Executive summary

International Benchmarking

Expansion of Generation of Electric Power from **Renewable Sources**

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by:

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TCU

OLACEFS
ORGANIZACIÓN LATINOAMERICANA Y DEL CARIBE DE ENTIDADES FISCALIZADORAS SUPERIORES

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Expansion of Generation of Electric Power from **Renewable Sources**

Technical assistance and training for the Federal Audit Court (TCU) in relation to the monitoring of public policies in the field of renewable energies.

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DISCLAIMER

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Presentation

The current work was developed to support the activities of prior training and coordinated operational audit planning to be carried out by Supreme Audit Institutions (SAIs) in Brazil and in several countries of Latin America and the Caribbean on renewable energies. This inspection is part of the activities of the Public Works Audit Working Group (GTOP) of the Latin American and Caribbean Organization of Supreme Audit Institutions (OLACEFS).

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In the context of climate change, renewable energies have gained prominence on the world scenario.

In particular, the UN Agenda 2030, which set the Sustainable Development Goals (ODS), in its 7.2 target aims to substantially increase the share of renewable energy in the global energy matrix by 2030.

The Paris Agreement, which aims to strengthen the global response to the threat of climate change and to strengthen countries' capacity to deal with the impacts of these changes, requires each country to present its commitments to maintain the global average temperature at well below 2 ° C above pre-industrial levels, striving to limit this temperature rise to 1.5 ° C.

In this context, the experiences of other countries in renewable energies can be both inspirational in relation to best practices, but they can also "shorten the way" by exposing opportunities for improvement.

Thus, the publication contains updated information on various experiences for insertion and expansion of renewable energy participation in the electricity matrixes of 10 selected countries: South Africa, Germany, Chile, China, Denmark, Spain, United States (State of California), India, Italy and Mexico.

Therefore, it is with great satisfaction that this work is made available, as a result of the partnership of the Audit Court of Brazil with GIZ and OLACEFS, in favor of improving public management.

RAIMUNDO CARREIRO
President of TCU

1 Introduction

The "International Benchmarking Report" identifies good practices and lessons from 10 selected countries (South Africa, Germany, Chile, China, Denmark, Spain, the United States, India, Italy and Mexico) related to the expansion of electric power generation from renewable sources. In all variables analyzed, Brazil was included in order to make a permanent international comparison possible.

This report characterizes the countries under analysis, including: socioeconomic aspects, energy profile, per capita consumption, emissions, among other variables. Particular attention is paid to the presence of renewable sources in these countries, the investments made and the most relevant public policies applied to them.

The report aims to map and systematize documents with comparable methodologies, as well as to consolidate information about:

• Institutional organization of the electric sector in force in the indicated countries;

• Strategy adopted for insertion of renewable electric energy sources (especially wind, solar, biomass, tide) in the generation matrix of the indicated countries;

• Actions taken over the years, main difficulties and solutions that allowed the expansion of renewable sources in the indicated countries, observing the following parameters: evolution of the national market; subsidy policies and other applicable public policies, regulatory solutions adopted, operational challenges for insertion of renewable energy sources in the matrix, evolution and comparison of energy prices, diversification of the industrial park, evolution of the technologies used, impacts on energy security, among others;

• Status quo of the sources of electricity generation from renewable sources (in particular wind, solar, biomass, tide) in the indicated countries, specifying the current panorama of the following parameters: potential of the various sources of generation; current energy matrix, extension of the national and international market, subsidy policies and other applicable public policies, adopted regulatory solutions, remaining operational challenges, energy prices of different sources, industrial park, technologies used, among others;

• Evolution and current stage, if pertinent, of the implementation of smart grids in the indicated countries.

2 Socioeconomic characterization of countries

Among the countries selected for this analysis, the socioeconomic variety is enormous. Demographic, geographic, produced wealth (GDP) and access to electricity characteristics influence the pace of expansion of renewable energy sources and should be taken into account throughout the Benchmarking study. Figure 1 presents all these characteristics for the countries analyzed and for Brazil.

The pace of population growth among the countries analyzed also varies greatly. Population growth and economic indicators such as GDP are factors that pressure the country's energy demand. While some countries have accelerated population growth, such as India, Mexico and South Africa, other countries have experienced stagnation or even declining populations such as Italy and Spain, with a reduction of between 0.21% and 0.01% between 2015 and 2016, respectively.

While many developed countries, which usually have 100% of the population with access to electricity, seek a cleaner energy matrix driven by the international commitments made in relation to the reduction of GHG emissions, some developing countries are looking at renewable technologies as a way of increasing access to electricity such as South Africa and India, where, respectively, 14% and 21% of the population still do not have access to electricity.

