IMPACTS OF CHANGES TO THE BRAZILIAN ELECTRICITY MATRIX

instituto Escolhas

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Instituto Escolhas is a non-profit organization, established in 2015, that works to qualify the discussion on sustainability, quantifying the economic, social and environmental impacts of public and private decisions. Through studies, analyses and reports, we embrace new approaches and arguments to overcome the ideological polarization of the conflicting choices that are inherent to planning processes. Only qualified arguments can support conscious decisions and allow the construction of effective solutions for sustainable development.

Escolhas' mission is to become the benchmark for boldness, independence and consistency, using mathematical language to dimension and compare the degree of sustainability of the public and private policies, thereby providing innovative scenarios through the crossing of information. We develop the ability to process data using rigorous methodology, creating solid arguments, systematic statistics and comparative charts to support analyses and decisive choices. We work as a network with independent studies that are open to multiple perspectives and points of view so as to overcome prejudices and comprehensively clarify facts and figures.

INTRODUCTION

The energy debate is one of the most intense on the national agenda due to its obvious impact on the lives of Brazilians and the economic interests of the country. Generally, this debate examines only the economic aspects, addressing, for example, the structure of energy tariffs paid by consumers. Alternatively, it may focus only on the controversial effects of adopting a particular energy source, such as nuclear power or the construction of large hydroelectric dams in the Amazon.

This study endeavors to bring new dimensions to the debates surrounding this topic, starting with the joint and systematic analysis of the potential economic, environmental and social impacts of a variety of energy scenarios proposed for Brazil.

This approach authentically reflects the Choices Institute's commitment, through its studies, to the support of new analyses that lead to the construction of effective solutions for sustainable development.

Sergio Leitão

Director of relations with society of Instituto Escolhas

Introduction

The electricity sector is a major emitter of greenhouse gases (GHG) throughout the world. According to the IPCC[1], the generation of electricity and heat accounted for approximately 25% of global emissions in 2010. In Brazil, this sector accounted for 7% of emissions in 2014, but the contribution from carbon-emitting sources (natural gas, oil and coal) is increasing in the national energy matrix. In contrast to this, the Brazilian INDC[2] proposes a transition to an energy system with a greater share of renewable energies by 2030.

In this context, this study from the Platform of Energy Scenarios (abbreviated as PCE in Portuguese), developed by the Choices Institute and organized by the Avina Foundation, seeks to understand the impact from various electricity generating scenarios on the economy, employment and GHG emissions, in Brazil.

Platform of Energy Scenarios (PCE)

At the invitation of the Avina Foundation, four scenario projection teams participated in the construction of the PCE between 2013 and 2014, each elaborating two projections for the Brazilian electric matrix in 2050 — a business as usual (BAU) and another with an energy efficiency factor (EEF):

Alberto Luiz Coimbra Institute of Post-graduate and Engineering Research, Federal University of Rio de Janeiro (Coppe/UFRJ);

Greenpeace Brazil;

Beneficent Association of the Santa Catarina Coal Industry (SATC), with support from the Brazilian Association of Mineral Coal (ABCM);

Technological Institute of Aeronautics (ITA).

In seven of the eight proposed scenarios, the hydro source remains predominant in 2050. In addition, all scenarios point towards the prioritization of renewable sources, including wind and solar, as well as hydropower. Natural gas is also considered in all scenarios, to a greater or lesser degree, especially in the scenarios estimated by the ITA, but also in the Greenpeace matrix, which prioritizes a reduction in the dependence on fossil and nuclear sources. In the SATC scenarios, expanding coal technology supplements part of the electricity from natural gas power plants.

Furthermore, it is important to note that only the BAU scenarios from Coppe and Greenpeace include the hydropower projects set out by the federal government, taking into account investments and construction schedules, in order to compare them with the ideal matrix suggested in the EEF scenario. The SATC and ITA scenario teams gave greater relevance to the EEF scenario, treating the BAU scenario as an expanded proportion of the energy efficiency scenario.

[1]Intergovernmental Panel on Climate Change.
[2]Brazil's Intended Nationally Determined Contribution to the Paris Climate Agreement.

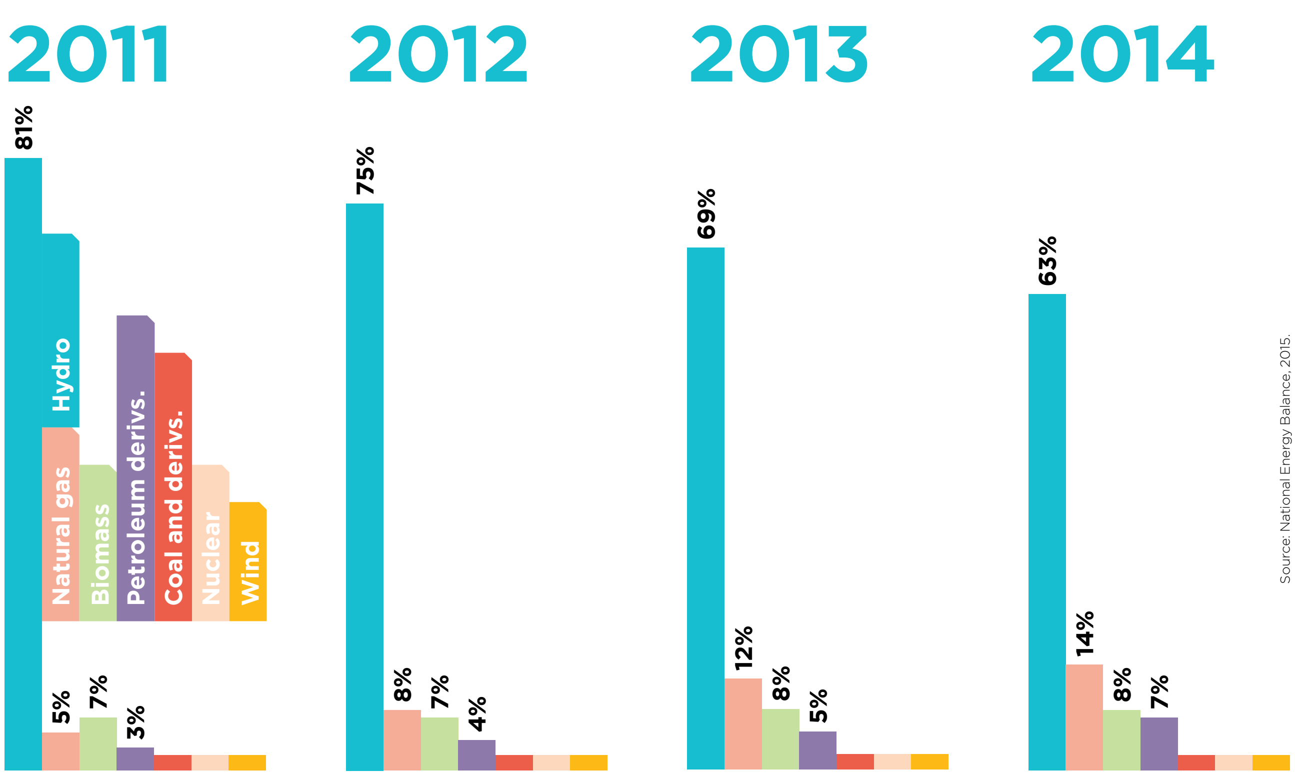
The electricity sector and climate change

