ENERGY EFFICIENCY LEGISLATION IN BRAZIL TOWARDS NET ZERO EMISSIONS: PROJECTIONS AND PROPOSITIONS FOR SÃO PAULO STATE

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ABSTRACT

Currently, countries worldwide are debating their strategies to achieve net-zero emissions by 2050. The International Energy Agency (IEA) has called energy efficiency (EE) the "first fuel," the most cost-effective way to reverse this unprecedented challenge and provide significant benefits to society. In this sense, a proposal for the Brazilian Ten Years Energy Efficiency Plan (PDEf) was launched in 2020, which brings actions and goals for the year 2030 on EE at federal government level, aiming to generate lower energy intensities in the country. Looking to establish a further disaggregation level of the energy conservation policies portfolio, this paper intends to go to the state government level, taking the state of São Paulo as a case study. The aim is to make projections of electricity and fuel savings in relevant sectors for the year 2030 and propose adjustments in public policies. As results, electricity savings of 11,171.46 GWh and fuel savings of 7,486.74 ktoe are expected by 2030. These values represent 5,1% of the electric energy consumption and 11% of the fuel consumption projected for São Paulo in 2030.

Keywords: Paris Agreement; Energy efficiency policies; Energy conservation; Energy savings.

RESUMO

Atualmente, países em todo o mundo estão debatendo suas estratégias para atingir emissões líquidas zero até 2050. A Agência Internacional de Energia (AIE) chamou a eficiência energética (EE) de "primeiro combustível", a maneira mais econômica de reverter esse desafio sem precedentes e fornecer benefícios significativos para a sociedade. Nesse sentido, foi lançada em 2020 a proposta do Plano Decenal de Eficiência Energética (PDEf) do Brasil, que traz ações e metas para o

ano de 2030 sobre EE no âmbito do governo federal, visando gerar menores intensidades energéticas no país. Buscando estabelecer um maior nível de desagregação do portfólio de políticas de conservação de energia, este trabalho pretende ir para o nível do governo estadual, tomando o estado de São Paulo como estudo de caso. O objetivo é fazer projeções de economia de energia elétrica e combustível em setores relevantes para o ano de 2030, e propor ajustes nas políticas públicas. Como resultados, espera-se uma economia de energia elétrica de 11.171,46 GWh e economia de combustível de 7.486,74 ktep até 2030. Esses valores representam 5,1% do consumo de energia elétrica e 11% do consumo de combustível projetado para São Paulo em 2030.

Palavras-chave: Acordo de Paris; Políticas de eficiência energética; Conservação de energia; Economia de energia.

1. INTRODUCTION

The International Energy Agency reports that the energy sector is responsible for approximately 75% of the total global emissions (IEA, 2021a). It has been debated since before the Paris Agreement on climate change that it is necessary to transform this sector in order to face the climate crisis. The goal that the Agreement signatory countries are discussing and committing to is to reach zero liquid emissions by 2050, for which one of the paths is to create strategies in terms of energy efficiency (IEA, 2021b).

Brazil is one of the leading countries in energy terms. In 2020, the country was the 6th world's largest energy consumer (286 Mtoe) (ENERDATA, 2020). Despite the significant presence of renewable sources in the Brazilian supply of energy, one of the most important challenges is the growing trend of greenhouse gases (GHG) emissions in the country (LIN et al., 2017).

The National Energy Plan (PNE) deals with long-term energy planning in Brazil. EE strategies are consolidated in the National Energy Efficiency Plan (PNEf) within this horizon. On the other hand, the National Ten Years Energy Plan (PDE) will drive investments in production and consumption, linking the trends observed for the national energy supply and demand, and PNE's energy forecasting scenarios. In 2021, a proposal for the Ten Years Energy Efficiency Plan (PDEf) was published, a stage in the PDE preparation concerning actions to generate lower energy intensities (ELETROBRAS, 2021).

The PDEf provides a portfolio of EE actions for the main components of the country's economy: buildings, transportation, industry, public services, and agriculture, at the federal government level. Aiming at creating a further level of disaggregation of the energy conservation policies portfolio proposed in PDEf, this paper addresses

the state government level. Forecasts of electricity and fuel savings for the year 2030 are carried out in the paper, together with proposals of adjustments in public policies, taking the state of Sao Paulo as a case study.