2.1 ENERGY PROFILE OF ANALYZED COUNTRIES

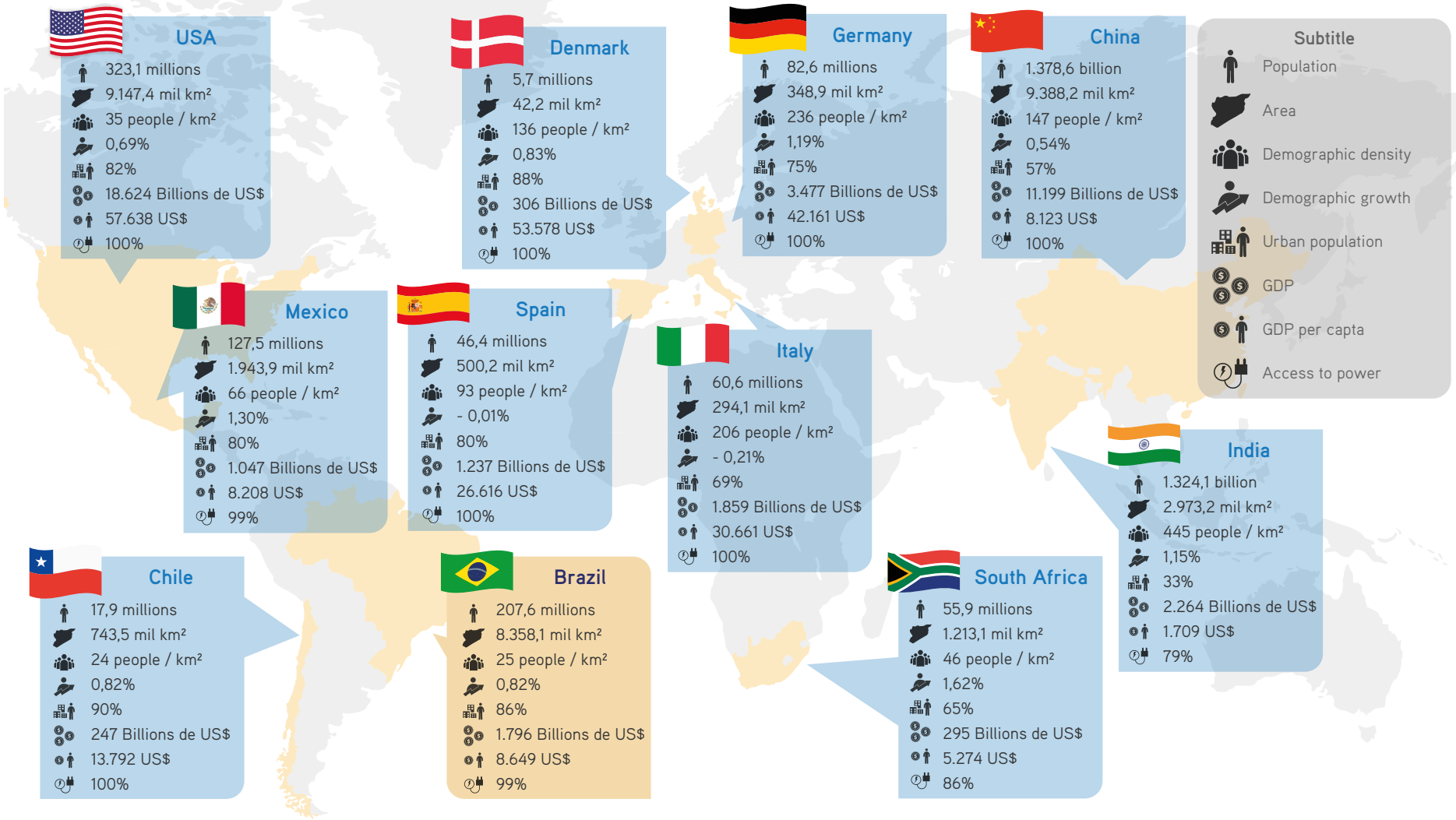
In order to define a profile for each of the countries evaluated, four indicators were calculated: Country per capita consumption; Electrical Intensity; Intensity of CO_2 emissions; and CO_2 emissions per capita.

To complement the energy profile of each country, the current participation of renewable sources and their attractiveness for investments in renewable energy were also evaluated. Figure 3 presents a consolidated profile of each country analyzed.

2.1.1 Penetration of Renewable Energy in the Analyzed Countries

When all hydroelectric dams are included, regardless of their size, Brazil has the largest share of renewables (74%), as might be expected. The country is closely followed by Denmark (65.4%), which has a very relevant wind generation capacity (BP, 2018) (IRENA, 2018).

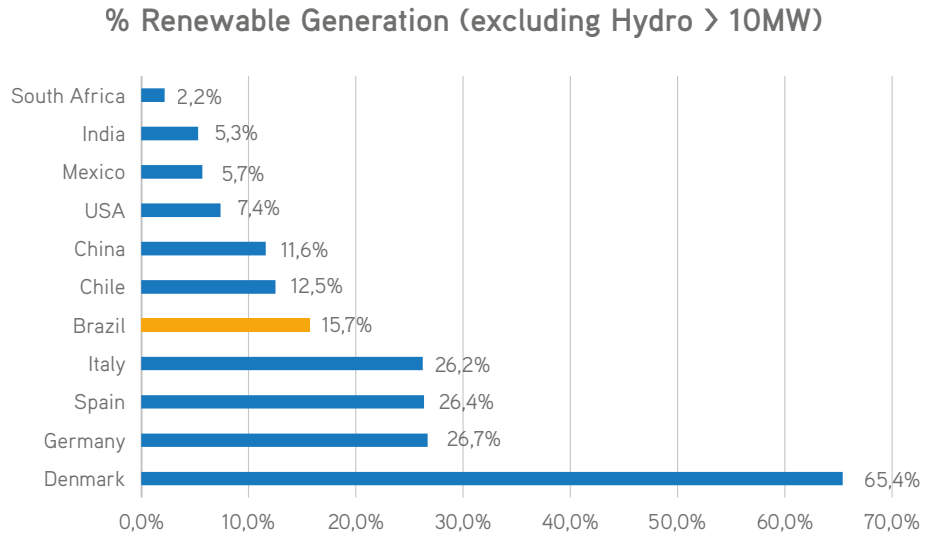
Figure 1. Socioeconomic characterization of the analyzed countries