Climate issues strongly influence the electricity sector in Brazil and throughout the world. Two of Brazil's recent and largest power crises (2001 and 2015) resulted from the lack of rain coupled with the lack of planning. While the dams continue to present social and environmental challenges, nuclear accidents increase security costs. A consequence of this is that technological advances in wind and solar generation will be required if those energy sources are to gain competitiveness in the country, contributing to Brazil's INDC goals within the COP-21. Other important issues, including current geopolitics, also present new challenges, such as the discovery of large deposits of bituminous shale in North America and the feasibility of pre-salt exploration in Brazil. The dynamics of power generation for the coming years will depend on the cost of generating energy from each of these sources in the near future, the stimulus given by the government for the development of new clean technologies, and aspects related to security of supply and international incentive mechanisms.

Energy matrix in Brazil and in the world

According to the National Energy Balance (2015), between 2011 and 2014, domestic electricity supply in Brazil increased by 11%, from 531 TWh to 591 TWh. A notable feature in that period was the reduction in the share of hydroelectricity, which decreased by 12.8% (from 428 TWh to 373 TWh). The cause of this reduction was a prolonged period of drought in some regions of Brazil and the delay in the commissioning of new hydroelectric plants. In response, the federal government triggered fossil-fueled thermal power plants, which increased the generating share of other sources.

Participation of electric power generation sources, 2011-2014



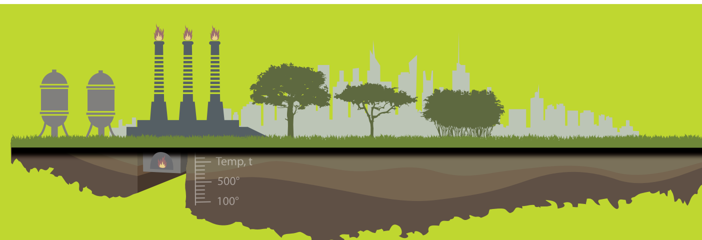
Source: National Energy Balance, 2015.

The participation of wind and biomass sources in electricity generation had a significant increase during the period, indicating their increasing competitiveness with the more traditional sources. The supply of wind energy more than tripled in the period and biomass grew 22%. In terms of installed capacity, solar power increased 15-fold and wind power has increased almost by 2.5 times. Meanwhile, the thermoelectric and water sources increased their capacity by 21% and 8% respectively, in the period.

Between 2011 and 2014

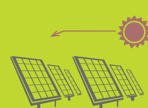
Biomass: Supply increased by

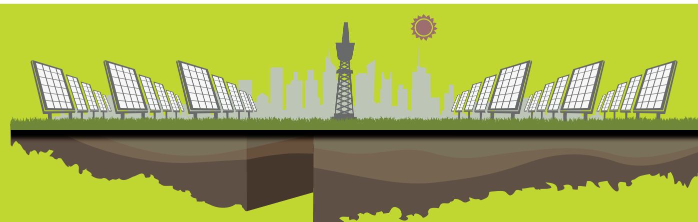
↗ 22%



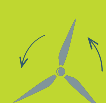
Solar: Installed capacity grew

↗ 15 times

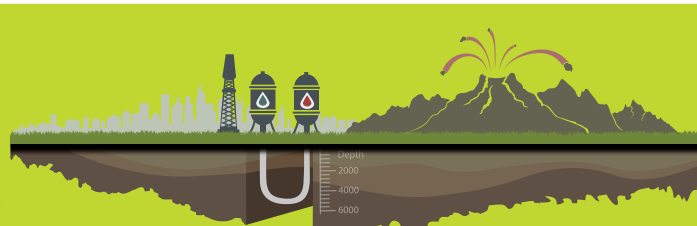




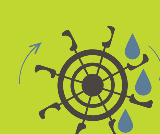
Wind: Supply tripled



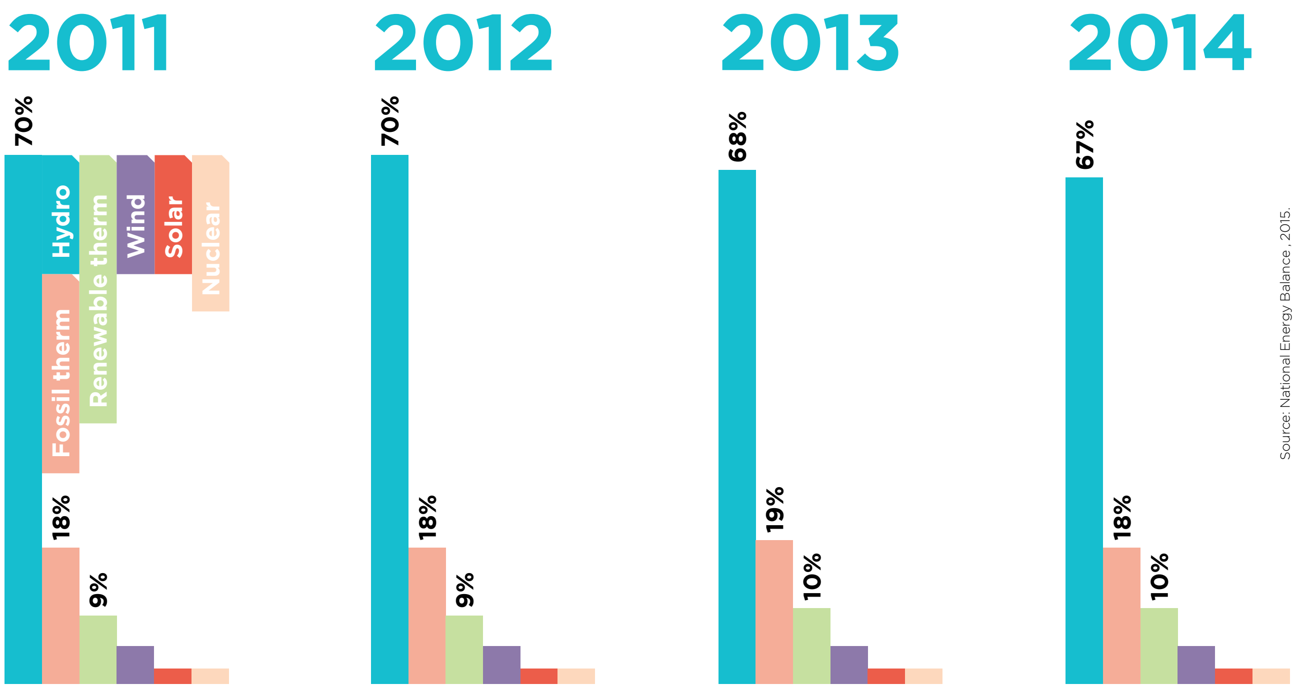
Thermoeletric: Installed capacity grew by 21%



