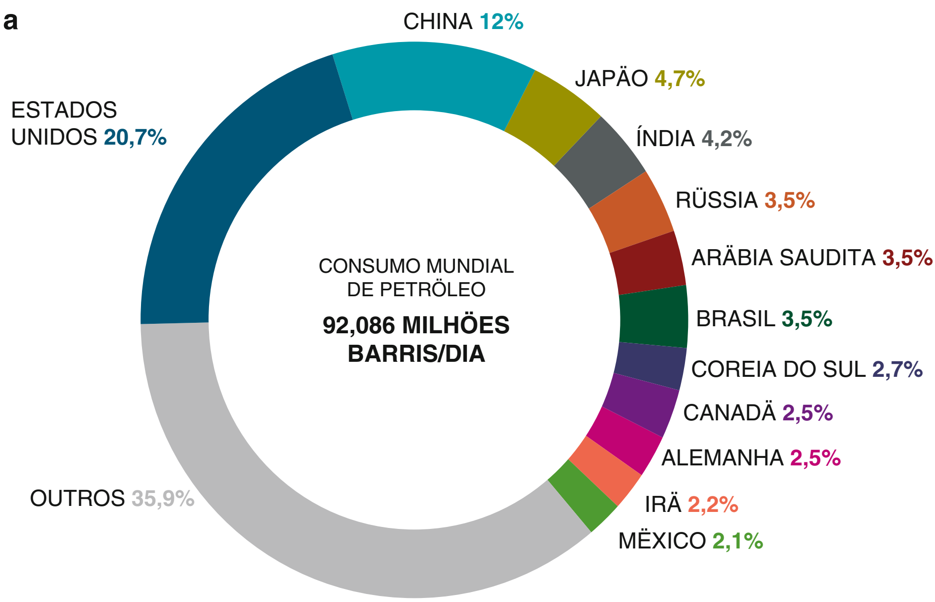
Main Hydropower Plants in the World

Nº	Hydorpower Plants	Country	River	Capacity
1	Three Gorges	China	Yangtze	22.500 MW
2	Itaipu	Brasil	Paraná	14.000 MW
3	Xiluodu	China	Jinsha	13.860 MW
4	Guri	Venezuela	Caroni	10.235 MW
5	Tucuruí	Brasil	Tocantis	8.370 MW
6	Grand Coulee	Eua	Columbia	6.809 MW
7	Xiangjiaba	China	Yangtze	6.448 MW
8	Longtan	China	Hongshui	6.426 MW
9	Krasnoyarsk	Rússia	Yenisey	6.000 MW
10	Nuozhadu	China	Lancang	5.850 MW

Geopolitics of Energy in Brazil, Fig. 6 Main hydroelectric plants in Brazil and the world (base year 2016). (Source 1: https://pt.wikipedia.org/wiki/Lista_de_usinas_hidrel%C3%A9tricas_do_Brasil and Source 2: https://top10mais.org/top-10-maiores-hidreletricas-mundo/)



Geopolitics of Energy in Brazil, Fig. 7 Main flows of oil in the world. (Source: National Energy Plan 2030 (BP 2006)) a



