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## SOLAR ENERGY AS A SUSTAINABLE DEVELOPMENT FACTOR

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# SOLAR ENERGY AS A SUSTAINABLE DEVELOPMENT FACTOR

# ENERGIA SOLAR COMO UM FATOR DE DESENVOLVIMENTO SUSTENTÁVEL

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**ABSTRACT:**

This article examines the possibility of using solar energy as a viable alternative, necessary to diversify the country's energy matrix under the potential the Northeast presents. The approach is made with a view to highlighting clean and renewable energy and a global effort to preserve the environment, embodied in treaties and legal instruments of International Law. The central core is the idea of sustainability. The methodology approach is qualitative, in which legal and doctrinal surveys will be used in the legal literature. The text is divided into an introduction that gives an overview of the subject studied, then subdivided into 3 (three) specific topics that discuss the search for alternatives to the Brazilian energy matrix, considering about solar energy and, finally, the regulation of that energy. In the research, the economic viability is verified when the installation expands through this energy matrix, as well as the incremental benefits generated to the environment, in addition to the cost savings in the productive sector.



**Keywords:** Solar energy. Sustainability. Sustainable development. Energy matrix.

**RESUMO:**

O presente artigo examinar a possibilidade da utilização da energia solar como uma alternativa viável e necessária a diversificação da matriz energética do país, tendo em vista o potencial da região Nordeste. A abordagem é feita numa perspectiva de destacar a energia limpa e renovável e o esforço global da preservação do meio ambiente, consubstanciado em tratados e instrumentos jurídicos de Direito Internacional. Tendo como núcleo central a ideia de sustentabilidade. A abordagem metodológica aponta-se qualitativa, na qual se utilizará de levantamento legal e doutrinário na literatura jurídica. O texto divide-se em uma introdução que dá um panorama geral acerca da temática estudada, em seguida se subdivide em 3 (três) tópicos específicos que discutem a busca por alternativas para a matriz energética brasileira, considerando acerca da energia solar e, finalmente, a regulação dessa energia. Na pesquisa, constata-se a viabilidade econômica quando da expansão da instalação por essa matriz energética, bem como benefícios incrementais gerados ao meio ambiente, além da economia dos custos no setor produtivo.

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**Palavras-chave:** Energia Solar. Sustentabilidade. Desenvolvimento sustentável. Matriz energética.

## INTRODUCTION

The Federal Constitution of 1988 foresees the possibility of hydraulic energy potential, in order to understand that renewable energy can be contemplated in this context. This interpretative expansion derives from a teleological analysis of the constitutional text in the face of the pressing need for sustainable energy alternatives, in which the environment and energy are interacted, as the country's developmental forms.

It is worth mentioning that human and economic activities have gained impulses for growth with the collaboration of the capitalist system. A society of consumerist standards was established that reflected in the use of natural resources for the production of goods to serve, precisely, this consumer society. The use of electric energy in this industrialization process stands out.

From the first scientific discoveries on electric energy, among which the memorable and pioneering researches by the philosopher Tales de Mileto, and, until the beginning of its use in the productive sectors of civilizations, electric energy has always been a factor that has led to development both in economic and social fields. Nowadays, technological advances have boosted human activities that made them dependent on energy.



The role played by access to electricity, as well as its generation, distribution and transmission, materialized in the possibility of economic development in the productive sectors, including, although to a lesser extent, locations further away from large urban agglomerations. The development of activities impacted by access to energy sources has led to the pursuit and development also of forms to obtain energy, evidenced by the evolution of alternative energy production.

Energy alternatives matter in the aspect of life in society from the perspective of sustainability, guaranteeing the well-being of present and future generations. This guarantor development cannot be restrictive, that is, it must reach economic, environmental and social aspects. On this issue of sustainability, it triggers the economic aspect together with the need of preserving the environment.

A first initiative in the construction of environmental protection standards was given by the implementation of the United Nations Conference on the Human Environment, in Stockholm, in 1972. In fact, this event represented a milestone in International Environmental Law with proposals to consolidate principles for the purpose of preserving and protecting the environment. It is worth mentioning that the questions about the preservation of the environment in view of the degradation caused by the advancement of economic activities started to be gradually inserted in the direction of the evolution of technologies, in order to minimize the impacts and make the activities aligned with the concept of sustainable development. It is noteworthy that the scarcity and finitude of more traditional energy resources, such as coal, and oil, directed the development of the energy sector within the technological field. In this context, the advancement of technology has led to research of alternative forms of energy generation, among which stand out the derivative of the wind, biomass and solar sources.