Hydraulic: Installed capacity grew by 8%



Installed capacity of electricity generation (MW), 2011-2014



When referring, however, to the world's electrical matrix, fossil fuels are the main source in seven of the world's top ten electricity producers and comprise more than two-thirds of the world's generation. Only Canada and Brazil use mostly hydropower. The main source in France is nuclear power. Despite this, most developed countries have, in recent years, presented targets and plans for institutional changes to achieve more environmentally sustainable electricity production in the medium and long term, especially after the Paris Agreement signed at the end of 2015, at COP-21.

Sources of Electricity power generation

Country (Year)	Hydro	Natural Gas	Oil derivatives	Coal derivatives	Nuclear	Renewables[(a)]
All countries	16,3%	21,7%	4,4%	41,3%	10,6%	5,7%
China (2012)	22,0%	3,0%	3,0%	64,8%	1,0%	6,2%
USA (2013)	7,0%	27,7%	1,0%	39,0%	19,4%	5,8%
India (2014)	16,0%	9,0%	1,0%	59,0%	2,0%	13,0%
Russia (2011)	20,0%	50,1%	2,6%	15,3%	11,0%	1,0%
Japan (2013)	10,0%	43,0%	14,0%	30,0%	1,0%	2,0%
Canada (2013)	59,0%	7,0%	7,0%	15,0%	10,0%	2,0%
Germany (2013)	3,6%	10,7%	1,1%	44,6%	15,4%	24,6%
France (2012)	11,3%	3,9%	0,8%	3,8%	75,4%	4,7%
Brazil (2013)	**68,6%**	**12,1%**	**4,7%**	**2,8%**	**2,6%**	**9,3%**
South Korea (2012)	0,5%	27,0%	1,6%	41,4%	29,0%	0,5%

(a) biomass, wind and solar.
Source: U.S. Energy Information Administration (EIA), International Energy Agency (IEA) and National Energy Balance (2014).

How the calculations were made

The Choices Institute inserted the PCE scenarios into an input-output matrix for the Brazilian economy, with 2011 as the base year. This methodology permits an estimation of the variation in production, employment and greenhouse gas emissions arising from the investments necessary to generate the electricity matrices proposed by the scenarios.

The methodological framework for the formulation of the scenarios was elaborated by the PCE's group of experts and agreed with the scenario teams, ensuring methodological rigor in the database used, in the proposed matrixes and estimated impacts.

The scenario teams each presented two proposals and estimated impacts, one for a Business as Usual (BAU) scenario and the other for scenarios reflecting an Energy Efficiency Factor (EFF). The projection horizon of the scenarios was 2050, based on 2013 values, and the results were released in 2015.

Details on the input–output matrix and how it was applied in the study are in the full version of this paper, available in **http://escolhas.org/biblioteca/estudos-instituto-escolhas/.**

[4] MIP 2011 is the most recent lauched by IBGE.
[5] Data on the National Energy Balance and the Decennial Energy Plans.

Main impacts of change in the energy matrix

This study seeks to understand how reorganizing the Brazilian electricity sector towards increased generation of electricity from renewable sources would impact on the economy, employment and GHG emissions of all sectors in an horizon projected until 2050.

The proposed investment spike is annual and a percentage of GDP, that is, it represents the average annual increase in investments required to achieve the change in the electricity matrix by 2050 (depending on the GDP for each year), according to the projection of each scenario team.

General Impacts

Investment
The transition to an electricity matrix with fewer emissions necessarily requires greater investments;

The impacts of the energy efficiency scenarios (EEFs) boost the economy most, as they represent an investment 52% higher than the BAU scenarios, adjusted to generate the same amount of energy as the EEF.

GDP & Employment
The scenarios' effects on the economy are directly linked to the level of investment needed to achieve them. As the level of investment increases or the longer the time period considered, the impacts on the economy are greater.

The growth in the GDP of the economy as a whole is higher in the EEF scenario, when compared to the BAU, for all the scenario teams except for the ITA. This growth stems from the promotion of related economic activities

All scenarios in 2030 and 2050 point to higher growth in GDP and employment in the EEF scenario when compared to the BAU scenario. In addition, as the level of investment increases, the impacts on the economy are greater.