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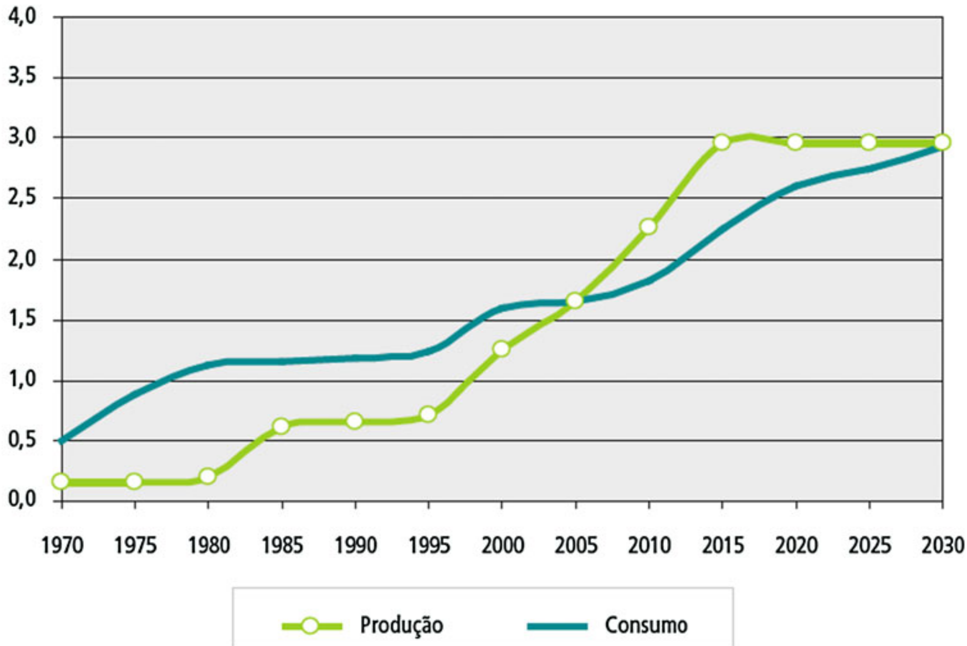
	Reservas em 1995	Bilhões de barris petróleo 2005	2014	
Venezuela	66,3	80,0	300,0	4,5x
Cazaquistão	6,3	9,0	30,0	4,8x
US	29,8	29,9	55,0	1,8x
Angola	3,1	9,0	12,7	4,1x
Brasil	6,2	11,8	80,0	12,9x
Iraque	100,0	115,0	143,1	1,4x
China	16,4	15,6	18,5	1,1x
Libia	29,5	41,5	48,4	1,6x
Iran	93,7	137,5	157,8	1,7x

Fonte: BP (2016)

Geopolitics of Energy in Brazil, Fig. 8 Part A- World oil consumption in 2014 – main countries. (Source: https://fernandonogueiracosta.wordpress.com/2015/12/19/consumo-mundial-de-petroleo/; BP Statistical Review of World Energy 2015 (Table 1.3), Part B- Evolution of hydrocarbon reserves from 1995 to 2014 Source: http://brasildebate.com.br/o-brasil-no-jogo-de-tabuleiro-mundial-do-petroleo/; (BP 2016)

domestic oil production has been a long-term objective of the Brazilian government, and the discoveries of large offshore and pre-salt oil deposits have made Brazil one of the ten largest producers of liquid fuels, as shown in Fig. 8.

It is interesting to notice that in 2006, the International Energy Outlook (IEO), in a scenario of reference prices, projected Brazilian oil production as going from 2.7 million barrels per day in 2010 to 4.5 million barrels per day in



Geopolitics of Energy in Brazil, Fig. 9 Production and consumption of petroleum in Brazil (million barrels/day). (Source: PNE 2030)

	2011	2016	2020
DR - Out Pre Salt	2,022	2,774	2,387
DR - Pre Salt	0,303	1,283	3,08
RND - Out Pre Salt	0	0,201	0,215
RND - Pre Salt	0	0,023	0,074
Total	2,325	4,281	5,756

Geopolitics of Energy in Brazil, Fig. 10 Estimated oil production in Brazil – new reserves and existing reserves in the areas already granted (2011, 2016, and 2020) in million b/d. *DR* Discovery reserve, *RND* Reserve not discovery. (Source: EPE 2011)

2030, therefore, with an even greater production in the last year of the scenario than the one projected in PNE 2030, demonstrated in Fig. 9.

Pre-Salt Layer

In 2005, Petrobras drilled exploratory wells and discovered hydrocarbons below the salt layer. In 2007 it discovered an estimated 5.8 billion barrels of oil. Pilot projects began production in 2009 and 2010. The average production of Brazilian pre-salt oil in 2016 was a record 1.02 million barrels/day of oil. The National Energy Plan 2030 does not mention the pre-salt. However, it should be pointed out, as described in the text by Schutte (2012) "Pre-Salt Panorama: Challenges and Opportunities" that increasing potential reserves represent a new perspective for Brazil, as it allows the overcoming of what has already been one of the country's most important external vulnerabilities – the need to import oil – and opens the prospect of a significant potential exporter. We can note this estimated growth according to EPE data presented in Figs. 10 and 11.