It is possible to affirm that we are starting a new disruption, given that in the search for a more economical energy matrix, with less polluting effects and causing the least impact on the ecosystem. This proposal can be materialized in the long term, gradually, through

the planning of alternative energy matrixes considered renewable. The energies derived from alternative sources for being clean, renewable, and available in abundance in Brazil, appear as a path that will invariably be followed in changing the composition of our energy matrix.

One of the most promising alternatives is the energy from the solar source, precisely because of the climatic and geographical condition of Brazil. The abundance of solar irradiation, considering the most relevant solarimetric indices for the exploitation of this energy source, Brazil can be considered as one of the major beneficiaries of the expansion of this matrix. The increase in this source stands out especially due to the potential of these indexes in territories with prospects for the development of economic activities, such as those in the states of the Northeast region.

Solar energy then starts to stand out, in this scenario, as a promising option in the composition of the Brazilian energy matrix with the potential to generate sustainable economic development, varying with the degree of investments, incentives and promotion, both in the public and private sector. Among the characteristics that enable the potential for growth and development of the solar power generation market, especially photovoltaic, we mainly list: (i) the levels of solar irradiation in the Brazilian territory, higher than in countries where the use of solar energy it is more explored, (ii) availability of land in areas with excellent levels of incidence of solar radiation; and (iii) high availability of the raw material used in the production of photovoltaic cells, that is, silicon - extracted from quartz, being Brazil one of the largest world reserves of this ore.

The research method predominantly used will be the deductive method, with the predominantly used research technique will be the bibliography review.



## 1 SUSTAINABLE DEVELOPMENT AS A GOAL TO BE ACHIEVED

The principle of sustainable development was echoed from the Stockholm Conference and established a standard of respect for the environment, which advocated for meeting the needs of present generations, also guaranteeing the future one to fulfil their aspirations. This principle aims to make the process of economic development compatible with the preservation of natural resources, in order to guarantee life on Planet Earth.

It is certain that its content has, over time, improved. Nevertheless, it maintains a constant and immutable core that consists on the need to always seek a balance, giving the man of the present the obligation to guarantee a balanced relationship with his surroundings, both to safeguard his own life, and the life of generations to come. This search for balance that permeates the relationship between human beings and their surroundings makes it necessary to find real mechanisms that must be present in the daily life of the human species. Such daily pursuit compose sustainability. Having a sustainable posture, therefore, means seeking a balanced relationship with the surroundings on a daily basis. For this reason, sustainability must be viewed under a multidimensional bias, in order to allow this balance to extend to all areas of human life.

The starting point for awakening ecological awareness was raised, unequivocally, with the Stockholm Conference in 1972, which drew attention to the importance of international cooperation in matters related to the environment (COMPAGNONI, undated). From it, it was observed at the international level that there was a problem, in a greater or lesser extent, in all countries whose proportions could not be assessed individually by each member of the international community, but to be understood from a global perspective.

According to Le Prestre (2000), the conference was held to address four factors that influenced the environmental society at the time: the increase and importance of the scientific community, who were beginning to question the future of the planet; the climate change and the quantity and quality of water; the increased exposure, by the media, of environmental disasters (oil spills, disappearance of wild territories, changes in the landscape), generating greater questioning by society about the causes and solutions for such disasters; and the unrestrained growth of the economy, and consequently of cities, which have grown with no planning for the future; other environmental problems such as acid rain, pollution of the Baltic Sea, large quantities of heavy metals and pesticides.

The result of this international meeting led to the elaboration of a legal framework for the protection of the environment with the enunciation of principles that, later, were moulded in the Constitutions. These principles came into force and served to instigate the preservation of the environment, in which the protectionist responsibility for natural resources rests with States and society.

In this sense, the United Nations (UN) formally positioned itself on sustainability, in 1987, in the report Our Common Future, in which it was recommended to hold a world conference to address the environmental issue: Rio-92. In that report, the following was stated:

> Many of us live beyond ecological resources, for example, in our energy consumption patterns. At the very least, sustainable development should not jeopardize the natural systems that sustain life on Earth: the atmosphere, waters, soils and living beings. In essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are in harmony and reinforce the current and future potential to satisfy human aspirations and needs. (UN, 1991, p. 49).



The concept of sustainable development revealed the premise of seeking a balance between meeting present needs and the viability of existence for future generations. This idea of sustainability, born at the end of the 20th century, made clear the insolvency of the economic growth model adopted until then and emphasized that it was not able to ensure the qualitative development of human beings (COELHO; ARAÚJO, undated). Based on these premises, it is possible to affirm that sustainable development is a development model that recognizes the need to combine economic growth with the preservation of environmental resources. In turn, sustainability reveals the necessity of fulfilling human daily life for a conscious society. Bearing in mind that sustainability materializes the sustainable development model, it must be comprehended from systemic perspective, from a social, economic, cultural, political and environmental perspective.