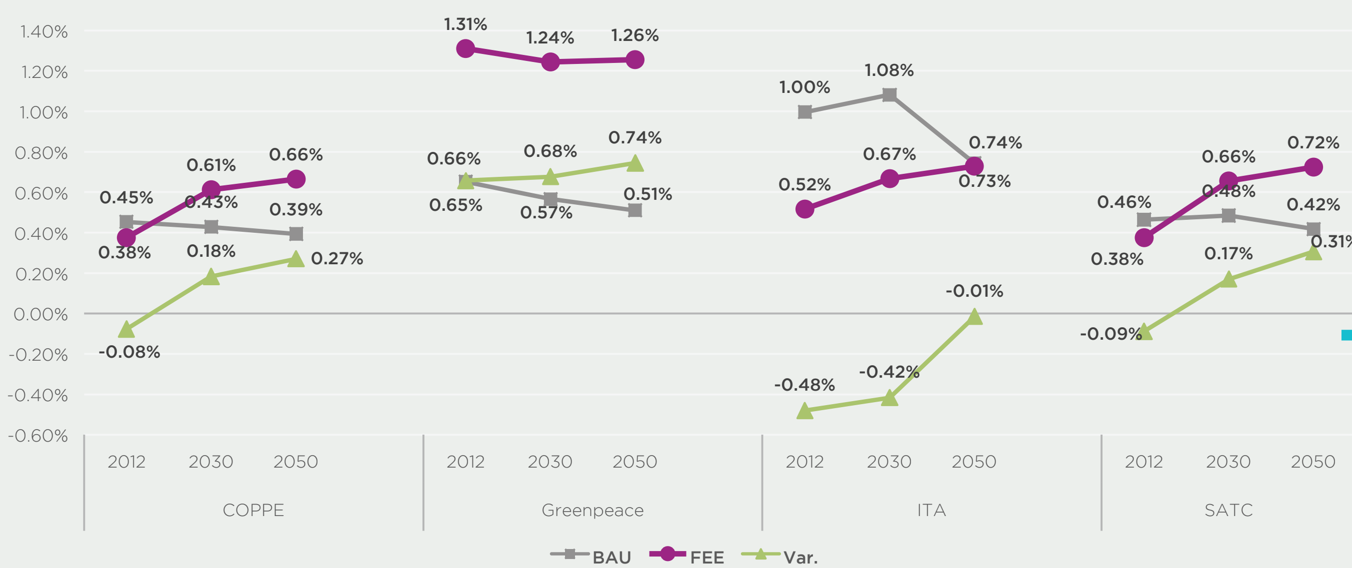
Total effect of investments in electric power generation on jobs for the years 2012, 2030 and 2050 (all scenarios)

2012	Units for 1 year			%		
Scenarios	**BAU**	**FEE**	**variation**	**BAU**	**FEE**	**Percent change**
COPPE	243.747	202.474	-41.274	0,24%	0,20%	-0,04
Greenpeace	350.918	706.133	355.215	0,35%	0,71%	0,36
ITA	536.260	278.354	-257.907	0,54%	0,28%	-0,26
SATC	249.594	202.284	-47.310	0,25%	0,20%	-0,05

2030	Units for 1 year			%		
Scenarios	**BAU**	**FEE**	**variation**	**BAU**	**FEE**	**Percent change**
COPPE	225.117	333.183	108.066	0,21%	0,31%	0,1
Greenpeace	298.531	630.751	332.220	0,28%	0,59%	0,31
ITA	567.405	380.421	-186.984	0,53%	0,36%	-0,18
SATC	254.952	355.829	100.877	0,24%	0,33%	0,09

2050	Units for 1 year			%		
Scenarios	**BAU**	**FEE**	**variation**	**BAU**	**FEE**	**Percent change**
COPPE	222.140	412.072	189.932	0,19%	0,36%	0,17
Greenpeace	291.925	685.241	393.316	0,26%	0,60%	0,34
ITA	417.431	473.048	55.617	0,37%	0,41%	0,05
SATC	236.933	453.347	216.415	0,21%	0,40%	0,19

Total effect of investments in eletric power generation on jobs for the years 2012, 2030 and 2050 (all scenarios)



Emissions

All the scenario teams projected declines in GHG emissions in the long term. The fall in the ITA's EEF scenario is the largest, more than offsetting the warming of the economy generated by investments. Unlike the impacts on GDP and employment, the impacts on GHG increase over time, reaching 6% in the ITA’s BAU scenario.

The differences between the BAU and EEF scenarios in relation to GHG emissions are quite substantial, reaching an economy of 4.1 MtCO2e/year for the ITA (in 2030), which presented the biggest differences between BAU and EEF.

Total effect of investments in electricity generation on GHG emissions for the years 2012, 2030 and 2050 (all scenarios)

2012	tCO_2e			%		
Scenarios	**BAU**	**FEE**	**variation**	**BAU**	**FEE**	**Percent change**
COPPE	117.221	91.044	-26.176	0,58%	0,45%	-0,13
Greenpeace	162.397	288.962	126.564	0,81%	1,44%	0,63
ITA	254.862	135.111	-119.751	1,27%	0,67%	-0,6
SATC	124.438	97.041	-27.397	0,62%	0,48%	-0,14

2030	tCO_2e			%		
Scenarios	**BAU**	**FEE**	**variation**	**BAU**	**FEE**	**Percent change**
COPPE	526.313	467.137	-59.175	0,96%	1,61%	0,65
Greenpeace	244.241	498.282	254.041	1,08%	1,79%	0,71
ITA	5.156.526	1.052.520	-4.104.007	6,01%	2,59%	-3,42
SATC	468.792	477.897	9.104	1,06%	1,59%	0,53

2050	tCO_2e			%		
Scenarios	**BAU**	**FEE**	**variation**	**BAU**	**FEE**	**Percent change**
COPPE	1.350.196	967.220	-382.976	1,28%	3,03%	0,0175
Greenpeace	1.531.345	511.052	-1.020.293	1,85%	3,54%	0,0169
ITA	1.752.324	2.641.219	888.895	2,05%	4,28%	0,0223
SATC	1.353.781	654.248	-699.533	1,35%	3,35%	0,02

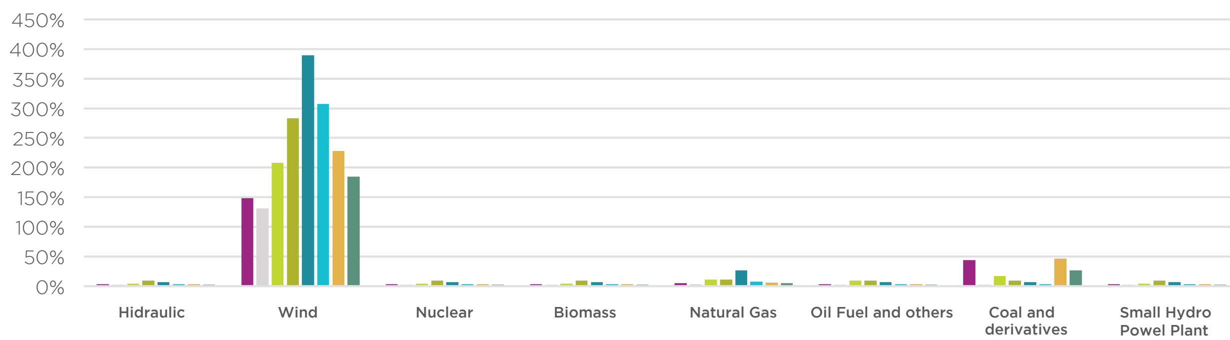
Sectorial Impacts

The impacts on GDP from the Brazilian electricity matrix are more significant in the sectors that generate electricity. In other sectors, the impacts are small (between 1% and 2%). This is because the effect on these sectors is indirect and derives from investments made in the sectors producing electricity.