Natural Gas

Natural gas in generation of electric energy has advanced worldwide in the last decades, as shown in Fig. 12, replacing part of the market dominated by oil and coal with natural gas having an environmental advantage, a reduction in CO2 emissions – about 20%–25% less than fuel oil and 40%–50% less than coal.

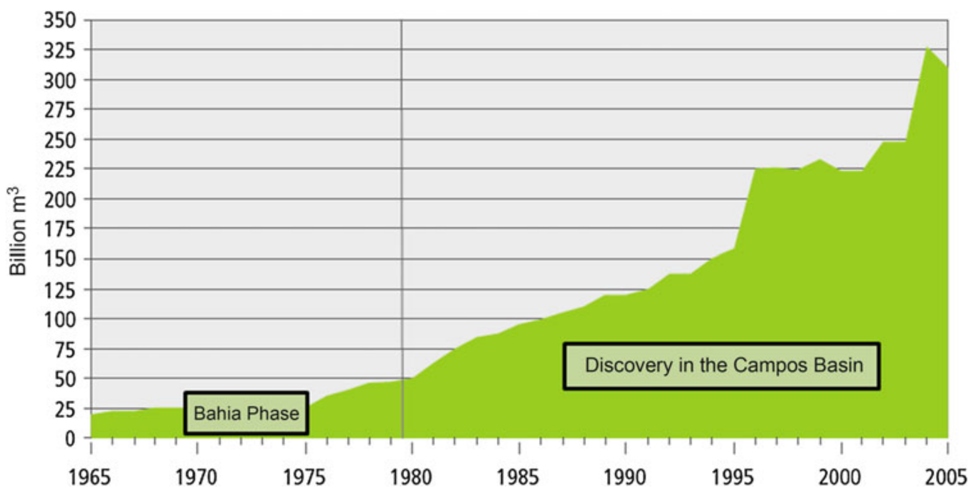
In Brazil, national reserves of natural gas were not considered sufficient to meet the market, especially considering the use in

Country	1999	2009	2010	2017	2020
Russia	6,20	10,00	10,27		
Saudi Arabia	8,90	9,70	10,00		
EUA	7,70	7,20	7,50		
Iran	3,60	4,20	4,25		
China	3,20	3,80	4,00		
Brazil	1,10	2,00	2,14	3,82	6,09

Geopolitics of Energy in Brazil, Fig. 11 Oil production in 1999, 2009, and 2010 and forecast for 2017 and 2020 (in millions of b/d). (Source: BP Statistics, for the numbers of other countries; EPE/Ministry of Mines and Energy of Brazil, for the numbers and forecasts for Brazil)

Geopolitics of Energy in Brazil, Fig. 12 Natural gas consumption in the world (million tep). (Source: PNE 2030 International Energy Agency 2005)

Natural Gas Consumption in the World (Million tep)			
	1973	2003	Δ per year%
Total Supply (Primary Energy)	**979,10**	**2244,10**	**2,80**
Electric Power Generation	160,00	468,60	3,70
Cogeneration	50,90	275,40	5,80
Heat Generation	0,70	87,70	17,50
Other Uses	96,10	220,50	2,80
Final Use	671,40	1191,90	1,90



Geopolitics of Energy in Brazil, Fig. 13 Evolution of natural gas reserves in Brazil in billions of m^3. (Source: ANP – 2006)

electricity generation. Recent announcements of additional discoveries of natural gas in the pre-salt layer of Brazil have generated enthusiasm for the new production of natural gas. It is estimated that the pre-salt areas contain large reserves of natural gas, considering that this exploration grew 36% from 2015 to 2016, according to the ANP, as demonstrated in Figs. 13 and 14.

Geopolitics of Energy in Brazil, Fig. 14 Estimate of resources total undiscovered natural gas in Brazil (billions of m^3). (Source: US Geological Survey 2001)

	Probability		
Basin	**95%**	**50%**	**5%**
River Mouth Amazonas	216,00	786,80	1644,60
Sergipe - Alagoas	38,70	198,30	563,80
Espirito Santo	105,10	775,30	2508,30
Campos	106,00	467,30	1321,50
Santos	498,40	2107,20	4634,20
Pelotas	0,00	556,20	1579,90
Total	964,20	4891,10	12252,30

Consumption	2005	2030
Other Uses	6,1	6,9
Oil Derivates Production	14,1	15,8
Energy Sector	16	17
Electrical Generation	19,8	24,7
Transportation	8,4	7,2
Industrial	35,6	28,4

Geopolitics of Energy in Brazil, Fig. 15 Structure of natural gas consumption in Brazil (%). (Source: PNE 2030)

The generation of electric energy is an important part of the use of gas; however there are other uses, as demonstrated in Fig. 15.

