The Role of the Renewable Energy Program in the State of Minas Gerais in the Process of Renewable Sources Expansion

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Abstract: The State of Minas Gerais (MG), in Brazil, has significant potential for the exploration of renewable energy, with emphasis on solar, wind and biomass. Since 2013, the State has created the Renewable Energy Program of Minas Gerais – PMER (in Portuguese), aiming the acceleration of the expansion of these renewable sources in the State's territory. Nonetheless, the use of renewable sources, excluding large hydropower plants, is still irrelevant in the energy matrix of the State. In this way, the present paper aims to perform an effectiveness analysis of the only instrument of the State Government to expand the number of renewable energy projects, and its contribution to achieve the goals of the energy sector of the Brazilian Nationally Determined Contributions – NDCs. In order to do that, the following parameters has been measured: (1) numbers of projects implemented by the program; (2) policy innovation; (3) job creation; (4) climate change mitigation. It is also briefly discussed the efforts of the Program to address actions that promotes energy storage and the needed infrastructure to supply the energy demand through renewable energy only. There is evidence that the expansion of the renewable energy sources at the regional scope has advanced through incentive policies with clearly defined goals and guidelines. However, the five indicators have shown that the PMER does not attend all the requisites in a satisfactory way to perform as the main state public policy of renewable energy expansion. Therefore, promoting a transformation of the energy sector suggests that a balanced mix of public policies must be implemented in the State.

Keywords: Renewable energy, Job creation, Climate change, Mitigation, Renewable energy program of minas Gerais – PMER.

1. INTRODUCTION

Planning a sustainable future is not an easy task. The way to conduct decision-making can deeply affect the economic, social and environmental aspects of a country. In this sense, energy plays a crucial role in ensuring the growth and development of a society. Traditionally, fossil fuels have been used as the main source in the world for energy generation. The high availability of these resources and its low cost of exploration have led several countries to base their energy matrix on fossil fuels. Taking as an example the countries of Europe and the United States, the predominance of petroleum, coal and natural gas as the main sources of energy is evident [1, 2].

The benefits of using fossil fuels for power generation are undeniable. However, the various problems associated with these resources have led to rethink the way to produce energy nowadays. Moreover, in the long term, such sources will be limited. In addition, according to data presented by the IPCC (2011), about 56.6% of the global anthropogenic GHG emissions in 2004 originated from the combustion of fossil fuels [3]. Thus, fossil fuels contribute substantially to the intensification of global warming.

In order to anticipate the risks related to energy security and the challenges of climate change, the State of Minas Gerais (MG) adopts some measures aimed at the transition to a sustainable low carbon economy, driven mainly by ambitious national commitments, international agreements, and fast technological progress. Among these, the State Renewable Energy Program of Minas Gerais (*Programa Mineiro de Energia Renovável* – PMER, in Portuguese), created by State Decree No. 46296 of August 14, 2013 [4], stands out as the main instrument for promoting renewable energy in the State. Its objective is to promote and encourage the production and consumption of energy from renewable sources and contribute to the sustainable development of Minas Gerais. Its instruments and actions include benefits and incentives for the generation of centralized and decentralized electric power through solar, wind,

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biomass and hydroelectric sources, the latter generated in Hydropower Generation Plants (*Centrais de Geração Hidrelétrica* – CGHs, in Portuguese) and Small Hydroelectric Plants (*Pequenas Centrais Hidrelétricas* – PCHs, in Portuguese).

Moreover, Brazil has stablished its nationally-determined contributions (NDCs) to achieve the Paris Agreement, signed at the 21st Conference of the Parties (COP-21) in Paris in December 2015. With regard to renewable energy sources, the Brazilian NDC expects that the country will reach an estimated 45% share of renewable energy in the energy matrix by 2030, including expansion of the use of renewable energy sources, in addition to hydropower, in the total energy matrix between 28% and 33% by 2030 [5].

In order to implement the Brazilian NDC's goals effectively and within the agreed period, it is necessary efforts and distribution of responsibilities among Brazilian States, the private sector and civil society, in order to promote a decentralization of goals. The purpose of this paper is to evaluate the effectiveness of the PMER as the main instrument of the Minas Gerais Government to expand the number of renewable energy projects in the state, as well as their impact in achieving the goals for the Brazilian NDC energy sector. In this way, results of analysis of several indicators are presented which are broadly accepted as effective tools to measure the capacity of public policies to act directly as a promoter of sustainable and low carbon economy.