GDP

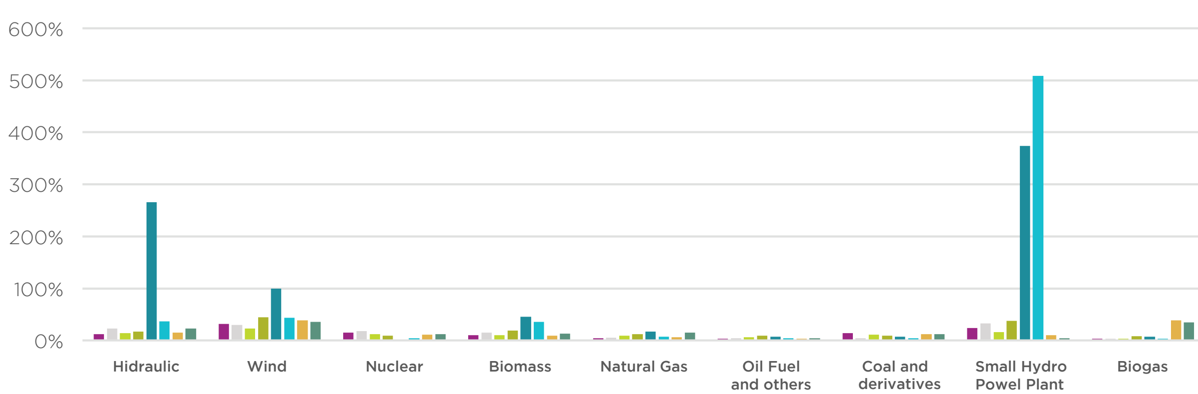
There is a strong impact on the wind sector in all scenarios in 2012, with GDP growth in the sector almost 400%.
In 2030, the highlights are the hydropower and small hydro sectors, with a 500% increase in the ITA's EEF scenario.
By 2050, there is more equal growth among sources, as most investments have already been made and sectors, previously small, have reached the desired shares in the projected matrices.

% (percentage) variation in the GDP of the electric power producing sectors (2012)



COPPE - BAU | COPPE - FEE | Greenpeace - BAU | Greenpeace - FEE | ITA - BAU | ITA - FEE | SATC - BAU | SATC - FEE

% (percentage) variation in the GDP of the electric power producing sectors (2030)



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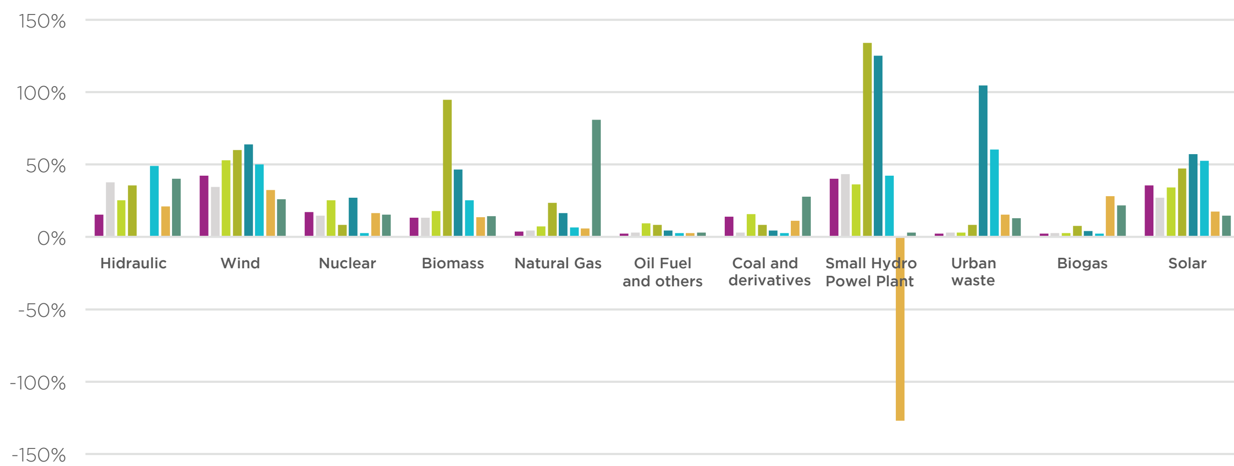
% (percentage) variation in the GDP of the electric power producing sectors (2050)



COPPE - BAU | COPPE - FEE | Greenpeace - BAU | Greenpeace - FEE | ITA - BAU | ITA - FEE | SATC - BAU | SATC - FEE

Employment

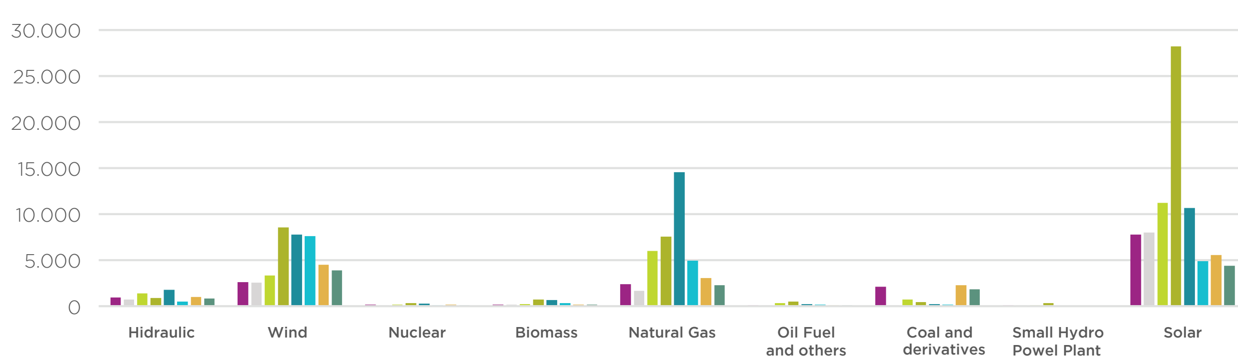
The impacts on the ocean energy, urban waste and biogas sectors are zero, since there were no investments in these sources.

The highlights are the solar, natural gas and wind sectors, which generated jobs in the order of 28 thousand in 2012, 11 thousand in 2030, and 8 thousand in 2050.