Regarding this argument, the Supreme Court ruled on the issue of national development (CF, art.3, II) and the need to preserve the integrity of the environment (CF, art.225

> The principle of sustainable development as a factor of achieving the right balance between the requirements of the economy and ecology. The principle of sustainable development, in addition to being imbued with an eminently constitutional character, finds legitimate support in international commitments undertaken by the Brazilian State. It represents a factor of the right balance between the requirements of the economy and those of ecology, subordinated, however, to the invocation of this postulate, when a situation of conflict between relevant constitutional values, to an unavoidable condition, the observance of which does not compromise or deflate the essential content of one of the most significant fundamental rights: the right to preserve the environment. It translates into the common use of generality of people, to be safeguarded in benefit of present and future generations.
> [ADI 3,540 MC, rel. min. Celso de Mello, j. 1-9-2005, P, 3-2-2006 DJ.]

From an economic point of view, it is characterized as the search for a balance between the use of natural resources and the production of wealth. In the environmental conception, the idea of sustainability elicits the preservation of natural resources for present and future generations. Sustainable, therefore, is something that remains balanced over time from a dynamic, multidimensional and collective perspective. (COELHO; ARAUJO, undated).

The Brazilian Constitutional Text, the constituent legislator highlighted the collective responsibility for achieving sustainability from a systemic perspective, recognizing that it is the duty of the entire community to defend and preserve the environment for present and future generations. This conception is also expressed in the Sustainable Development Goals (SDGs) and, with regard to energy, predicted in Goal 7, that countries should "ensure reliable, sustainable, modern and affordable access to energy for all" (UN, 2015). To achieve this goal, it is necessary to: a) ensure universal, reliable, modern and affordable access to energy services; b) considerably increase the share of renewable energies in the global energy matrix, and c) double the overall rate of improvement in energy efficiency. In addition, countries are expected to adopt such measures by 2030, such as: strengthening international cooperation to facilitate access to clean energy research and technologies, including renewable energies, energy efficiency and advanced and cleaner fossil fuel technologies, and promoting investment in energy infrastructure and clean energy technologies. (UN, 2030).

The objectives listed by the aforementioned international body make it clear that the need to foster renewable energy is an issue that runs through not only the issue of ecological sustainability, but also evokes a social aspect, namely, that of ensuring affordable prices for energy services. Renewable energies can represent sources of cheaper energy and, therefore, more accessible from the cost point of view, especially with regard to the object of analysis in this article, which is solar energy whose source is abundant in the Brazilian territory. Thus, what is observed is that the theme related to renewable energies evokes a social issue to which Brazil must be aware, in order to be able to reach the SDGs proposed by the UN.



## 2 THE SEARCH FOR ALTERNATIVES FOR THE BRAZILIAN ENERGY MATRIX

In the understanding of Gonçalves (2016, p.88), the role of energy in the energy matrix includes a substitute and complementary role for renewable energies. In this sense, renewable energy is used as a new energy provider for activities previously captive or simply wearer of other energy sources due to depletion, lower costs and greater economic efficiency when viewed from a substitute perspective. In the complementary question, renewable energy may add viable alternatives to the energy matrix made available to society (XAVIER; LANZILLO, 2010).

The energy matrix is considered as the set of energy sources available for use in the economic, social and human activities of society. When it comes to the energy matrix, it encompasses the generation and use of energy in various forms, such as: electrical energy, but in mechanical, thermal, chemical, nuclear energy, among others.

The diversification of the Brazilian energy matrix finds one of its historical moments, in the edition of Constitutional Amendment No. 1 of 1969, which aimed to bring a profound reform to the 1967 constitution, during the period of military governments, but specifically with regard to energy matrices. It highlighted the possible path of diversification of the national energy matrix, by providing and mentioning, in a pioneering way, other energy sources:

> Art.8thit is within the power of the Union
> [...]
> XVII - legislate on:
> [...]
> i) water, telecommunications, postal service and energy (electric, thermal, nuclear or any other);

In the field of "Energy Law", it should be emphasized that this mention made with the wording given to clause "i" of item XVII of art. 8 of the Federal Constitution, is endowed with a very expressive symbolism, once no other constitutional text had mentioned the forms of energy generation as the electric, thermal, and nuclear energies were expressly listed, recognizing the constitutional legislator yet, that the technological advance could bring the possibility of generating energy in other ways. In this sense, when dealing with the specific provisions for the energy sector, despite not having reserved a special topic to the theme, kept a relevant concern with the diversification of the national energy matrix, in favour of sustainable development and a productive technological market.