Source: Own elaboration with data from the World Bank (2016)

Figure 2 shows the same penetration analysis, but this time hydroelectric plants above 10 MW are excluded. Brazil has a matrix based on large hydroelectric plants, going from 74% to 15.7%. Similar situation is observed in Chile. Denmark has maintained its position, as it does not have large hydroelectric plants. In this respect, Germany has a situation similar to that of Denmark.

Figure 2. % Share of renewables excluding hydro > 10MW



Source: (BP, 2018) (IRENA, 2018)

2.2 INVESTMENTS MADE IN RENEWABLES IN THE WORLD

When observing the international scenario, it is important to scale the investments that are being made and to understand in which technologies they are allocated to. This variable can indicate how the energy matrix can evolve in the long term.

Solar and wind generation concentrates most of the investments, followed by far by projects in bioenergy and hydroelectricity (<50 MW). It should be noted that global investments are affected by macroeconomic, political, regulatory and technological changes, which may vary from country to country and from year to year.

Since 2014, EY has developed the market attractiveness ranking for investments in renewable energy. The Renewable Energy Country Attractiveness Index (EY, 2017) of October 2017 evaluated the factors driving the market's attractiveness in a world where renewable energy is overcoming dependence on subsidies. The pillars of the index, therefore, place greater emphasis on fundamentals such as political stability, project delivery (including capital availability) and diversity of natural resources - factors that will become increasingly differentiating as markets move toward tariff parity of the network and that "artificial" motivations, such as government goals, become less critical. The classification of the countries analyzed is shown in the last line of figure 3 as well as the variation of the position in relation to the last ranking, of May, 2017.

The number of direct and indirect jobs offered by the renewable industry in the world is also another variable of interest. In Brazil, according to the Brazilian Wind Energy Association (ABEEólica), 15 jobs are generated for each MW of installed capacity. Denmark reported that 10% of all jobs in the industrial sector are classified as Green Jobs (Copenhagen Capacity, 2018).

There is a strong reduction in the costs of electricity generation from renewable sources of energy (LCOE). Its main motivator is undoubtedly the reduction of technology costs. The cost of the generation of the renewable energy is composed, for the most part, of the cost of commissioning the plant, since there is no purchase of fuel during its operation. With the exception of hydropower and geothermal technologies, the generation of electricity from renewable sources has become increasingly competitive.

As a general trend, prices for solar and wind energy have declined in recent years. In 2010, solar energy was contracted at an average global price of almost US$ 250 / MWh, compared to the average price of US$ 50 / MWh in 2016. Wind technology prices also fell, albeit at a slower pace - the technology was already more mature in 2010. The average price in 2016 was 40 US$ / MWh, below 80 US$ / MWh in 2010 (IRENA, 2017b).

2.3 RENEWABLE ENERGY SUPPORT POLICIES

All the countries reviewed directly support the development and deployment of renewable energy technologies through specific policies as presented in Table 1. The broad range of policies identified provides direct or indirect support to renewable energy aiming for economic development, environmental protection and energy security.

More than 100 countries officially joined the Paris Agreement, formalizing their commitments to sustainable development, often through decarbonisation of the energy sector. Among them are Chile, China, South Africa, India and Brazil. These nations have made contributions to reduce emissions of greenhouse gases, following what each government considers feasible from the local social and economic scenario.

In the European Union (EU), the Nationally Determined Contribution (NDC) covers the participation of all Member States. To achieve the NDC target, the EU has a number of internal laws and regulations. Effort-sharing legislation, for example, sets binding annual targets for GHG emissions for Member States in the periods 2013-2020 and 2021-2030[1]. This objective is expected to boost continued investment in renewables, which means, for example, that the share of renewable energy in the electricity sector would increase from the current 21% to at least 45% by 2030.