In 2030, the impacts on the solar energy sector remain high, reaching 30 thousand jobs. Other sectors are beginning to gain prominence, such as hydro and biomass.

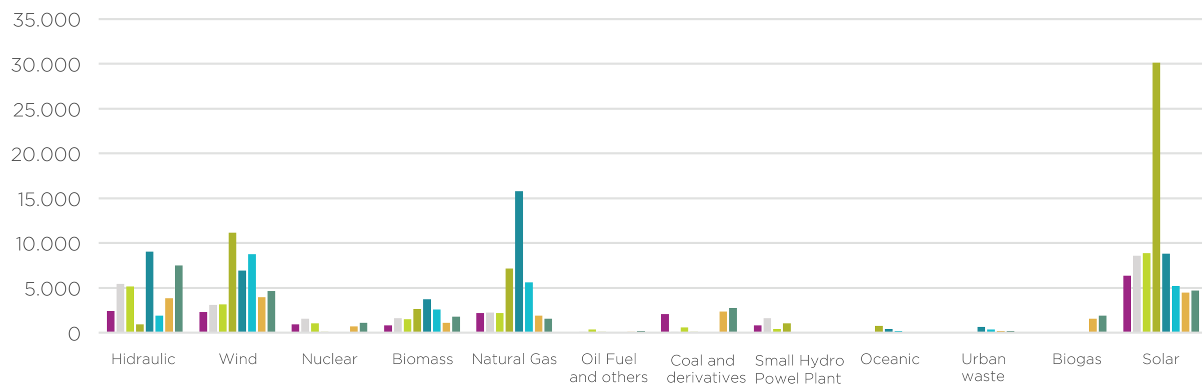
The same occurs in 2050, where solar energy generates approximately 50 thousand new jobs.

Variation in the number of employees of the electric power producing sectors (unitx por year - 2012)



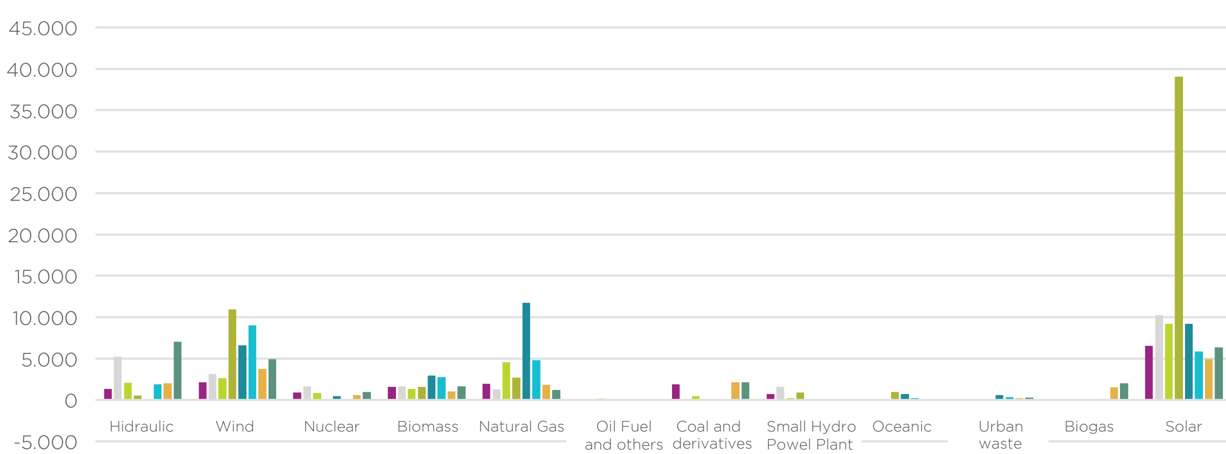
COPPE - BAU | COPPE - FEE | Greenpeace - BAU | Greenpeace - FEE | ITA - BAU | ITA - FEE | SATC - BAU | SATC - FEE

Variation in the number of employees of the electric power producing sectors (unitx por year - 2030)



COPPE - BAU | COPPE - FEE | Greenpeace - BAU | Greenpeace - FEE | ITA - BAU | ITA - FEE | SATC - BAU | SATC - FEE

Variation in the number of employees of the electric power producing sectors (unitx por year - 2050)



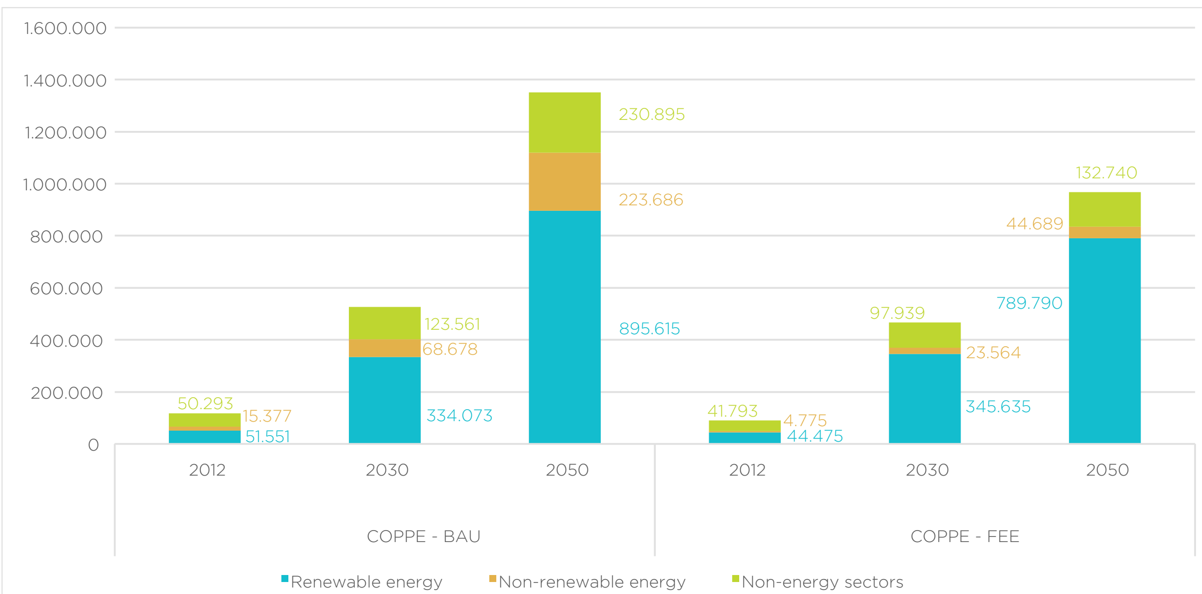
COPPE - BAU | COPPE - FEE | Greenpeace - BAU | Greenpeace - FEE | ITA - BAU | ITA - FEE | SATC - BAU | SATC - FEE