The 1988 Constitution, on the other hand, dealt with energy sources, specifically nuclear energy, oil products and hydroelectric power. It is worth observing that energy from other sources that could be developed and viable with the advancement of technology, notably renewable ones. As recommended by the Federal Constitution in § 4 of art.176, in which it recommends the non-dependence on authorization or concession for the use of the reduced capacity renewable energy potential. There is a legislative perspective, since no other constitutional text has mentioned renewable energies, even in a generic way.



Aware of these technological opportunities, the constitutional legislator, especially after the issuance of Constitutional Amendment 85, of 2015, demonstrated that the State in the role of economic inducing agent will prioritize innovation in order to promote the well-being of all, as well as national progress. Thereby, the 1988 Constitution thus provides:

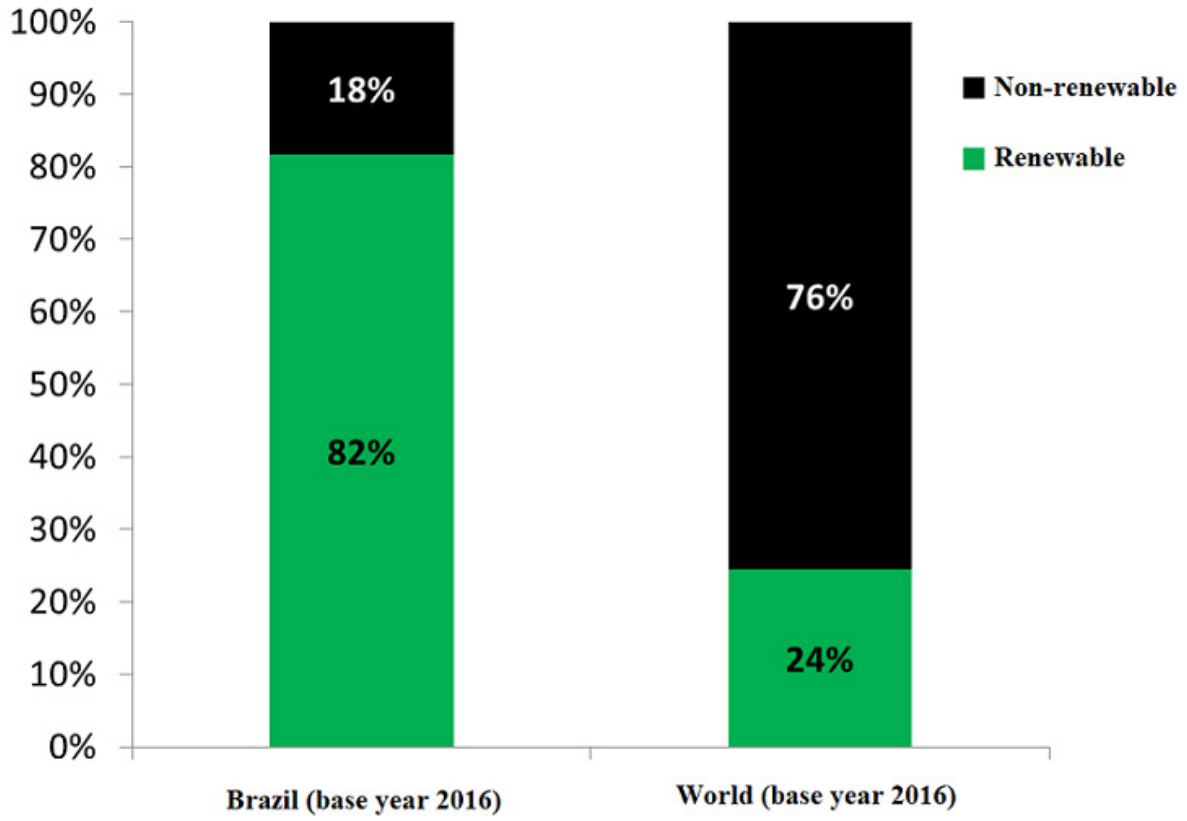
> Art.218 The State shall promote and encourage scientific development, research, scientific and technological training and innovation.
> § 1 Basic and technological scientific research will receive priority treatment from the State, in view of the public good and the progress of science, technology and innovation.
> § 2 The technological research will mainly focus on the solution of Brazilian problems and on the development of the national and regional productive system.

In this sense, the system being more opened for innovation in the energy field, adopted in the Federal Constitution of 1988, has played a fundamental role in the strategic direction of this sector and the country's sustainable development. This will provide a position of advantage for Brazil in fulfilling its international obligations regarding the reduction of greenhouse gas (GHG) emissions. This alignment is consistent with the current stage of the concept of sustainability, focusing its provisions on encouraging renewable energy sources, and also on the issue of energy efficiency (TAQUES; LOPES, 2016).