Associated natural gas projects in the pre-salt oil fields will account for most of the growth of future production, but the gap does not close between supply and demand in Brazil, as shown in Fig. 16. However, the reduction in demand for natural gas and the continued growth of domestic production have helped Brazil to reduce dependence on LNG imports in 2016. Foreign dependence is a risk to the country's energy security, but LNG arises as an important energy source. Brazil will have an increase in use according to projections of the International Energy Outlook 2016, as shown in Fig. 17.

Mineral Coal

Mineral coal is classified according to carbon content: peat, low carboniferous content; lignite, with a carbon content between 60% and 75%; bituminous (coal), having a content between 75% and 85%; and anthracite, with a carbon content higher than 90%.

In spite of being a potentially polluting fuel, its availability and distribution around the world make it continue to play an important role as a source of energy. It has a low cost of extraction and transport. India, China, and Australia are the countries that will most contribute to the growth of world production by 2040, with China decreasing its contribution from 48% to 44% by 2040.

Most consumer countries have significant reserves and resulting in a small volume of world trade, accounting for about 15% of the coal consumed worldwide. In Brazil reserves are concentrated in Paraná, Santa Catarina, and Rio Grande do Sul. Mineral coal accounts for a little more than 5% in the Brazilian energy matrix and only 1.3% in the electric matrix. The main use of coal occurs in the steel industry and for electricity generation. The Brazilian mineral coal is considered of low quality; therefore, more than 98% of the product is imported.

Biomass

Biomass comprises the plant matter generated by photosynthesis and its various products and by-products, such as forests, crops and agricultural residues, animal waste, and organic matter contained in industrial and urban waste. This material contains chemical energy accumulated through the energetic transformation of solar radiation and can be directly released by combustion or converted into energy products of a distinct nature, such as charcoal, ethanol,

Geopolitics of Energy in Brazil, Fig. 16 Projection-supply and demand-natural gas in Brazil (million m^3/day). (Source PNE 2030)

	2005	2010	2020	2030
Produciton	48,5	94,2	169	251,7
Importation	24,6	47	45,9	71,9
Loss and Reinjection	15,7	25,9	40,1	56,6
Total Consumption		115,3	174,8	267

	History		Projections					Average annual percent change, 2012-40
Region	2011	2012	2020	2025	2030	2035	2040	
OECD								
OECD Americas	**30.8**	**31.8**	**32.8**	**34.3**	**36.5**	**38.2**	**40.1**	**0.8**
United States*	24.5	25.5	26.1	26.9	28.1	28.8	29.7	0.5
Canada	3.7	3.7	3.9	4.2	4.7	5.2	5.6	1.5
Mexico and Chile	2.6	2.6	2.8	3.2	3.6	4.2	4.8	2.2
OECD Europe	**18.6**	**17.8**	**19.2**	**20.6**	**22.3**	**23.7**	**25.3**	**1.3**
OECD Asia	**7.6**	**7.9**	**8.9**	**9.8**	**10.4**	**11.3**	**12.2**	**1.6**
Japan	4.5	4.7	5.1	5.6	5.7	5.9	6.0	0.9
South Korea	1.6	1.8	2.1	2.2	2.4	2.7	3.0	1.9
Australia and New Zealand	1.4	1.5	1.7	2.0	2.3	2.7	3.2	2.9
Total OECD	**56.9**	**57.5**	**60.9**	**64.7**	**69.2**	**73.2**	**77.6**	**1.1**
Non-OECD								
Non-OECD Europe and Eurasia	**22.8**	**23.0**	**22.5**	**23.9**	**25.0**	**26.0**	**26.0**	**0.4**
Russia	15.3	15.7	15.3	15.8	16.2	16.5	16.0	0.1
Other	7.5	7.3	7.2	8.1	8.9	9.5	10.0	1.1
Non-OECD Asia	**14.6**	**15.1**	**20.8**	**27.2**	**34.0**	**42.5**	**50.8**	**4.4**
China	4.6	5.1	9.1	13.5	17.6	22.7	27.5	6.2
India	2.3	2.1	2.3	2.9	3.8	4.9	6.0	3.9
Other	7.7	7.9	9.4	10.8	12.7	14.9	17.2	2.8
Middle East	**13.9**	**14.7**	**17.7**	**20.5**	**23.5**	**26.1**	**28.9**	**2.5**
Africa	**3.9**	**4.5**	**5.5**	**6.2**	**7.7**	**9.4**	**11.1**	**3.3**
Non-OECD Americas	**5.0**	**5.1**	**5.8**	**6.5**	**7.2**	**8.0**	**8.9**	**2.0**
Brazil	0.9	1.1	1.4	1.5	1.7	1.9	2.2	2.6
Other	4.1	4.0	4.4	5.0	5.5	6.2	6.8	1.9
Total Non-OECD	**60.3**	**62.3**	**72.3**	**84.4**	**97.5**	**112.0**	**125.7**	**2.5**
Total World	**117.1**	**119.8**	**133.2**	**149.1**	**166.6**	**185.2**	**203.3**	**1.9**