1.1. The PMER: Renewable Energy Program of Minas Gerais

The main aim of the PMER is to promote the expansion of electric power generation from renewable sources, excluding large hydropower plants. The program has a specific scope, since it restricts its effects exclusively to promote the generation of electricity through non-fossil sources. Thus, renewable sources whose objectives are for energy substitution in the transportation sector and for thermal generation were not contemplated by the program.

It should be noted that the Decree creating the PMER does not discriminate specific conditions and instruments for distributed generation (DG). However, simultaneously with the construction of the program, incentives were discussed for the distributed micro and mini-generation that ended up being contemplated with specific tax incentives through Law No. 20824, dated July 31, 2013 [6]. In this way, it can be considered that DG is part of the PMER scope.

Due to strategic political interests to achieve the government goals set forth in the Government's Multi-Year Plan of Action [7] in the energy sector, the PMER has been created to be the main strategy of the State Government to attract investment, in order to expand the number of projects of power generation from renewable sources. The instruments contemplated in the Program Decree are [4]:

1. Tax and tributary incentives;
2. Partnership agreements for transmission lines through Public Private Partnerships (PPP);
3. Priority in the solicitation and access to the system;
4. Priority in environmental regularization processes;
5. Priority in the formalization of energy purchase contracts;
6. Specific funding line; and
7. Technical-scientific cooperation and training and qualification of human resources.

The present article will analyse the effectiveness of the instruments that compose the Program in order to correlate them to the following indicators:

I. Innovation;

II. Number of implemented projects by the PMER;

III. Creation of jobs;

IV. Mitigation of greenhouse gases; and

The results reveal that the renewable energy generation has increased in the last few years in the State, and suggest it is not possible assign that to the PMER, once is not clear the impact and effectiveness of its instruments to promote the renewable expansion in the MG energy matrix.

2. INSTRUMENTS OF MEASUREMENT OF THE INDICATORS

2.1. Innovation

It is a great challenge for the current public administration proposing policies aligned with

innovation criteria in order to improve the State's strategic role, giving at the same time, the business environment enhancement and economic development. This shouldn't be achieved only through traditional tools, but also through the introduction of modern methods that can add greater participation of society, transparency, speed and modernization of the tools of the public machine [8].

Government policies to create renewable energy markets must have mechanisms that facilitate the development of renewable technologies and promote cost reduction through economies of scale and technological gains. In this sense, the types of policies required differ according to national and local contexts [9]. In order to direct the appropriate selection of the necessary mechanisms to develop a policy aimed at the expansion of renewable energies, the International Renewable Energies Agency - IRENA established the main instruments that should be considered in the construction of an effective policy, considering the context.

In Figure **1**, these mechanisms are summarized. The evaluation of the innovation indicators is being made based on the attendance of such mechanisms. In order to do that, each PMER instrument was categorized as national policy, regulatory instruments, fiscal incentives, grid access, access to finance or socio-economic benefits in order to see if it attends the requisites to be considered as an innovative policy.

2.2. Number of Implemented Projects by the PMER

In order to evaluate the results of the PMER in terms of the number of implemented projects, it is necessary to measure the reach of the objective of the program by evaluating, at the State level, the generation of electricity from renewable sources. In this sense, possible indicators for the analysis are listed; however, these are subject to criticism about their ability to capture the effectiveness of the program, its measurement failures, as well as possibilities to obtain data in a timely manner. In Table **1** are described the measurement instruments listed with their advantages and disadvantages.

After the data collection, graphics were plotted in order to make possible the analysis of the expansion of the renewable energy in the state by analysing the historical series of its growth. Also, it was included a graphic to compare the distributed generation by renewables sources in the States of Brazil federation, in order to correlate the advance on the matter of MG State.

2.3. Creation of Jobs

The IRENA annually issues the number of jobs generated worldwide in the renewable energy market. These reports, combined with data on the expansion of renewable sources in the world, allow generating an average number of jobs created per installed MW.

In Table **2** are summarized the aggregated data, taking into account the first four years of the program, for the number of jobs and installed capacity in the world of sources contemplated in the PMER. The ratio between generated jobs and the installed capacity was calculated, and the result is an average data, since the selected factor is not individual for each source.