In line with the notion of sustainability, there is a gradual decarbonisation and replacement by the electrification of energy matrices. This scenario places Brazil in a very favourable position in relation to the world average indexes, mainly due to the availability of natural resources. Consequently, it allows the expansion and diversification of the Brazilian energy matrix to develop from renewable energy sources, such as the hydroelectric plant derived from Small Hydroelectric Plants (PCH, in the Portuguese acronym) and from biofuels, respectively from wind and solar sources.

When comparing data from the Brazilian Electric Matrix and the average of the World Electric Matrix, the numbers of the Brazilian energy sector are quite significant.

Comparison - Brazilian Electric Matrix Vs. World Electrical Matrix




Source: Energy Research Company (BEN 2018).



According to the graph, 82% (eighty-two percent) of the Brazilian electrical matrix comes from renewable sources, while the world average represents only 24% (twenty-four percent) of its electrical energy derived from renewable sources. That number is extremely favourable to Brazil. It is explained, mainly, by the hydroelectric potential and investments in infrastructure in the electric sector boosted from the 40s of the last century, aiming to meet industrial growth.

The counterpoint to the Brazilian hydroelectric potential is that although only one third of this potential has been exploited, that is, there is still 70% of this potential not yet used, mainly in the Amazon and *Cerrado* biomes. Therefore, it becomes an obstacle to an eventual movement of expansion of hydroelectric energy in the country, considering the environmental impact caused by the construction of hydroelectric plants (EPE, 2007).

One of the points to promote the use of renewable sources is the incentive through public and private investments, since Brazil is also promising in the field of wind and solar energy. Within the scope of public power, the State has the role of inducing economic agent seeking to direct the Brazilian electricity sector to attract private investors, and, therefore, assume the sector's regulatory function. The private sector should have market conditions with open investments and regulatory standards that provide public development policies.

The energy sector must pursue economic and social objectives as instruments to stimulate the production of energy diversity. Adopting the strategy that solar energy can occupy the space in the Brazilian electrical matrix of that 18%, today occupied by non-renewable sources. In this case, there would be an expansion of the sustainability capacity of the Brazilian electric sector, that is, following this strategic option, the equation of the

Brazilian energy matrix would tend to become even more sustainable. According to Pereira (2017), "the Northeast region has the greatest solar potential, with an average value of the daily total of global horizontal irradiation of 5.49 kWh/m² and the normal direct component of 5.05 kWh/m²". The Southeast and Midwest regions present daily totals close to the global horizontal irradiation around 5.07 kWh/m². These indexes place Brazil as one of the greatest potentials for exploiting solar energy in the world.

## 3 BRIEF CONSIDERATIONS ABOUT SOLAR ENERGY

According to Amado (2017, p. 873), "the word energy it means force in action, it cannot be created or destroyed, but only captured and transformed. In turn, energy sources are elements or bodies that contain or transform energy, as the sun and hydroelectric plants".

Energy sources are classified as renewable sources, which are those that are not exhausted, that is, they can be renewed, as the sun and wind. Non-renewable sources, on the other hand, are those that run out, as fossil fuels, which, once the planet's capacity to supply it has been exhausted, will no longer be able to produce energy through it.

However, the greatest source of energy that exists on the planet, emanating from it almost all other sources of energy, is undoubtedly the sun (SIRVINSKAS, 2018, p. 444). The discovery of energy by solar radiation comes from the experiments of the French physicist Edmond Becquerel[4], to whom the discovery of its origin is attributed, when first observed the photovoltaic effect, in 1839, of the 19th century.



For a long time, solar energy was seen as a very futuristic and expensive energy, which would not be used in general. It is worth noting that in the 50s, the American chemist Calvin Souther Fuller developed a silicon doping process and with the advance of experiments he managed to produce and present the first solar cell[5].

The direct conversion of solar energy into electrical energy occurs due to the effects of radiation (heat and light) on certain materials, particularly semiconductors. Among these, the thermoelectric and photovoltaic effects stand out. The first is characterized by the appearance of a potential difference, caused by the joining of two metals, under specific conditions. In the second, the photons contained in sunlight are converted into electrical energy, through the use of solar cells. (ANEEL, 2015).

Nowadays, with the global need to produce more and more energy from renewable and clean sources, due to the international commitments of nations to reduce their emissions of polluting gases, solar energy has received investments from large private corporations. Sirvinskas (2018, p. 433), describe how some large global companies are attentive to investing in renewable energy:

> Google is building a giant solar plant - the Ivanpah Solar Electric Generating System. It is located in the Mojave Desert of Southern California and is the largest solar plant in the United States. It will have the capacity to generate enough electricity to supply 140 thousand homes. Alone it will increase the production of solar energy in the USA by 60%. The investment was US$ 2.2 billion and was partnered by the companies BrightSource and NRG Energy. The plant occupies an area of 1,300 football fields with 346,000 mirrors.