*Includes the 50 States and the District of Columbia.

Geopolitics of Energy in Brazil, Fig. 17 World natural gas consumption by region 2011–2040 (trillion cubic feet). (Source: US Energy Information Administration|International Energy Outlook 2016)

combustible and synthetic gases, combustible vegetable oils, and others.

Brazil has a leading position in the world due to the natural and geographical conditions. Africa and Australia theoretically also have good climatic conditions; however they have large desert regions. Brazil presents a great development in the technology of tropical agriculture, with international recognition of the alcohol agroindustry. According to data from the Bioenergy Worldwide Association (WBA 2014, 2015), electrical and biomass energy generation between 2000 and 2012 has grown 140% in the world, reaching 4391 Wh.

The Brazilian sugar and alcohol sectors present a biomass production with huge potential for use, both for electric energy and for other forms of energy production derived from cellulosic biomass. Today, all the bagasse produced is used in the generation of electric energy and process heat. Since 2013, the sugar and energy sector has been generating a surplus of 60% of energy for the grid, and PDE 2014 points out that bioelectricity has the technical potential to grow about six times the amount offered in 2015, with a generation of 165TWh/year up to 2024. If the country fully exploits this potential, according to the EPE, only sugar cane can represent 24% of the national consumption of the power grid by 2024.

Solar Energy

We currently have two distinct technologies: photovoltaic, which converts light into electricity, and heliotherm, which is a form of thermoelectric generation, producing heat vapor. Given the need for a balance between supply and demand, heliotherm is less susceptible to variations in insolation, as it is a thermoelectric plant connected to the grid, while photovoltaic has non-generation periods that influence the distribution of the grid. However, investments to reduce value and technology have been concentrating on photovoltaic energy, which grew by 47% per year between 2004 and 2014, according to REN21-2015, mainly due to subsidies from European countries.

Different business models allowed the growth of photovoltaic generation: (a) premium rate, purchase of energy generated by fixed value with long term; (b) direct subsidies, grant of direct benefit or tax reduction; (c) auctions, used for large projects with long-term energy purchase; (d) net metering, consists of the deduction of the invoice of the energy consumed by the energy distributed to the grid; and (e) share, instrument that requires distributors to purchase a certain level of energy from renewable sources. Brazil will be within the 20 major solar energy producers by 2018. Photovoltaic generation will reach 7.000 MW in Brazil by 2024, not including the distributed generation.

Wind Energy

The oil crisis of 1973 boosted studies for other energy sources, especially wind power. Between 1981 and 1990, the USA generated 1.8 GW due to government incentives. Europe concentrates market and technology, for environmental reasons and to reduce energy dependence. Since 2000 the technology has diversified around the world, with the emergence of facilities and manufacturers mainly in Asia. Wind power generation has grown exponentially in the world, in recent years, with a still small contribution in the world energy matrix, with the exception of some countries like Denmark, where the wind supplied 39% of the electricity demand in 2014. The PDE2024, of the MME, forecasts that installed Brazilian wind generation reaches 24GW in 2024, accounting for 11.4% of the total. The Northeast Region (NE) is expected to be 90%. Wind energy, added to solar, will make the NE an exporting region of electricity by 2024.