NATIONAL POLICY	REGULATORY INSTRUMENTS	FISCAL INCENTIVES	GRID ACCESS	ACCESS TO FINANCE	SOCIO-ECONOMIC BENEFITS
◆ Renewable energy target	◆ Feed-in tariff	◆ VAT/ fuel tax/ income tax exemption	◆ Transmission discount/ exemption	◆ Currency hedging	◆ Renewable energy in rural access/cook stove programmes
◆ Renewable energy law/ strategy	◆ Feed-in premium	◆ Import/export fiscal benefit	◆ Priority/ dedicated transmission	◆ Dedicated fund	◆ Local content requirements
◆ Technology-specific law/ programme	◆ Auction	◆ National exemption of local taxes	◆ Grid access	◆ Eligible fund	◆ Special environmental regulations
	◆ Quota	◆ Carbon tax	◆ Preferential dispatch	◆ Guarantees	◆ Food and water nexus policy
	◆ Certificate system	◆ Accelerated depreciation	◆ Other grid benefits	◆ Pre-investment support	◆ Social requirements
	◆ Net metering	◆ Other fiscal benefits		◆ Direct funding	
	◆ Mandate (*e.g.*, blending mandate)				
	◆ Registry				

Figure 1: Overview of the main types of instruments and measures adopted in renewable energy policies [9].

Once the average number of jobs created by MW was found, this ratio was applied to find the approximate number of jobs created in the State by the expansion of renewables sources in the energy matrix in the established period.

2.4. Mitigation of Greenhouse Gases

Among the final objectives of the PMER we can mention the mitigation of the greenhouse gases (GHG) with a view to combating climate change, as well as transition to low carbon economy. In order to measure

Table1: The Measurement Instruments Listed with their Advantages and Disadvantages

Measurement Instrument	1) Renewable energy generation ventures in operation in Minas Gerais	2) Renewable energy generation ventures with special regime at SEF / MG	3) Renewable energy generation ventures with environmental license	4) Production of electricity power by renewable source	5) Distributed micro and mini-generation ventures installed
Unit	MW or percentage (MW renewable energy/MW total energy).	Number of projects (possibility to use MW, according to information held by SEF-MG).	Number of developments (possibility to use MW)	Thousand tonnes of oil equivalent (thousand toe)	It can be in MW, in number of ventures, in percentage of participation of MG.
Data Source	ANEEL*	SEF*/MG	SEMAD*	BEEMG*	ANEEL
Advantages	Measures the expansion of energy generation from renewable sources. The information is updated with periodicity greater than annual. When calculated (in MW or in %) it is possible to measure the pace of the implantation of renewable energy in a given period in relation to other periods.	It identifies the quantity of ventures that benefited from the special tributary regime granted to the generation of renewable energy. If the SEF has information about the electric power of the projects, it allows to evaluate the installed power of ventures with special regime contemplated in the PMER.	It identifies exactly the quantity of ventures that obtained an environmental license, in any of its stages, with the state. It allows identifying ventures that were planned before and after the PMER, which may denote the influence of the Program.	Measures the increase of the generation of energy from renewable sources. Actual energy by renewable source. When calculated (in thousand toe or %), it is possible to measure the pace of the implantation of renewable energy in a given period in relation to other periods.	It measures the expansion of DG in the State, in terms of ventures, installed capacity and position in relation to other federative units. Allows cuts by renewable energy source. Updated with periodicity greater than a yearly basis.
Disadvan-tages	The indicator sums up the electric power of all renewable energy generation ventures without discriminating against those who actually benefited from some PMER action. It does not show which electricity actually generated by renewable sources, only the generation potential installed.	Receiving the special regime does not mean that the ventures is in operation. The indicator does not allow to know if the project was contemplated with another benefit coming from the PMER. Difficulty in obtaining data from the SEF.	Licensed ventures may not be installed. It does not allow to know if it was contemplated with another benefit of the PMER. Difficulty in obtaining data from the SEMAD. It only presents information of installed power, not the amount of renewable energy actually produced.	Annual frequency with lag of 2 years.	It does not measure the energy actually generated, so it does not inform if the installed capacity is efficient or if it is working.

*ANEEL – *Agência Nacional de Energia Elétrica*: National Electric Energy Agency.
*BEEMG – *Balanço Energético do Estado de Minas Gerais*: Energy Balance of the Minas Gerais State.
*SEF – *Secretaria de Estado de Fazenda*: Secretary of State for Finance.
*SEMAD – *Secretaria de Estado de Meio Ambiente e Desenvolvimento Sustentável*: Secretary of State for Environment and Sustainable Development.