2. METHODS

Table 1 summarizes the main socioeconomic and energy data for the state of São Paulo in 2019, which is the most populous in Brazil, home to approximately 22% of the national population. The state also has the highest GDP among all Brazilian states - 33% of the national GDP (SÃO PAULO, 2021a).

Table 1 – São Paulo state's socioeconomic and energy data in 2019

General data	**2019**
State area	248,222 km^2
Total population	44,315,000
Demographic density	178.53 hab./km^2
Total households	15,108,000
Gross Domestic Product - GDP	R$ 2,388,247,000,000.00
Electricity generation capacity	26,898 MW
Electricity production	67,942 GWh
Electricity consumption	151,120 GWh
Final energy consumption	70,116,000 toe
Total energy intensity	0.072 toe/1000 R$ of 2005
Final energy consumption per capita	1.509 toe/hab.
CO_2 emissions per inhabitant	1.614 tCO_2/hab.

To begin with, a qualitative analysis of EE legislation in Brazil and specifically in the Sao Paulo state was carried out.

Then, a quantitative analysis provided the energy demand forecasts for the main components of the state of São Paulo economy, based on the corresponding forecasts of the PDEf proposal (ELETROBRAS, 2021). A fixed ratio between the state and the national energy consumptions in each of these economy components was assumed. The 2030 energy demand forecasts for the state also assume that the regional distribution of the population and energy consumption in each of these economy components will not suffer significant changes.

2.1. Data Collection and Analysis

Legislation data on EE in Brazil and São Paulo were collected from May to July 2021. The collected legislation, reports, and papers were mainly available online from government agencies, legislative branches, and related energy institutions. On the other hand, the data on energy and electricity consumption in the state of São Paulo were obtained from BEESP 2021 (SÃO PAULO, 2021a), while the corresponding data at the national level were collected from BEN 2020 (EPE, 2020) and PDE 2030 (EPE, 2021b).

The data analysis was carried out in two stages, considering different assumptions. First, energy consumption and EE forecasts for 2030 for the state of São Paulo were made based on the PDE 2030 (EPE, 2021b), with the impacts of the Covid-19 pandemic on the economy duly incorporated. For the second stage, such forecasts were obtained as shares of the forecasts presented at the PDEf proposal. These forecasts also took into account the main mechanisms and policies identified at the state level, from state level studies. Whenever necessary, modifications considering the Covid-19 impacts were made. Some EE forecasts use annual growth rates based on similar EE programs in other countries, or through empirical observations.

2.2 General information on PDE 2030

The PDE plan is prepared annually by the Energy Research Office (EPE) and the Ministry of Mines and Energy (MME). The main objective of the plan is to indicate the perspectives, under the government's view, of the energy sector expansion within the horizon of ten years, in an integrated approach for the several sources of energy. PDE 2030 started in March 2020 and it was concluded in December 2020. This plan explored the economic recovery uncertainties due to the Covid-19 pandemic and its impacts on planning. In PDE 2030's Chapter 9, conserved energy forecasts are presented, as differences between the forecasts not considering the expected EE gains, and the forecasts not taking into account them.

The state of São Paulo was responsible for 27.7% of the country's electricity consumption (151,120 GWh) and 25.42% of fuel consumption (50,396.103 toe) in 2019 (SÃO PAULO, 2021a). These percentages were applied to the PDE's forecasts producing the state of São Paulo electricity, fuels and energy savings forecasts shown in Table 2.

It should be pointed out that this paper, unlike the PDE 2030, does not include forecasts of the following Distributed Energy Resources: solar thermal energy for the residential sector, micro and mini distributed generation, and the self-production of energy not injec-

ted into the grid. PDE 2030's fuel savings forecasts do not consider fuel savings in the residential sector. The plan assesses EE gains in electricity consumption in the services, transportation, residential, industrial, and agricultural sectors.