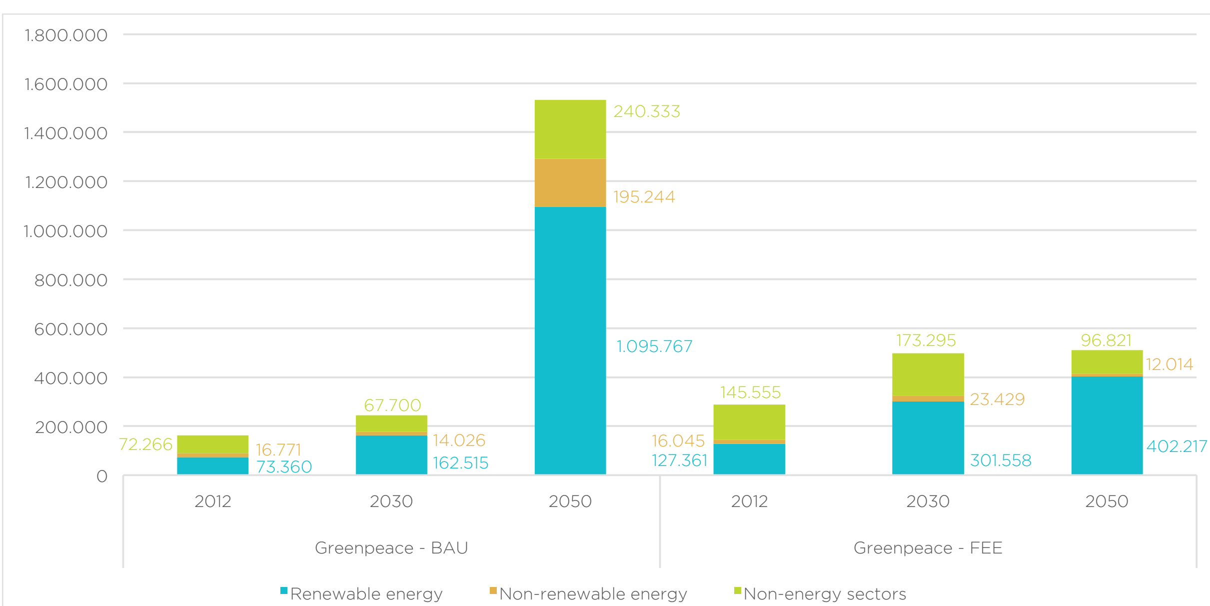
Emissions

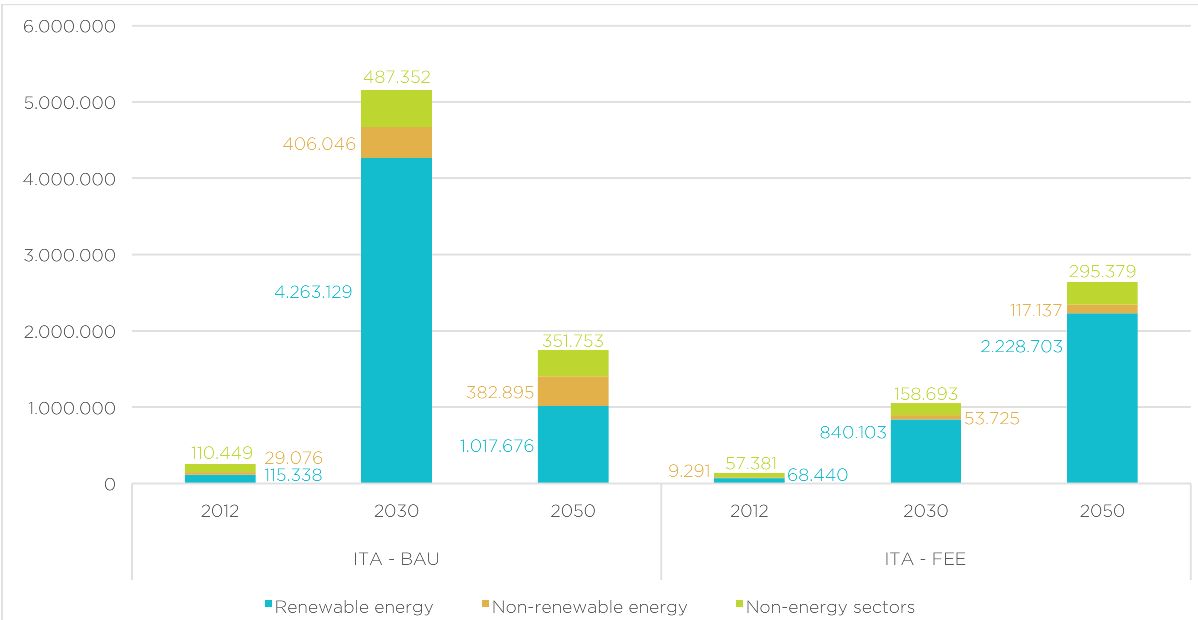
The EEF scenarios present lower emissions for almost all the teams due to efficiency gains in the renewable energy sector, as well as the non-renewable and non-energy sectors. This is not the case in the ITA scenario, as GDP growth in the BAU scenario is higher than the EEF (in 2012 and 2030, even in 2050).

In the case of Greenpeace, since GDP growth in the EEF scenario is much greater than the BAU scenario (in particular in 2030 and 2050), it is understood that the emissions are proportionally smaller in the EEF scenario.