Table 2: Average number of jobs generated by GWh [10, 11, 12, 13]

Year	Generated Jobs (10^3)	Installed Capacity (GW)	Average Number of Jobs Generated by MW/YEAR
2014	9.3	1,693,695	5,49
2015	9.7	1,851,384	5,23
2016	9.8	2,011,446	4,87
2017	10.3	2,179,426	4,72
			Average number of jobs generated by MW: 5,07

the results of the Program to achieve this objective, the Greenhouse Gas Emission Factors for the energy sector is provided by the Ministry of Science and Technology (*Ministério de Ciência e Tecnologia* - MCTI, in Portuguese), on an annual basis [14].

As the program started to enforce in 2013, the analyses are being performed for the first 3 full years of the PMER, according to the average annual factors of Table **3**.

Table 3: Average Annual Factor (t_{CO2} / MWh) [14]

Year	Average Annual Factor (t_{CO2} / MWh)
2014	0.1355
2015	0.1244
2016	0.0817
2017	0,0028

Multiplying the average annual emission factor by the amount of MWh generated by renewables sources in the established period, it is possible to obtain the saved emissions, as it is being presented in the next section.

The emission factors provided by MCTI are based on the types of primary source of the Brazilian electric matrix, and the values are attributed mainly due to the presence of fossil fuels. As the program addresses the generation of electricity through renewable sources, the emission factor for these are being considered as zero during its operation phase, and the technology lifecycles will not be considered [15].

Thus, the result is based on the emissions that the sector stopped emitting when using renewable energy instead of sources with fixed emissions.

Additionally, it is presented an estimation of the GHG emissions in the medium and long term in order to have an instrument of comparison of the PMER results. This scenario was built with the tool Long-range Energy Alternatives Planning (LEAP)[1] based on the state energy balance [16].

3. RESULTS

3.1. Number of Ventures Implemented by PMER

As previously mentioned in Table **1**, five measurement instruments were selected to carry out the PMER impact analysis on the expansion of the number of renewable energy projects in the State of Minas Gerais associated with the Program. However, although the instruments demonstrate efficiency in the measurement of the PMER results, instruments 2 and 3 do not have sufficient data available to perform the analysis.

Regarding the instrument 4, related to the BEEMG data, it is assumed that the information published in the last report refers to the period until 2014, so it is understood that these data are not yet capable of reflecting the PMER effects on the Minas Gerais ventures, and it is necessary to wait the publication of more recent reports [18].

In this way, in this paper are presented the results of the instruments for which it was possible to obtain timely data (1 and 5). A more in-depth analysis of the numbers found in ANEEL's Generation Information Bank databases is also performed [18].

In Table **4** is shown the total generation capacity installed by source, in Minas Gerais, from 2010 to 2016. The ventures analyzed were Hydro Power Plant - HPP, Small Hydroelectric Plants - SHP, Hydropower Generation Center - HGC, Wind Generation Plant - WGP, Photovoltaic Solar Plant - PVP, Distributed Generation - DG, and Thermoelectric Plant - THP. The data allows to verify the expansion of the capacity of each renewable source encouraged before and after the PMER, since it covers three years before and three years after the implementation of the Program and discriminates between renewable sources, including large and small hydroelectric. In the case of renewable thermals, the majority (around 80%) corresponds to the generation by means of sugarcane bagasse, but there are also plants that use biogas from urban and agricultural residues, black liquor, charcoal, blast furnace gas resulting from the use of biomass and wood residues.

There is a continuous increase in total installed generation capacity from 2010 to 2017, 1,550.34 MW more at the end of the period compared to 2010. Regarding the sources addressed in the program, the photovoltaic is the one with the highest increase between the period of 2013 and 2017. However, from the launch of the PMER, the entry of new installed power from the others renewable sources presented a slow pace when compared with the photovoltaic, as shown in the graph of Figure **2**.

[1] LEAP is a widely-used software tool for energy policy analysis and climate change mitigation assessment developed at the Stockholm Environment Institute.