Table 2 - Forecasts of savings in electricity and fuel consumptions in the state of São Paulo based on PDE 2030

Electricity (GWh)	**2019**	**2025**	**2030**
Electricity consumption without conservation measures (EC)	151,120	181,347	220,169
Electricity consumption with conservation measures	151,120	177,146	210,937
Electricity savings (ES)	0	4,201	9,232
(ES/EC) %	0.00%	2.32%	4.19%
Fuels (x1000 toe)	**2019**	**2025**	**2030**
Fuel consumption without conservation measures (FC)	50,396	56,844	65,872
Fuel consumption with conservation measures	50,396	55,221	62,186
Fuel savings (FS)	0	1,623	3,685
(FS/FC) %	0.00%	2.86%	5.59%

2.3 Assumptions regarding the PDEf

This paper, as well as the PDEf, addresses the following branches of the economy: (i) residential, commercial, and public buildings; (ii) industry (not including the energy sector); (iii) transportation; and (iv) services (only public lighting and sanitation). Regarding EE, unlike other energy studies, the energy sector is not considered within the industry. All energy savings growth assumptions for programs at the federal level adopted in the PDEf were considered in the paper.

For the public sector and buildings, in which only electricity savings were considered, the forecasts for the state of São Paulo were obtained multiplying the PDEf forecasts for Brazil by 0.277, which was the share of the state's electricity consumption in the country's electricity consumption in 2019. For the other three sectors, energy consumption data by sector from BEESP 2021 (SÃO PAULO, 2021a), at the state level, and from BEN 2020 (EPE, 2020), at the country level, were used to calculate the rates applied to the PDEf forecasts. For the transportation sector, the adopted rate was 28%, which was the share of the state of São Paulo (SÃO PAULO, 2021a) in the energy consumptionof the transportation sector in Brazil (EPE, 2020). The share of electricity consumption by industries in the state of São Paulo was 31.18% of the corresponding consumption in the country in 2019. Therefore, this was

the rate used to forecast electricity savings for this sector in the state. The state's industrial sector consumed 39.31% of the total fuel consumption in the Brazilian industry in 2019; this rate was used to forecast fuel savings in the state industry. The agricultural sector in São Paulo's was responsible for 11.65% of the country's electricity consumption in this sector and 4.3% of its fuel consumption in 2019; so, these rates were employed to forecast electricity and fuel consumption in this sector at the state level.

The PDEf divides programs and mechanisms into two groups: (1) current programs and respective enhancements, which were presented in Chapter 2 of the report, and (2) additional energy efficiency policies and mechanisms, which were proposed in Chapter 3. The proposed EE actions in the Plan were classified as impact actions and structuring actions. Impact actions are those activities that will directly contribute to create an energy efficiency market (with direct energy benefits of energy in Wh or avoided Joules, for example). The structuring actions remove barriers for the attainment of the impact actions results and allow the implementation of energy efficiency projects that are not economically attractive to the market, such as qualification courses. Some of the structuring actions proposed in the PDEf for all branches of the economy are: (i) Integrated information system on energy efficiency; (ii) Digital energy efficiency; and (iii) Incentive program for energy management systems. A program to boost digitalization in buildings and the setting-up of digital systems aimed at energy efficiency in transportation are also structuring actions proposed in the PDEf. The operationalization of a national program for the efficient use of oil products, natural gas and biofuels is a structuring action proposed for the transportation sector. The PDEf proposes some obligations, as structuring actions, for energy-intensive industries, such as the requirement of energy managers in each plant, and the provision of regular energy audits and energy consumption reports by all of these plants. A National Program for Energy Efficiency in Rural Areas is a structuring action proposed for the agricultural sector.

Table 3 presents the current programs and policies (CPP) by sector, while Table 4 shows the additional policies and mechanisms (APM) proposed in the PDEf (ELETROBRAS, 2021).

Table 3 - Current energy efficiency programs and policies at the federal government level

Current programs and policies (CPP)	Branches of the economy							
	Public sector		Buildings		Transportation		Industry	Agriculture
	Public lighting	Sanitation	Commercial and public	Residential	Passengers	Cargo		
Energy Efficiency Law (LEE) and its regulations (since 2001)			X	X			X	X
Brazilian Labelling Program (PBE) (since 1984)	X	X	X	X			X	X
Electricity Efficient Cities Network (RCE) (since 1998)	X	X						
National Electric Energy Conservation Program (Procel) (since 1985)	X	NA[1]	X	X			X	X
National Program for the Rationalization of the Use of Petroleum and Natural Gas Products (Conpet) (since 1991)			NA	NA	NA	NA	NA	NA
Energy Efficiency Program (PEE/ANEEL), Law no. 9.991/2.000	X	X	X	X			X	X
Brazilian Vehicle Labelling Program (PBEV)					X	X		
Other government programs and policies affecting energy efficiency								
Renovabio								X
Actions within the scope of Embrapa								X
Rural credit								X
Rota 2030					X	X		
Energy Efficiency in Urban Mobility (EEMU)					X	X		
National Logistics Plan (PNL)						X		