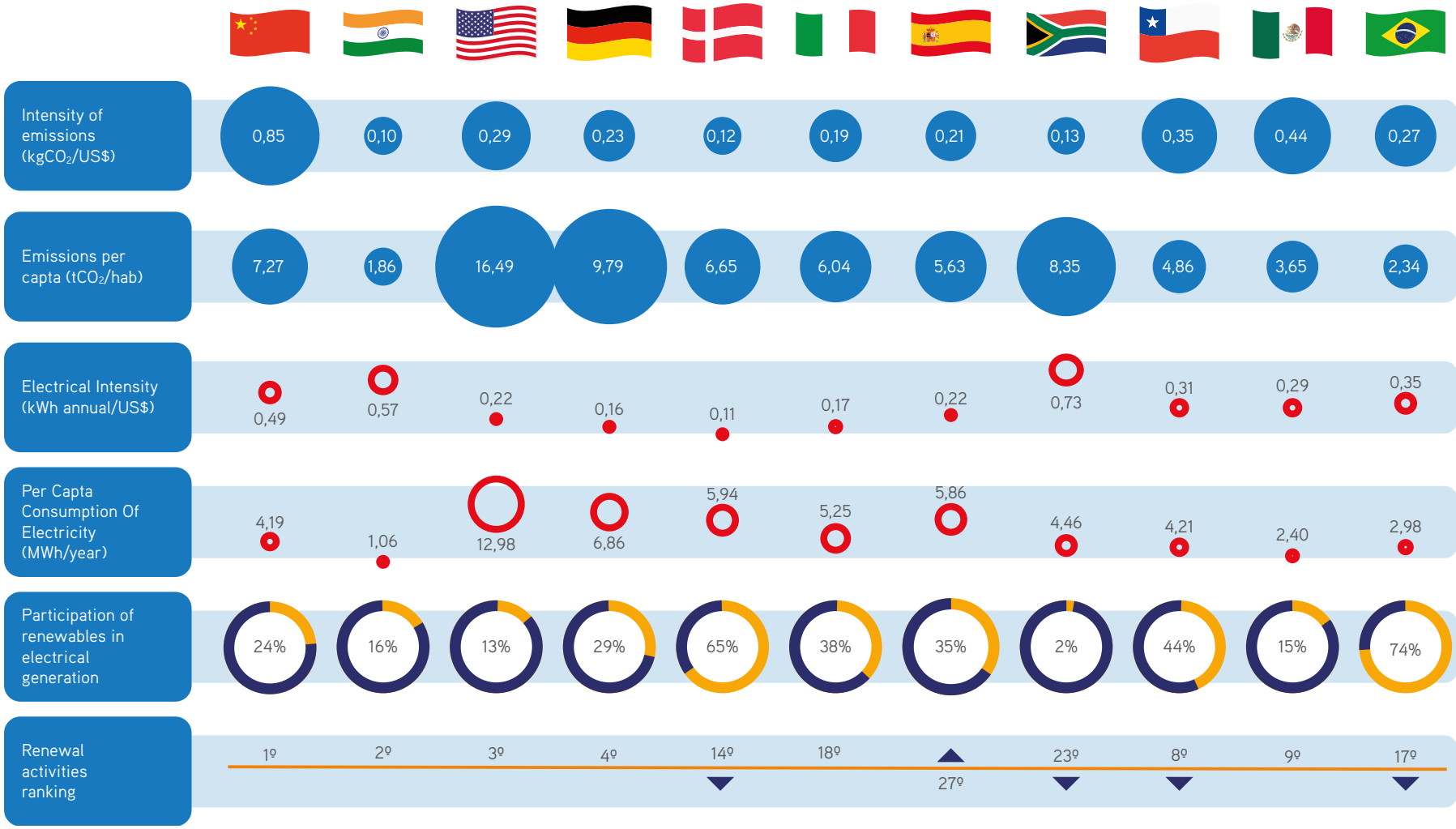
1 The targets have been described in COM (2016) 482 final of 20 July 2016 on annual mandatory greenhouse gas emission reductions by the Member States between 2021 and 2030 for a resilient Energy Union and to fulfill the commitments made under the Paris Agreement.

It should be noted that the targets for reducing GHG emissions are mandatory for Member States. However, the targets for participation of renewables, established in their individual plans, are only indications of the proposed contributions. The national plans for Germany, Spain, Denmark and Italy are aligned both with the so-called agreement (20-20-20)[2] - which aims to achieve a 20% share of renewable energy sources in the European Union's final gross energy consumption by 2020 – and with the 27% share of renewables in 2030 set by the Climate and Energy Policy Framework for the period 2020-2030[3].

2 Directive 2009/28 / EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources

3 COM (2014) 15 final of 22 January 2014 - A political framework for climate and energy for the period 2020-2030.

Figure 3. Country energy profile



Source: Own elaboration based on data from the World Bank, IEA (2015 and 2016) and worldometers (2015 and 2016), (BP, 2018), (IRENA, 2018) e (EY, 2017)

Worldwide, FIT remains the most prominent way of supporting regulatory policy for the promotion of renewable energy. However, countries around the world (especially in Europe and Asia) have begun to move away from these policies. Particularly when it comes to supporting large-scale project deployment, where this mechanism is often replaced by auction-based procurement. China, for example, reduced the value of fees by up to 19% for solar FIT, but kept FIT for unaltered distributed generation (REN21, 2017).

In addition to regulatory policies, several countries have provided public funds, through subsidized loans or tax incentives, to boost investment in the deployment of renewable energy. In early 2016, India launched a 30 per cent capital subsidy for solar photovoltaic roofing systems, supported by US$ 750 million (Rs 50 billion) to finance a new program (REN21, 2017).