Table 4: Total Installed Generation Capacity in MG by Source in MW, 2010-2017 [18]

Year	Generation Capacity (MW)								
	Source								
	HPP	SHP	HGC	WGP	PVP	THP Renewable	THP Gas	THP others	Total
2017	12,578.70	710	156.5	0.2	323	1,594.50	381.7	556.8	16,301.04
2016	12,568.70	689	125.4	0.2	2.1	1,518.50	381.7	512.5	15,815.10
2015	12,568.70	665	122.6	0.2	1.4	1,496.70	381.7	510.6	15,748.60
2014	12,568.70	665	100.5	0.2	1.4	1,452.30	381.7	498.4	15,668.50
2013	12,516.20	637.8	93.1	0.2	0	1,401.30	379.3	476.7	15,504.70
2012	12,210.50	614	79	0.2	0	1,346.90	374.3	453.1	15,078.00
2011	12,210.50	580	72	0.2	0	1,273.30	374.3	434	14,944.30
2010	12,210.50	521.7	68.5	0.2	0	1,159.10	374.3	416.4	14,750.70

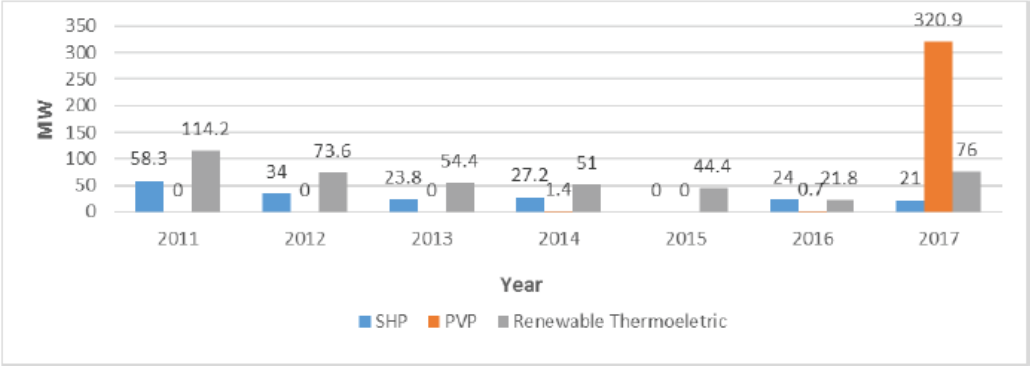

Figure 2: Annual Renewable Energy entry, except HPP, in the MG electric matrix, by source, from 2011 to 2017 (MW). Adapted from [18].

Considering the different sources of renewable generation, it is notable the reduction of new installed capacity annually of renewable thermal source and small hydro. In the case of small hydroelectric plants, however, there was a small increase between 2015 and 2016. The representative increase in the pace of the entry of new installed capacity of photovoltaic plants in the period was a positive highlight. Before 2013, there was no plant installed, while in 2017 the input of photovoltaic electric generation capacity was significant in relation to the other sources.

As shown in Figure **3**, the share of renewable energy in the MG electricity matrix, excluding HPP, increased in all the observed period. However, the pace of increase in the proportion of these sources has decreased from 2013 to 2016. In 2017, the rate had a significant increase because of the new photovoltaic plants installed on the state territory. This result partially reflects what has been shown in Figure **2**. The share of renewable energy continued to increase from 2013 to 2017, as the entry of installed capacity by non-renewable source decreased. However, with the reduction of new renewable energy ventures, the pace of growth in the share of renewables has not remained at the same level at the first 3 years of the PMER.

In Figure **4** is shown the total installed power of micro and mini-generation in Minas Gerais from 2013 to 2017. Since 2015 there was an increase of micro and mini-generation power installed in the State of more than 35 times. In 2018 august, about 99% of the 7.876 micro and mini-generation plants installed in the state corresponded to photovoltaic generation [18]. The remainder consisted of generators from biogas from urban, animal or agro-industrial residues, or hydroelectric, or from blast furnace gas from biomass.

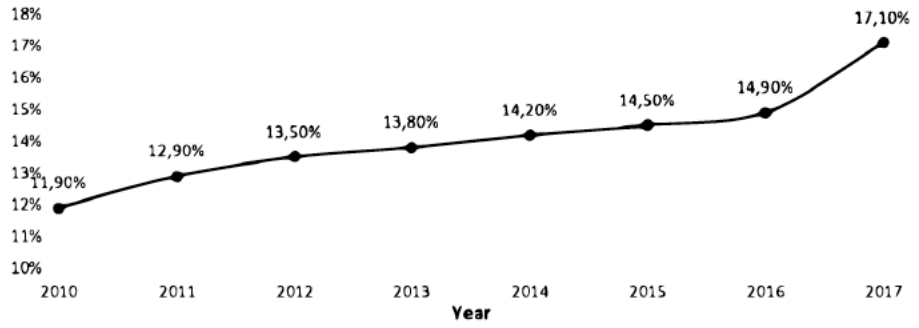

Figure 3: Participation of Renewable Energy, except HPP, in the MG electric matrix, from 2010 to 2017 (%). Adapted from [18].