4 SUPERIOR TECHNICAL INSTITUTE.Universidade Técnica de Lisboa. **Brief History of Solar Energy**. Available at: < http://web.ist.utl.pt/palmira/solar.html > Accessed on: Feb. 13, 2019.

5 SOLAR PORTAL. History of solar energy: how it all started. Available at < https://www.portalsolar.com.br/blog-solar/energia-solar/historia-da-energia-solar-como-tudo-comecou.html > Accessed on September 22, 2019.

This concern with the sustainability of the energy sector in other countries is also related to the gradual increase in the consumption of electric energy driven by the increasing dependence of everyday life on the use of equipment such as smartphones, tablets, smartwatches, and notebooks, among others. Google and Facebook alone consume more energy than some small countries (SIRVINSKAS, 2018 p. 432).

It is also worth remembering that in a relatively medium term, electricity consumption will be strongly impacted by the transport sector due to the prospect of replacing fossil fuel vehicles with electric cars. This process has already started in some countries, and it remains to be seen whether the refueling of these vehicles will be done at gas stations. Currently, in the users' own homes, which would reflect a change in social habits and certainly a positive impact on the market for electricity generation from the solar source.

In Brazil, although not receiving investments of the magnitude of other countries where solar energy is more widespread, such as the United States, China, Germany, Spain and Japan, there is a tendency to expand the renewable energy generation market in Brazil. In this sense, according to Silva (2015, p. 29), the prospect of expansion of wind energy is also an opportunity for growth in solar energy since wind and solar energy can operate in a complementary regime. The two have the characteristic of being intermittent, that is, one generates more energy at night (wind) and the other produces its energy during the day (solar).

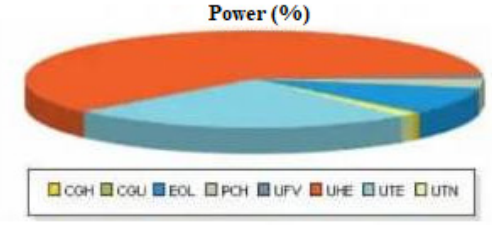
The *Renova Energia* company, one of the leaders in wind energy in Brazil, announced the start of construction, still in 2014, of the first hybrid complex for the generation of solar and wind energy in Brazil (SILVA, 2015, p. 29). This expansion trend is confirmed by ANEEL in data provided by its Generation Information Bank (BIG, in the Portuguese acronym)[6], which informs that of the power generation projects, among all sources within the "in operation" status, the Central Photovoltaic Solar Generator (UFV) represent 1.21% of the total, while that of the projects "under construction" in the country, the Central Photovoltaic Solar Generator (UFV) type represents 5.61%. Subsequently, the data of the projects "in operation", of the type Central Photovoltaic Solar Generator (UFV) now represent 1.36% of the total, whereas of the projects "under construction" increased to 8.7%, as shown in Figures 1 and 2, with information obtained on February 11, 2019 and September 27, 2019, respectively, in UFV type.



Figure 1.Generation Information Bank (BIG) - Projects in Operation

| Projects in Operation | | | | |
|---|---|---|---|---|
| Type | Quantity | Granted Power (kW) | Supervised Power (kW) | % |
| CGH | 713 | 744.410 | 744.224 | 0,45 |
| CGU | 1 | 50 | 50 | 0 |
| EOL | 618 | 15.163.989 | 15.145.093 | 9,06 |
| PCH | 425 | 5.277.049 | 5.232.466 | 3,13 |
| UFV | 3.052 | 2.267.679 | 2.267.554 | 1,36 |
| UHE | 217 | 102.932.608 | 100.834.417 | 60,32 |
| UTE | 3.022 | 42.492.255 | 40.948.974 | 24,5 |
| UTN | 2 | 1.990.000 | 1.990.000 | 1,19 |
| Total | 8.050 | 170.868.040 | 167.162.778 | 100 |

**The percentage values refer to the Supervised Power. The Granted Power is equal to that considered in the Granting Act. The Supervised Power is equal to that considered from the commercial operation of the first generating unit.**

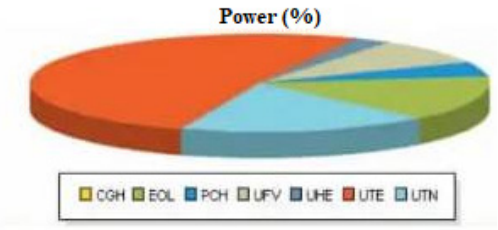



Source: Aneel

6 ANEEL. BIG – Banco de Informações de Geração. Updated on 11/02/2019. Available at: < http://www2.aneel.gov.br/aplicacoes/capacitybrasil/capacitybrasil.cfm > Access on Feb 11, 2019 and Sep 27, 2019).