Table 1. Mechanisms to Support Renewable Energy in the countries analyzed

			Regulatory Policies					
Country	**Renewable Energy Targets**	**Renewable Energy in INDC or NDC**	***Feed-in tariff (FIT)/ premium (FIP)***	**Mandatory quota for renewable energies**	***Net metering***	**Bonds for heating**	**Renewable Energy Certificates (REC)**	**Auctions**
Chile	X	X		X	X		X	H
Denmark	X		R		X		X	H
Germany	X		R			X	X	H
Italy	X		X		X	X	O	X
Spain[1]	X					X	X	H
USA[2]	R*		X*	R*	R*	X*	X*	
Brazil	X	X			R	X*		R
China	R	X	R	X		X		H
Mexico	R				X			H
South Africa	R	X		X		X		H[3]
India	R	X	R*	X	X*	X*	X	H

*X – exists at national level (can also include regional level); X * - exists at the regional (but not national) level; N - New (one or more such policies); R - Revised (one or more policies of this type); O - Removed; R * - Revised at regional level; H - Proposals made in 2016, or in previous years; 1 - Spain has removed FIT support for new projects in 2012. Incentives for projects that have previously qualified for FIT support continue to be reviewed. 2 - US state goals include RPS policies. 3 - Includes thermal energy (heating and cooling).*

Source: Own elaboration based on data from Renewables 2017 Global Status Report (REN21, 2017)

3 Lessons learned and recomendations

Solar energy finally begins to thrive in Brazil, after years of being seen, along with wind, as secondary and extravagant, including by governments that had large-scale hydroelectric power their main paradigm of energy generation. However, according to data from the EPE (2017), in 2016, only 0.01% of the electricity generated in the country came from solar sources and 5.4% from the wind power source.

There is undoubtedly a growing trend in solar PV generation, as is the case with wind power since 2009. Other renewable technologies such as tides and geothermal, however, have a less promising future in Brazil. In the exercise carried out in the report "[R] Energy evolution" (Greenpeace, 2016), it was estimated that only in 2030 the tidal power technology would become one of the major sources of electricity in Brazil. Geothermal technology has a geographical limitation due to the fact that the energy is only generated where there is intense volcanic activity, excluding the possibility of using this source in countries such as Brazil (Goldemberg, 2017).

The analysis of countries with strong use of the solar source, such as Germany, Japan, China and the United States, shows that the investments are based mainly on public policies of incentives, such as fiscal benefits and efficient regulatory mechanisms. The space for expansion of the solar sector in Brazil is gigantic. The country's solar radiation (or insolation), is only smaller than in Australia. While in Germany the irradiation rate between 900 and 1,250 KWh / m² per year, Brazil registers between 1,500 and 2,400 KWh / m².

Chile, which is almost 10 times smaller than Brazil, has higher PV installed capacity. The country uses the mechanism of mandatory quotas for renewables for concessionaires - an example that can be followed by Brazil without much difficulty. The system of penalties adopted by Chile is a way of guaranteeing compliance with quotas. It should be noted that, so far, quotas have been met with clearance. Another interesting aspect of quotas is that they can be defined by reference to the country's goals, be it national or international.

India and USA promote the installation of distributed generation, mainly photovoltaic, in government buildings, as a way to support market development and

lead by example. In the state of Delhi, India, the policy of mandatory installation of solar panels on roofs of public buildings was introduced as a way to reach the 2016 target of 35 MW of PV installed capacity on roofs (DoP of Delhi, 2016). Delhi exceeded this target reaching 35.9 MW in December 2016 (MNRE, 2017), demonstrating the effectiveness of policies like this. Similarly, Executive Order 13693 (2015) set gradual targets for the share of renewables in the US federal government's electricity consumption. With the publication of the document, the share of renewables jumped from 8.3% in 2015 to 12.4% in 2016 (DOE, 2017), surpassing the initially established 10% target.

Despite the great fear among the sector's players regarding the cross subsidies present in the Brazilian net metering mechanism, its tariff impact for consumers should be minimal. ANEEL (2017) estimates that the increase in the electricity tariff caused by the insertion of distributed photovoltaic generation would be only 1.1% on average. This would be the amount accumulated in the period from 2017 to 2024, not annual. ANEEL (2015) also reveals that, even in the scenario of greater penetration of photovoltaic systems in distributed generation, the accumulated reduction of distributors' revenues would not exceed 0.30%.

There is a latent need to periodically reassess the tariff impacts on consumers without a panel in the face of market developments. California's compensation system, for example, has gone through a long period of maturation and has been remodeled to the current Net Energy Metering (NEM). After four years of evaluation and several public consultations conducted by the California Commission of Concessionaires (CPUC), the current program brings a better balance between the interests of participating and non-participating program consumers, as the fees charged reflect the actual costs of generating systems for distribution network. These charges, charged to participants, prevent these costs from being shared among all network consumers, including those not benefiting from the NMS, as in the past.