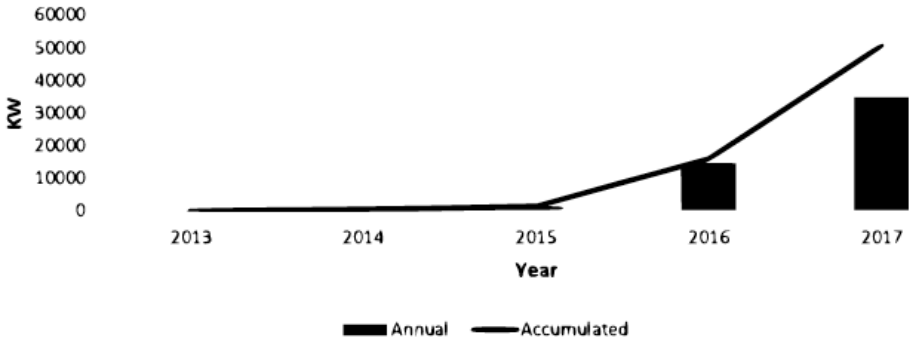

Figure 4: Installed power of micro and mini generation in Minas Gerais from 2013 to 2017 (kW). Adapted from [18].

It must be emphasized that Minas Gerais is the Brazilian State with the highest number of distributed generation DG plants, as well as greater state with installed generation capacity of this type, as observed in Figure **5** (see Minas Gerais – MG). This is due to the high potential of renewable sources of the State, specially the incidence of solar radiation, such as the high value of the electricity fare. It also must be considered the positive effect produced by the regulation of the ICMS for distributed generation, relieving the energy produced by these plants, not only because it improved the financial return on investments, but also because it demonstrated the state's commitment to the development of this technology.

Improvements in the framework, especially regarding environmental legislation coming from the PMER, also favored the expansion of photovoltaic energy in the State, since it especially benefited the installation of projects of remote consumption.

Until the beginning of 2017 there was already distributed generation installed in 256 municipalities of MG [18]. It is verified by these numbers that the use of DG technology tends to be higher in municipalities with higher income, but that there is still a great distribution of the installation of these projects throughout the state.

3.2. Innovation

The Decree No. 9073 of June 5, 2017 [5], which promulgates the Paris Agreement under the United Nations Framework Convention on Climate Change, celebrated in Paris on 12 December 2015, meets in part the requirements of the criterion of the first item, National Policy, since it has specific targets for the expansion of Renewable Energies. However, the PMER, although it has common goals, it does not have a defined quantitative goal to increase the number of projects in a specific time frame. Regarding the requirements related to the Specific Law or Strategy for Renewable Energy, it can be seen that there is no action in this regard at both national and State level, and the Ten-Year Energy Plan (*Plano Decenal de Energia* – PDE, in Portuguese) [18] is in charge of establishing the guidelines for expansion of Energy sector. It should be noted that the majority of the investments foreseen in the PDE are for the Oil industry.

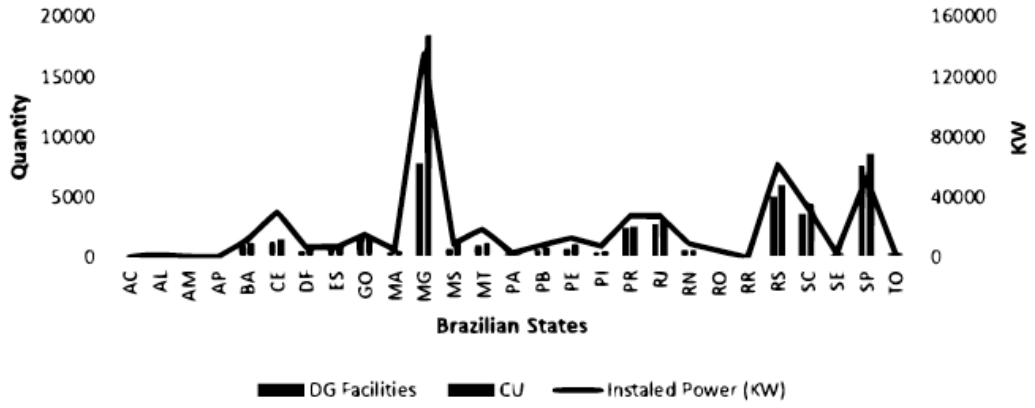

Figure 5: Number of distributed generation (DG) facilities, number of Consumer Units (CU) served and Installed Power by Brazilian State in 2017 (in kW). Adapted from [18].