1 Information was not available.

Table 4 - Additional energy efficiency policies and mechanisms at the federal government level

Additional policies and mechanisms (APM)	Economy Branches							
	Public sector		Buildings		Transportation		Industry	Agriculture
	Public lighting	Sanitation	Commercial and public	Residential	Passengers	Cargo		
Energy efficiency auctions	X	X					X	X
Equipment, engines and pumps labelling and certification		X				X	X	X
Minimum level of energy efficiency for equipment		X					X	X
Market for energy efficiency certificates (white certificates)							X	X
Institutional instruments for promoting energy efficiency in the public sector: public-private partnerships and performance contracts (ESCOS)	X	X						
Energy performance certificate for real estate transaction (CDE)			X	X				
Energy efficiency program in the use of natural gas in buildings (PEEUGN)			X	X				
Cogeneration promotion mechanisms (MFC)			X					
Inclusion of energy efficiency clauses in public transport service concessions					X			
Program to support the expansion of light electric vehicles					X			
Program to encourage the electrification of light trucks and buses					X	X		
Promoting the use of more efficient fuels for passenger transport					X			
Integrated optimization of the operation of hydro power stations reservoirs to enable/encourage waterway transportation						X		
Program aimed at streamlining municipal public service routes						X		
Voluntary agreements and energy efficiency networks (AV/REE)							X	
Mandatory energy efficiency targets (MM) for energy-intensive industries							X	

3. RESULTS AND DISCUSSION

3.1. Public policies in São Paulo state concerning EE

Currently, cross-cutting EE mechanisms at the state government

level refer mainly to promoting scientific research and providing credit lines to develop EE projects (SÃO PAULO, 2012; 2019). The envisaged EE mechanisms of each sector of the state were compiled mainly from the São Paulo Energy Plan - PPE 2020 (SÃO PAULO, 2012) and the Energy Matrix SP 2035 (SÃO PAULO, 2011).

The envisaged state government policies and mechanisms, presented in Table 5, can be summarized as follows: 1) for the public sector and buildings, the focus is, in addition to implementing existing federal mechanisms, such as Procel programs, promoting energy management actions, public-private partnerships and performance contracts (ESCOs), tax incentives, public purchases with EE requirements, and the introduction of EE requirements in buildings codes; 2) in the transportation sector, the most significant initiatives are the São Paulo State Vehicle Pollution Control Plan (PCPV), which proposes actions to reduce vehicle emissions and fuel consumption, the optimization of the passengers and cargo transportation, which includes the expansion of the metropolitan subway and train networks and other projects to replace less efficient modes of transportation (São Paulo, 2021b) and 3) in the industrial sector, the mechanism called “EE in the industry,” which focuses on electricity consumption stands out (São Paulo, 2011). Other envisaged measures for this sector are the creation of a “Market of Conserved Energy Certificates” and tax policies. In addition, there are also structuring actions, such as disseminating knowledge about EE, through educational campaigns, EE courses in schools and universities and technical training projects.

Table 5 – Envisaged policies and mechanisms of the São Paulo state government

	Economy Branches							
	Public sector		Buildings		Transportation		Industry	Agriculture
	Public lighting	Sanitation	Commercial and public	Residential	Passengers	Cargo		
Efficiency in public lighting	X							
Public-private partnerships and performance contracts (ESCOS)			NA					
Integrated energy efficiency Program (PIEE): energy management actions			X					

Table 5 – Envisaged policies and mechanisms of the São Paulo state government (cont.)