Impediment of Adoption of Breen Buildings in Higher Education Institutions

Government incentives boosted the Brazilian construction sector in 2013, responsible for significantly collaborating with the gross domestic product (GDP). On the other hand, we have that the sector is responsible for a large generation of solid waste and high energy consumption for extraction, handling, and use of raw material. In addition, buildings account for one-sixth of the world's freshwater consumption, a quarter of the wood harvest, and two-fifths of the energy consumed in the world (Alshuwaikhat and Abubakar 2008).

We have a concept that has been disseminated in the last 30 years of sustainable development, which is defined as meeting current needs without compromising capacity for future generations (Wilkinson et al. 2001).

If there is a possibility of success for this concept, this necessarily involves the civil construction sector. However, there is much difficulty in implementing this concept due to the scarcity of literature on the subject, lack of specialized training, lack of training on new technologies, and financial and organizational barriers.

The construction of greener buildings tends to bring several advantages, including property valuation, reduction of water consumption, reduction of energy consumption, and reduction of waste generation, in addition to an average resale price.

In general, the adoption of sustainable constructions faces technical and economic challenges; however if the HEI presented themselves not only as a vector of direct dissemination theories of sustainable constructions and management of energy but also as a manager of sustainable practices, the knowledge generated could positively influence society as a whole.

The adoption of green buildings by universities, as well as the positive impact of the IES image, also serves as a focus for further studies, contributing to research projects, generating knowledge, and also representing a further step toward the sustainable development of university and society.

Another important point is that we can consider some HEIs as small cities, so the impact on direct power generation economy is no longer just informative and is gaining significant proportions (Kasai and Jabbour 2014).

Conclusion

The PDE2030, object of this study, is a long-term planning. Changes are made in the Ten-Year Energy Expansion Plan (PDE2024) which shows an average growth of renewable energies of 4.5% per year and oil and derivatives a 3% reduction by 2024.

With the difference between supply and demand of primary energy decreasing, Brazil will register a surplus of 20% of total production, reaching self-sufficiency.

In relation to natural gas, imports are expected to decline and domestic supply and demand to grow. Analyzing the energy matrix, despite the decline, oil continues to play a fundamental role, and the status of self-sufficiency in the pre-salt extraction is an achievement that must be supported by investments for internal industrial growth. As the oil market is sensitive to global political and economic changes, and even the exploitation of shale in the USA may lead to a drop in the price of a barrel of oil, consequently making it unfeasible to exploit the pre-salt. This would certainly lead Brazil to import oil and consequently natural gas, since it has been exploited associated with oil. Hydroelectricity is responsible for 68.4% of the electricity supply, but the implementation of new plants has run into environmental issues and requires investment for distribution, since the potential to be harnessed today is in the Northern Region of the country. It is also important to point out the energy matrix for renewable energy, such as biofuels, wind, solar, and biomass. These sources should be encouraged in view of the challenges for energy independence and economic growth, with sustainability and environmental responsibility. Brazil must reshape its energy matrix in order to achieve climate goals, based on the objectives of Agenda 2030. This way, more incentives will be needed. Brazil has one of the largest and most successful biofuel programs in the world, including cogeneration of electric energy from biomass. The increase in the share of renewable energy sources in the Brazilian energy matrix will certainly pass through this important energy source. In order to consolidate these forecasts, it is necessary to work jointly between society and HEI, seeking to consolidate sustainability in the various sectors of society, working on the construction of green buildings, and increasing energy efficiency in these establishments through educational policies, programs, and standards, which must be developed through R&D in HEIs. The strategies of UNIFAAT to implement these proposals include the insertion of sustainability proposals in the curriculum of its different courses and areas of research. However, the resizing of an energy matrix, for a totally green matrix, does not occur immediately; it will only be possible through R&D, along with normative agents in partnership with HEIs and society.

Cross-References

▶ Bio-Construction Potential for Sustainability in São Paulo, Brazil
▶ Dimensions of Sustainability Ranking

- ▶ Energy Management and Sustainable Development
- ▶ Importance of Sustainability Indicators

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