In Table **5** is shown the results regarding the compliance with the requirements proposed by IRENA to set up an innovative policy to encourage renewable energy sources.

Regarding the regulatory instruments, the program is also unsatisfactory, as it has only two actions aimed at speeding up environmental regularization processes and energy purchase contracts. Important instruments, such as special tariffs and renewable energy certificates are not contemplated.

In terms of tax incentives, again, the PMER has only the exemption of ICMS as an attractive for investments in the sector. In relation to the item of access to the network, the PMER uses the same artifice of the item of regulatory instruments, which is speed to the requests of access to the network. There are not incentives for new transmission lines or other types of benefits.

In the financing item, the PMER has a specific line of financing and contracts of public private partnerships for the construction of transmission lines. However, the creation of a specific fund would be a substantial differential for the program implementation.

In terms of socio-economic benefits, PMER foresees technical-scientific cooperation for the development of renewable technologies in the state territory, as well as the training of human resources in this area. However, there is a lack of specific actions to meet the needs of the rural population, as well as local programs.

3.3. Creation of Jobs

In Table **6**, it is possible to verify a growth in the number of jobs generated in the last three years from the expansion of renewable energy projects. It is possible to see that from 2014 to 2017 4,037.44 new jobs was created. In 2017, there was a substantial increase in the employment generation, with more the 2,400 jobs created. In the latter period, the number of new jobs more than tripled in relation to the first year of the PEMR. In large part, it is due to the expressive number of photovoltaic plants installed on Minas Gerais State, and also to the increase in the installed capacity

Table 5: Classification of Instruments Addressed by PMER [9]

National Policy	Regulatory Instruments	Tax Incentives	Network Access	Financing	Knowledge and Human Resources
Decree No. 9073 of June 5, 2017 Ten-Year Energy Plan	Priority in environmental regularization processes. Priority in the formalization of energy purchase contracts.	ICMS exemption	Priority in the solicitation and access to the system.	Partnership agreements for transmission lines; Specific funding line.	Technical and scientific cooperation. Training and qualification of human resources.

Table 6: Generated Jobs [10, 11, 12, 13, 18]

Year	Average Number of Jobs Generated by MW	Installed Capacity	Renewable Energy Jobs	Annual Job Increase
2013	5.07	15,504.70	78,608.83	
2014	5.07	15,668.50	79,439.30	830.47
2015	5.07	15,748.60	79,845.40	406.11
2016	5.07	15,815.10	80,182.56	337.15
2017	5.07	16,301.04	82,646.27	2,463.72
			Total	**4,037.44**

of DG, which were the most developed in the state over this period.

3.4. Mitigation of Greenhouse Gases

According to Figure **7**, in 2010 was generated GHG emissions around 70 million tonnes of CO_2 equivalent - $MtCO_{2e}$ in the State of Minas Gerais, this amount reflects both demand and transofortion emissions of the energy sector. This value is supposed to almost double in 2030 and triplicate in 2050.

In Table **7** is shown the total emissions avoided over of the period of the PMER in relation to the expansion of the projects contemplated therein. It is notable that, when compared to the number of emissions in the sector, the total avoided emissions represented around 0.3% in the period between 2014 and 2016.

It should be noted that the years of 2014 and 2015 were characterized by a long period of drought that affected the water availability of the reservoirs of the hydroelectric power plants in Minas Gerais, thus, several thermoelectric of fossil fuel origin were turn on, which caused the increase of the emission factor for those years. With a more constant pluviometric regime in 2016, the thermoelectric of fossil fuel origin were turn off and the emission factor decreased in that year.