In Italy, the FIT mechanism (onompressive tariff) and the compensation system (Scambio sul Posto) coexist, demonstrating that the two forms of incentive can be used simultaneously. This allows the state to coordinate the expansion of renewable sources in the system while providing the market with the freedom to innovate in energy storage or compensation mechanisms based on market attractiveness and the compensation system. When the market is unable to achieve the penetration desired by the government, it relies on attractive FIT rates associated with a maximum capacity limit (MW). Thus, it contracts the necessary volume to reach the planned goal.

Even with changes to the improvement of net metering in several of the countries analyzed, they all maintained the benefits for those consumers who joined the incentive programs before the policy change, as in the case of Italy and California. This avoids the judicialization of the electricity sector and provides investors with the legal security necessary for future investments, as well as contributing to the increase of government credibility in relation to future programs.

With the objective of segmenting the conclusions, recommendations and possible learning that the analyzed countries can bring to Brazil, the conclusions were divided into topics:

3.1 PLANNING

- Recover the tradition of planning of the electric sector and incorporate the strategy of renewable energies in a clear and transparent way in the tools of long-term planning, quantifying the contributions in the energy matrix by type of source;

- Define how many MW of capacity should be installed from PV solar power, wind power, biomass, heliothermal, tidal, etc. to reach the defined target for the electric sector. At the same time it should be clearly defined, what time horizon in which this new capacity should be incorporated;

- Introduce mandatory targets, and if not met, apply financial penalties;

- Distribute the national goals between the agents of generation and the large consumers, defining the obligation to attend specific percentages within a predefined time horizon;

- Define what mechanisms will be used to achieve renewable capacity targets. For example, how much of this target will be served by centralized renewable generation auctions and by renewable energy certificates, and what should be the contribution of distributed micro-generation through net metering, etc.;

- Evaluate the possibility of conducting alternative auctions to those established by EPE to allow agents that are not meeting the targets to adjust their levels of renewable generation;

- Monitor the previously established renewable targets through effective and periodic monitoring and control mechanisms. It has been observed that in several of the countries studied the renewable targets are monitored and, when not met, alternative mechanisms are used, such as additional auctions, specific by type of source;

- Evaluate the creation of an agency in energy efficiency and renewable sources that is responsible for driving these two topics in the country.

3.2 INCENTIVE ALLOCATION

Denmark, which currently accounts for 29% of its coal-based energy, works to turn Copenhagen into the first carbon-neutral capital by 2025 and to see itself completely independent of fossil fuels by 2050. To achieve the objectives, renewables have gained incentives for many years, until it could compete with more polluting sources such as coal.

The path that China has trodden is similar. Currently, 60% of the country's energy is generated by coal sources, but the signal that the government has given is clear: this participation should be reduced rapidly. In the country, there are three types of industries: the so called encouraged, restricted and prohibited. The fact that the renewable energy industries are in the first group means that, in the interest of the government, it is possible to have a simpler approval process, tax benefits, subsidies and even special financing conditions.

In Spain, 72.3% of the energy consumed is imported, 20% higher than the EU average. The Spanish trade balance is affected by the price variation of these commodities. For this and other reasons, the renewable sector received strong economic incentives in order to consolidate an industry respected internationally.

The energy sector is one of the most strategic and competitive for any economy in the world. Far from operating as a free market, it is characterized by heavy subsidies and is the subject of several international agreements. In this scenario, it is practically impossible for new energy sources to arise and grow without adequate political and economic support. The International Monetary Fund estimates that around the world, fossil fuel companies (the main ones are oil, natural gas and coal) count on annual support of US$ 5.3 trillion in subsidies. That equals US$ 10 million per minute and outweighs government spending on health, for example.

The new edition of the Ten-Year Energy Plan, published for public consultation in July 2017 (EPE- Empresa de Pesquisa Energética), aims at directing about 70% of investments for oil and gas. Incentives for fossil fuels are an option that goes against countries that are managing to change their electricity matrix. It is easy to see that nations that register effective growth in renewable energies seek to balance policies, building the conditions for a necessary and urgent energy transition. Therefore, we recommend:

- Avoid independent initiatives that impact the objectives set by the planning agencies. It is suggested that the renewable targets and the mechanisms to achieve them have the force of law;

- Carefully assess any incentive to fossil fuels, quantifying the impacts on the electricity sector as a whole.

3.3 TRANSMISSION AND DISTRIBUTION NETWORKS

Problems with restrictions on transmission are not exclusive to Brazil. They were also identified in some regions of China and Chile. In Denmark, the system operator, Energinet, anticipates the interconnection of wind farms, based on the project development plan in execution in addition to the approved projects. In this way, the strengthening of the transmission system is reinforced in parallel to the development of the projects, and not later. The recommendations of this study in relation to the transmission and distribution sector are:

- Initiate the planning of the transmission systems before the implementation of the projects of renewable sources, considering both the projects in execution and the approved projects;

- Present economic signals that stimulate the participation of generation companies in the transmission segment. The "marriage" between generation and transmission makes sense, but there is need for security for the investor;

- Strengthen interconnections with neighboring transmission systems;

- To allow the remuneration of a distributor not to depend on the energy sold to the consumer, but on the remuneration of the infrastructure made available. Therefore, consumers owning this type of electricity should be charged with binomial tariffs (R$ / kW + R$ / kWh) that reflect their contribution in terms of energy generated and eventually assigned to the grid and ensure the remuneration of the facilities whose support is indispensable for the continuity of its consumption. Regulatory efforts must be carried out to meet this objective, which includes, among other things, greater liberalization of the energy market in the country, that is, the possibility of the low-voltage customer being a free consumer;