Variation in GHG emission for all scenaris (tCO2e issued - 2012, 2030 and 2050)



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Non-renewable energy
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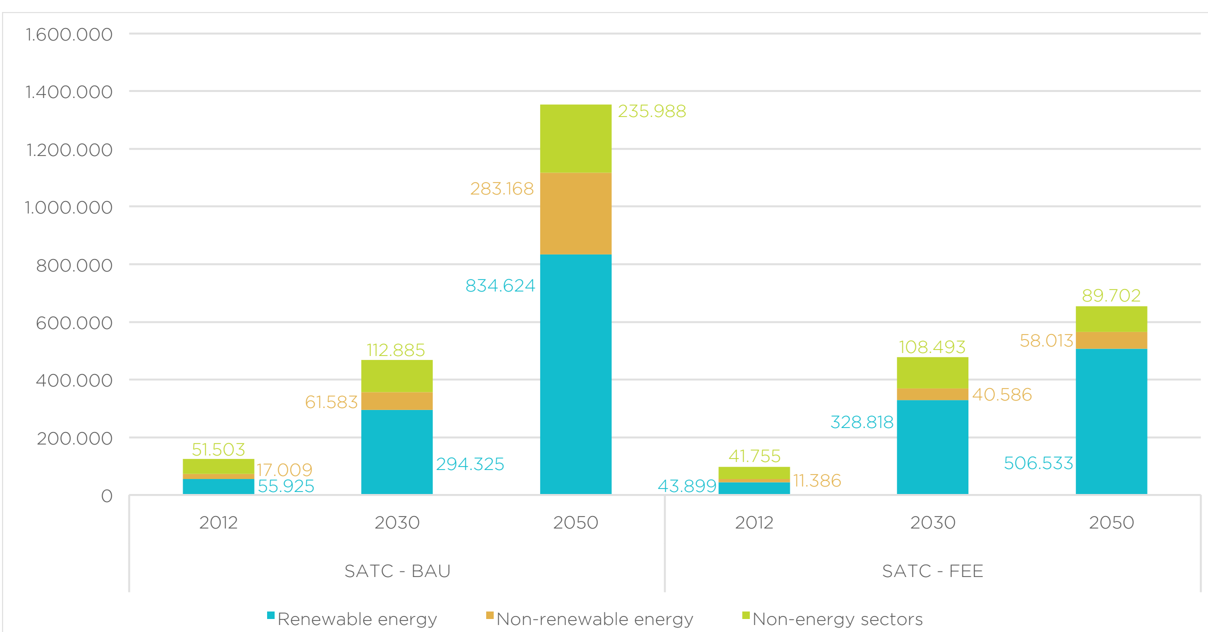
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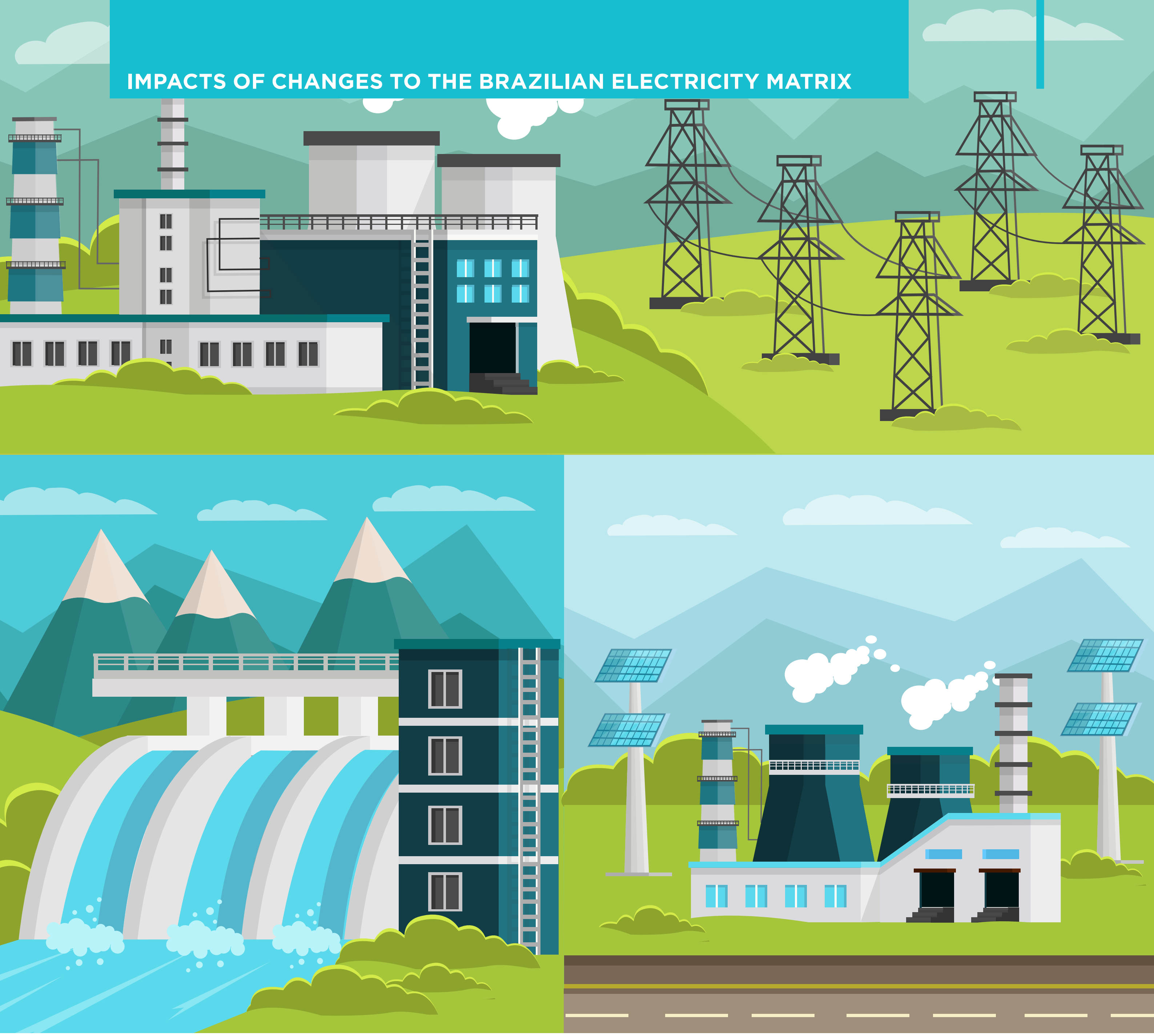
Renewable energy
Non-renewable energy
Non-energy sectors



CONCLUSIONS

The study indicates that the option for an electrical matrix focused on renewable sources, with significant growth of alternative energies such as solar, biomass and wind, bring positive net impacts to the economy in the medium and long term.

These positive impacts are derived from economic growth, as observed by the impact on GDP of the electricity sectors and by the cost savings generated after the completion of these investments, the social impact, a significant increase in the number of jobs and, principally, GHG emissions, which contribute to the achievement of the goals established in the Brazilian INDC.

The net benefits point to the possible economic viability of incentive policies for long-term energy planning that lead to energy security coupled with greater efficiency and reduced environmental impact.

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