Figure 2.Generation Information Bank (BIG) - Projects under Construction

| Projects under Construction | | | |
|---|---|---|---|
| Type | Quantity | Granted Power (kW) | % |
| CGH | 4 | 8.512 | 0,11 |
| EOL | 54 | 1.116.360 | 14,89 |
| PCH | 28 | 349.829 | 4,66 |
| UFV | 24 | 652.496 | 8,7 |
| UHE | 2 | 177.900 | 2,37 |
| UTE | 83 | 3.844.736 | 51,26 |
| UTN | 1 | 1.350.000 | 18 |
| Total | 196 | 7.499.833 | 100 |




Source: Aneel

## 4 THE CURRENT REGULATION OF ENERGY GENERATION BY THE SOLAR SOURCE IN BRAZIL

As already mentioned, Brazil since the beginning of this 21st century has been going through several legislative revisions in its legal framework regarding energy aiming at the optimization of this sector. That added to the environmental concern due to some energy crises of significant proportions and countless deleterious consequences.

Since then, the powers of the Republic have endeavoured to find solutions to the problem, revising and modernizing legislation, as well as encouraging investments in alternative energy generation in order to diversify the energy matrix and perfecting the planning of the energy sector as a strategic sector for the country's economy. Among the legislative changes that deserve to be highlighted is Law No. 10,295 of October 17, 2001, which provided for the National Policy for Conservation and Rational Use of Energy, aiming at both the efficient allocation of energy resources and the preservation of the environment.



Several other actions were taken by the public authorities, among them the creation of programs such as the "Alternative Energy Sources Incentive Program" (PROINFA), which, despite not mentioning solar energy, sought to increase the participation of electricity produced by independent producers, based on alternative sources, among other provisions of Law No. 10,438/02.

The Electricity Commercialization Law, No. 10,848, of March 15, 2004, also introduced provisions in order to include in the regulation of the commercialization of energy that produced by alternative sources, as it did in items II and III of §5 of art. 2, of which we quote the text:

> Art.2. The Concessionaires, permit holders and authorized service providers for the electricity distribution of the National Interconnected System - SIN shall guarantee the service to the entire market, by regulated contracting, through bidding, according to regulation, which, observing the guidelines established in the paragraphs of this article, will provide on:
> [...]
> § 5 The bidding processes necessary to comply with the provisions of this article shall include, among others, treatment for:
> [...]
> II - energy from new generation projects; and
> III - alternative sources.

There is a gradual insertion of alternative energy generation in the regulation of the electricity sector, which may encourage investors in this sector to increasingly seek to influence State planning decisions, and on the other hand, it will demand from the government greater attention. With regard specifically to solar energy, Nascimento (2017, p. 27) points out that the edition of the Normative Resolution from ANEEL No. 482, of April 17, 2012, as follows:

> In 2012, ANEEL took a major step towards expanding the generation of solar photovoltaic energy in consumer units by editing the Normative Resolution from ANEEL No. 482, of April 17, 2012. It establishes the general conditions for the access of microgeneration and mini-generation distributed to the systems of electricity distribution, creating the energy compensation system, in which the energy produced in the grid is injected back to the grid, and this mount is deducted from the consumption of the unit itself or of another of the same owner.

From this milestone, the distributed generation of photovoltaic solar energy began to advance in the country. According to Nascimento (2017, p. 29), there is a great growth in the number of consumer units with photovoltaic panels from 2014, reaching a total of 8,818 units and 67 MWp of installed capacity by February 2017. In accordance with ANEEL[7], the most used source for micro and mini-generation distributed by Brazilian consumers, is the photovoltaic solar, with 82,600 micro and mini plants and about 870 megawatts (MW) of installed power. That is, in a period of 28 months, there was an increase of approximately 936% in the number of consumer units derived from micro and mini-generation distributed. This is equivalent to an average of 2,635 new consumer units with generation of energy from photovoltaic panels.

The insertion of solar energy in the Brazilian electrical matrix is a precursor to the enactment of Law No. 10,438, which created, among other measures, the Incentive Program for Alternative Sources of Electric Energy (PROINFA), aiming at increasing the participation of alternative sources in energy generation produced nationally. This program, which initially did not contemplate solar energy, was the "driving force" for the development of alternative energies, giving impulse initially to the expansion of wind energy.



It should be noted that only with the edition of Normative Resolution No. 482 of April 17, 2012, by ANEEL, solar energy had a greater chance of expanding and really becoming a viable energy alternative. This Resolution encourages a tendency to reduce prices in the cost of equipment used in the installation of energy generation systems using the solar source, providing an increase in the generation of solar energy, although it still does not represent a significant percentage of the Brazilian energy matrix.