- The application of the net metering mechanism cannot affect the financial and economic balance of the distributors and, consequently, increase the tariff of customers that do not have microgeneration;

- The results of the pilot projects of intelligent networks carried out in Brazil must be gathered, evaluated and shared. The smart grid project conducted by ABRADEE (2013) should be reactivated with the aim of creating results projects or "open-air" laboratories, since the origin of these projects is 100% R&D;

- A long-term plan for Brazilian smart grids should be created, incorporating the learning of R&D projects and mapping a route to implement technologies for a predefined time horizon;

- The implementation of intelligent networks should prioritize: (1) the installation of intelligent meters on a larger scale than pilot projects, (2) the installation of a communication platform that supports these equipments and that guarantees the cybernetic security of the data. The regulator must guarantee the remuneration of these investments.

3.4 MITIGATION OF FLASHING AND INTEGRATION OF RENEWABLE SOURCES

At times of great renewable energy supply, the electricity production of gas and coal plants can be rapidly reduced to practically zero, giving way to clean production. These plants are considered to be very flexible and are often used as a back-up for times of low renewable generation in the countries analyzed. Nuclear and lignite[4] plants, however, do not have the same flexibility and usually only partially reduce their production, causing excess supply until the demand for energy increases or the generation of variable sources (wind and solar) is reduced.

In Germany, the increase in the share of renewables with variable power generation has put pressure on the transmission network. With around 22.2% of electricity generated from wind and solar sources, the country has shown to the world that a large level of variable generation can be integrated into the transmission system without causing problems, thanks to a robust network infrastructure and to international connections.

To improve the control of energy supply and demand, the countries analyzed work to introduce more flexibility to their electricity generation system. In the following topics, the main recommendations are presented to mitigate the flashing and promote the integration of renewable sources in Brazil.

4 Lignite (in Portuguese, lignite) is a soft, brown and combustible sedimentary rock formed by the compression of peat. It is considered low carbon because of its low caloric power.

3.4.1 Regional Electrical Integration

Electrical interconnection with other regions can mitigate intermittent problems by importing surpluses to compensate for local generation reductions and avoid other, more costly back - up features. There are three alternatives for regional integration that should be analyzed:

- **Southern Cone Market:** Among the three markets identified, the Southern Cone Market, which involves Argentina, Brazil, Paraguay and Uruguay, is the one with the greatest possibility of development in the short term.

- **Andean Market:** In a medium-term perspective, the development of an "Andean Integrated Market" appears as a possibility. The Andean Community of Nations (CAN), which includes Bolivia, Colombia, Ecuador, Peru and Venezuela, attaches great importance to the energy sector and considers that the effective integration of sub regional energy markets, with possibilities for integration in the area of oil and natural gas and electricity, could scale up and improve the efficiency of the Andean, South American, and even hemispheric energy business.

- **Northern Market:** The most incipient of the developing regional markets in the continent is the one that includes Brazil, Guyana, French Guiana, Suriname and Venezuela.

3.4.2 Ancillary Services and Storage

Any electrical system needs to ensure safety and stability in its operation. A common alternative is through technical services known as ancillary services. In a system with high renewable source presence, the need for compensation to maintain the permanent balance between generation and load becomes even more latent.

With hydropower reservoirs capable of storing around 287 GWmed (Tancredi & Abbud, 2013) and installed biomass capacity equivalent to 14 GW (IRENA, 2018), Brazil is in a privileged position to deal with the energy variation that will be introduced in the coming years by wind and solar sources. The country has larger hydropower installed capacity than India, Italy, Denmark, Germany, South Africa and Mexico combined. The installed capacity of biomass is about 10 times higher than in Denmark. Brazil can use the flexible generation of these plants as back-up in times of low wind and solar generation.

Thus, to further improve the situation of ancillary services and storage in Brazil, this study makes the following recommendations:

- Create mechanisms to encourage and reward the speed of response of generation plants (i.e. rapid start-up plants);

- Conduct pilot projects, through ANEEL´s R&D program, to assess the potential of markets for ancillary service delivery, particularly at the distribution level, in which it tends to focus on intermittent microgeneration in the coming years;

- The distributors, aiming at improving the quality of energy, could use energy storage assets instead, for example, the expansion of transformer substations;

- Create the regulatory conditions to stimulate the growth of energy storage and create a sustainable business model;

- Work on large-scale storage technologies with high maturity and low risk. Among them are the reversible hydroelectric plants, which through a pumping system allow the reuse of water to store energy and power;

- Implement GLD pilot programs that allow a controlled environment to analyze the response of load and generation units to financial incentives, preferably at hourly intervals. That is, to subsidize loads and small generators, when these allow the distributor to vary its levels of demand and generation.