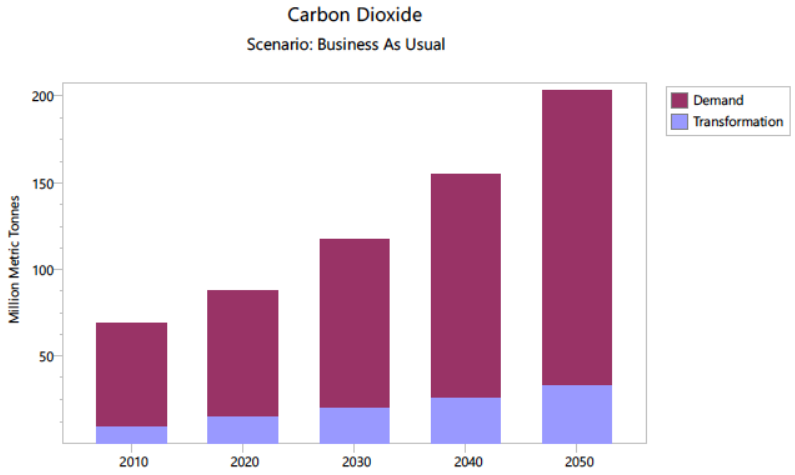

Figure 7: GHG emissions.

Table 7: Avoided Emissions of the Electric Sector in MG [14]

Year	Average Annual Factor (tCO_2/MWh)	Total (MWh/year)	Total Emissions Avoided (tCO_{2e})
2016	0.0817	2,050,795.0	167,549.95
2015	0.1244	2,002,287.0	249,084.50
2014	0.1355	1,943,482.0	263,341.81

4. CONCLUSIONS

The Renewable Energy Program of Minas Gerais is the main effort of the State Government to promote the generation of electricity from renewable sources. The program is limited in scope and does not serve the renewable energy sector as a whole, as it does not address all the biofuels and the thermal power generation. Its largest contribution was in the fiscal incentive axis with the consolidation of tax exemptions for the generation of electricity by renewable sources, except for large hydroelectric plants.

The results analyzed demonstrate that the generation of electricity from renewable sources has grown in Minas Gerais, especially after the first 3 years of the PEMR, however, it is not possible to make an association of this trajectory with the PMER. The data show the decrease of the entry of small hydroelectric and of biomass thermal plants in recent years, partially offset by the installation of solar ventures. The inversion of the path of decrease of the entrance of operation of small hydropower, however, can be a positive effect of the program.

The results that most clearly indicate positive effects of the program are those related to photovoltaic energy. There is an evident expansion of the installed capacity of photovoltaic energy generation since 2013, when the PMER was established. The micro and minigeration distributed specifically showed significant growth, although in terms of installed capacity, it still represents a small amount. However, it is not possible to define the degree of importance of the program for the realization of these ventures, considering that photovoltaic energy had other fundamental incentives for its development, originating from the Federal Government, market conditions and natural factors.

In terms of political innovation, the instruments addressed by the PMER are not enough to recognize the program as a robust, efficient and innovative policy for the promotion of renewable sources in Minas Gerais. Although meeting some requirements of the parameters proposed by IRENA, factors such as law and strategy specific to renewable energy are absent in the State. The lack of short-, medium- and long-term goals and guidelines also indicates the Government's low ambition on the issue. In addition, the PMER does not specifically go into the local context and the promotion of distributed generation, with their instruments taking a more general approach.

Just as there was an expansion of the installed capacity of renewable energy sources in the State, there was also an increase in the creation of new jobs from these ventures. It is worth noting the year 2017, where more than 2,400 jobs were created, probably due to the expansion of photovoltaic projects, which has a high rate of employability. However, is not possible to attribute this increase with certainty to the PMER.

Regarding the mitigation of Greenhouse Gases, the period in which it has been analyzed did not show large reductions in the emissions of the sector, since the mitigation of gases was less than 0.5% of the value issued in the period. Taking into account a growing increase in the demand for energy, it is possible to affirm that the emissions will also be increasing in a business as usual scenario. In this way, the renewable energies sources play an important role in the mitigation of GHG of the energy sector.

Increased generation and consumption of renewable energy to sustainable development and combat climate change depends heavily on public policies that improve the business environment and encourage investment in the sector. In order to accelerate the development of renewable sources in the State, it is important that the actions foreseen by the State Renewable Energy Program of Minas Gerais be strengthened and resumed. Complementary actions are also necessary to better define the objectives of the program, to include other renewables sources non-envisaged and to provide for further development instruments. Thus, it is considering necessary to reformulate the PMER so that it can assume the role of strengthening the actions of the State Government to promote renewable energy and the decentralization of the targets for compliance with the Paris Agreement, signed at the federal level.

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