According to the release of BP Statistical Review of World Energy 2019, (2019, p. 52) Brazil achieved a percentage growth of 277.1% (two hundred and seventy-seven point one percent) in its solar generation only from 2017 to 2018, going from 0.8 Terawatt/hour in 2017 to 3.1 Terawatt/hour in 2018. To exemplify the growth potential of this sector, it is enough to mention the case of Chile, which despite having a much smaller territory than Brazil, has a generation capacity of 5.1 Terawatt/hour of electric energy from the solar source. It should be added that, despite the large percentage of growth from 2017 to 2018, the generation of energy by the solar source in Brazil still has a percentage far below its potential. Solar energy accounts for only 1.3% of the Brazilian electrical matrix, according to ANEEL/ABSOLAR.

In the next decade, according to EPE (2018 p. 219), the 2027 Ten-Year Energy Expansion Plan predicts that there will be an increase of 7.5 GW with the implementation of plants

7 ANEEL. Brasil exceeds 1 GW in distributed generation. Posted on Jun 112019. Available at: < http://www.aneel.gov.br/sala-de-imprensa-exibicao/-/asset_publisher/XGPXSqdMFHrE/content/brasil-ultrapassa-marca-de-1gw-em-geracao-distribuida/656877 > Accessed on: Sep. 27, 2019.

planned mainly in the Northeastern semiarid. This region, according to the aforementioned estimate, should receive 80% of the amount of this expansion in 10 (ten) years.

In this sense, the last factor that should impact and enable this expected expansion of energy generation by the solar source is the economic one. In fact, the biggest obstacle to further growth in solar energy is costs. That is why it is extremely relevant to induce initiatives such as that of the current federal government that has been promoting auctions aimed at selling electricity by solar plants and taking action, such as, for example, the first floating solar plant in the Sobradinho hydroelectric reservoir, in Bahia. It is currently the largest power generation project in this situation and may open the opportunity for projects of this nature in other reservoirs of hydroelectric plants, which are extremely favourable due to the non-occupation of areas on the ground and the possibility of using the existing transmission network.

Another factor that if favoured with public policies of incentive and the exploitation of the potential is the development of a national industry of photovoltaic cells production, since these are manufactured with the use of silicon as a masterpiece, and Brazil has one of the largest reserves of that material. This would reduce the costs of acquiring solar panels that are currently imported mainly from China, since in Brazil there is no technology for manufacturing photovoltaic cells. One of the forms of incentives would be taxation, since it is a decisive economic factor for attracting investments to the sector, together with the promotion through financing by incentive agencies.



## 5 FINAL CONSIDERATIONS

The implementation of power generation from renewable and clean sources has attracted the sympathy of the global community, given that concerns about the maintenance of an adequate environment for the healthy development of present and future generations are growing.

It is true that the use of energy causes significant impacts on the environment, especially for fossil fuels, which in addition to emitting more polluting gases are also finite and distributed in the world quite unevenly, as is the case of oil and natural gas (GOLDEMBERG, 2015). In this context of environmental and economic concern, solar energy has emerged as a promising alternative to the solution of the issue of degradation and availability, as it is more inclusive and tends to cause a greater disruption in the established energy market, consecrating the traditional popular saying "the sun is for all".

In Brazil, the photovoltaic solar energy market has experienced excellent growth, although it still occupies a very small percentage in the electrical matrix and even lower in the country's energy matrix. The impediment factor is still found in the acquisition costs of equipment for power generation. But these costs have not discouraged the market, which continues to expand rapidly, given that it still has a lot of space to conquer. In addition, the fall in prices is a reality that has caused more and more people and companies to have access to the so-called distributed generation.

The legal system comes along a historical process, started at the beginning of the century with the electrical crises of 2001 and 2002, undergoing changes that have increasingly allowed the diversification of the national energy matrix and increasingly the diffusion of renewable energies. As PROINFA, the regulatory legislation, in particular edited by ANEEL, which promoted the expansion of solar energy. This new form of energy generation, in particular state agencies and entities is also attracting institutions.

Solar energy is a new opportunity that presents good prospects around the world, requiring only a promotion plan to be induced in the country due to its geographic and climatic situation, which has a potential above the world average for exploring energy generation through the Sun. Additionally, besides having abundance and regularity of sunlight, Brazil is also a major holder of reserves of the raw material of the so-called "solar plates", silicon.

Finally, it is worth noting that although sparse measures are identified, with no system of integration and joint efforts, several entities of the federation have already been enacting legislation aimed at promoting the generation of energy by solar and other renewable sources, especially in the granting of financing and tax benefits.

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