3.5 ENERGY AUCTIONS

In several countries, FITs have been replaced by auctions as the main incentive mechanism for renewables. In Germany, this replacement took place in 2015, mainly to improve the control of installed capacity in the country. In South Africa, the main explanations for the policy change include fears of increased Treasury spending due to FIT's assurance to buy all renewable energy (Renewable Energy Ventures (K) Ltd. and Meister Consultants Group Inc., 2012).

Using classification criteria that involve the social development provided by the participating auction mill is a good way to ensure the balance between economic and social development policies. In South Africa, projects need to reach defined limits of economic development in terms of job creation, local content, management control, preferential procurement, business development, socioeconomic development, and participation of small and medium-sized enterprises. In addition, a minimum 40% participation of South African company in the venture that will participate in the auction and a contribution to the government's plan to improve the financial situation of the non-white population of the country (BEE) is required.

As in Brazil, the demand for local content in participating South African auctions has achieved good results for the development of the industry. The obligation has led several manufacturers of technology and components to establish manufacturing facilities in the country. The IPPPP - an Overview (2016) report found that about 51% of the total value of projects already started or completed is relative to local content. Even with the 9.89% (Ettmayr & Lloyd, 2017) increase in the cost of this requirement, energy prices (US$ / MWh) achieved by auctions in South Africa for PV and wind technologies followed the international average and the worldwide downward trend, which shows that it is possible to stimulate local industry without causing major impacts on the final price of electricity for the consumer.

Using auctions for specific locations can reduce the cost of energy from renewable sources. In India, the last auction of the Bhadla Solar Park, which resulted in the lowest price in history until May 2017 ($ 38 / MWh), well illustrates this possibility. The cost reduction occurs mainly due to the abundance of solar resource of the region strategically chosen for the auction and its proximity to the transmission network. Targeting enterprises to specific regions can also contribute to the transmission network balancing, reducing compliance costs across the country's electricity system.

In Chile, in addition to large corporate auctions, large unregulated customers can negotiate electricity supply contracts directly with generators or organize a public auction (individual or aggregate). The last auction, for an aggregate demand of 56.2 GWh per year, was carried out in December 2016, with the participation of 13 companies (GTDT, 2017). In addition, several Chilean public institutions have held auctions to promote the deployment of renewable energy in the forestry, food and agriculture industries, as well as in public buildings.

The main recommendations of this study are:

- Include a long-term auctions agenda that is embedded in the industry planning tools. This would minimize investor uncertainties by providing an estimate of the annual capacity to be auctioned over a 10 year horizon;

- Innovate in the rules of the auctions, incorporating social decision variables, such as the generation of jobs, besides the local technological content;

- Evaluating the possibility of changing auction award criteria in specific cases, for example, when the venture risk is high the winning bid could be an average value and not necessarily the lowest price;

- Evaluate the possibility of including a variable component in the price of energy, as used in Denmark, where the price of energy is linked to estimates of future wholesale prices (for which a fixed premium is added).

3.6 RESEARCH AND DEVELOPMENT

The clean technology industry in Copenhagen is supported by a number of incentives and funding opportunities, underpinning research and development of technologies. The Danish capital is currently a hub for investing in green innovations. The Cleantech cluster is a technology hub that excels in the areas of smart cities, smart grids, renewable energy, water and waste management, recycling technologies and upcycling. The industry in the country is so developed that 10% of jobs are green jobs.

Spain has also developed great expertise in renewable energy. Its companies have expanded internationally and are considered players in the sector of wind, photovoltaic and CSP. The Redes 2025 project, for example, is an important joint and integrating initiative of the Spanish electricity sector for Research, Development and Demonstration (P + D + D), stimulated by the Spanish Technological Networks Platform - FUTURED.

In Brazil, ANEEL Research and Development Program (P&D/ANEEL) has been the main tool used in the electric sector. The annual values of investments fluctuate around R$ 450 million. This amount is not exclusive to renewable energy and can be used for any segment of the electricity system (generation, transmission and distribution). Aspects related to renewable energies were addressed using the calls for strategic projects. Among them are wind power, solar PV, heliotherm, storage systems and smart grids.

However, it has been proven that these initiatives are not enough to leverage a renewable industry - in fact, few products and equipment, even at prototype stages, have been produced. Most R&D activities in Brazil do not generate products with market potential. That is, it is far from being the solution for the country to develop its own technologies.

To strengthen R&D initiatives in Brazil we recommend:

- Direct most of the resources of the R&D / ANEEL Program to start up companies that are developing research in areas such as internet of things, intelligent metering, management software for distribution systems with high intermittent generation presence, etc.. Companies with this profile have shown greater capacity to generate patents and products for the market than universities;

- Exploring new markets via R&D, for example, to supply frequency regulation at the distribution level and a demand (direct) management program.

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5 List of abbreviations

C

REC: Renewable Energy Certificate 14

CSP: Concentrated Solar Power / Heliotherm 24

E

EPE: Energy Research Company 15, 17, 19

F

FIP: Feed-in Premium 14

FIT: Feed-in Tariff 14, 16

PV: Photovoltaic 15, 16, 17, 23, 24

G

GHG: Greenhouse gases 7, 11, 12

L

LCOE: Levelized Cost of Electricity / Cost of generating electricity 11

N

NDC: Nationally Determined Contribution 11, 14

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