	Economy Branches							
	Public sector		Buildings		Transportation		Industry	Agriculture
	Public lighting	Sanitation	Commercial and public	Residential	Passengers	Cargo		
Decree no. 45.643/2001: public purchases of more efficient light bulbs			NA					
Introduction of energy efficiency requirements in building codes.			NA	NA				
Tax incentives, such as green IPTU			NA	NA				
Efficiency in electricity consumption in several end uses in industry							X	
Energy efficiency plans with targets; credit lines; tax exemption on the use of certain fuels; conserved energy certificate markets							X	
Expansion of subways and metropolitan train networks and other projects to replace less efficient modes of transport.					X	X		
Expansion and modernization of the São Paulo Metropolitan Trains Company (CPTM) network.					X	X		
Expansion of the use of the waterway modal, with the elimination of bottlenecks in the Tietê-Paraná Waterway and upgrades in intermodal connections					X	X		
Creation of the Multimodal Transport Operator (OTM).						X		
Creation of a state program to control the smoke emissions of the circulating diesel fleet						X		
Implementation of a truck fleet renewal program						X		

3.2. Forecasts

According to the forecasts described in this paper, it is estimated that 11,171.46 GWh of electricity and 7486.74 ktoe of fuel could be saved in the state of São Paulo in 2030. These values represent, respectively, 5.1% of the electric energy consumption projected for São Paulo in 2030 and 11% of the fuel consumption. As shown in Table 6, the industrial sector has the greatest potential for electricity savings (51% of the total electricity savings), followed by the residential sector (26%) and the commercial and public sector (19%). In terms of fuel economy, the transportation of passengers has the greatest potential

(41% of the total fuel savings), followed by the industrial sector (38%) and transportation of cargo (21%). From the perspective of total energy savings, the industrial sector is the first (39.2% of the total energy savings), followed by the passenger (36.4%) and cargo (18.6%) transportations.

Table 6 - Forecasts of energy savings in the state of São Paulo, by sector, in 2030

Sector	**Electric energy savings (GWh)**	**Fuel savings (103 toe)**
Agriculture	248.46	16.79
Public Lighting	228.96	0.00
Sanitation	36.68	0.00
Residential	2921.48	0.00
Commercial and Public	**2075.03**	**0.00**
Industry	5660.85	2826.73
Transportation of passengers	0.00	3071.01
Transportation of cargo	0.00	1572.22
Total	11171.46 GWh	7486.75 ktoe

The forecasts of electricity savings year by year and by sector are presented in Table 7 and Figure 1, while in Table 8 and Figure 2 there are the forecasts for fuel savings.

Table 7 - Forecasts of electricity savings by sector, in GWh, in the state of São Paulo

Year	**Agriculture**	**Public sector**		**Buildings**		**Industrial sector**
		Public Lighting	**Sanitation**	**Residential**	**Commercial and Public**	
2020	32.29	90.34	4.11	101.38	1515.79	872.79
2021	49.75	95.62	4.17	198.89	1561.24	1254.69
2022	68.51	101.20	4.23	331.29	1608.09	1654.82
2023	87.87	129.28	8.10	499.43	1690.97	2093.17
2024	108.60	135.55	8.22	720.20	1740.64	2550.43
2025	129.98	183.75	36.04	999.69	1795.04	3025.06
2026	153.05	193.56	36.17	1308.55	1847.80	3498.39
2027	176.56	201.02	36.29	1658.40	1902.26	3990.39

Table 7 - Forecasts of electricity savings by sector, in GWh, in the state of São Paulo (cont.)

Year	Agriculture	Public sector		Buildings		Industrial sector
		Public Lighting	Sanitation	Residential	Commercial and Public	
2028	202.43	211.70	36.42	2021.55	1958.13	4505.47
2029	224.26	220.07	36.55	2429.01	2015.98	5049.57
2030	248.46	228.96	36.68	2921.48	2075.03	5660.85

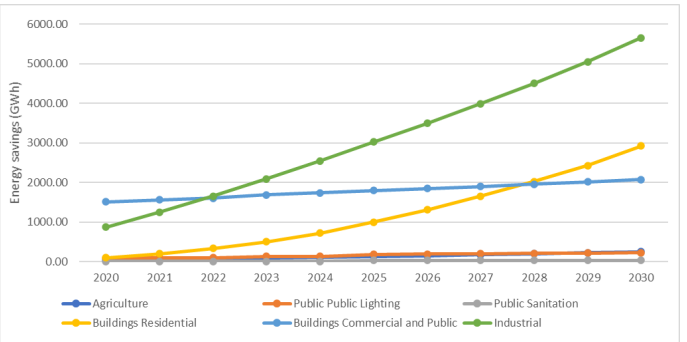

Figure 1 - Forecasts of electricity savings by sector in the state of São Paulo

Table 8 - Forecasts of fuel savings by sector, in 1,000 toe, in the state of São Paulo

Year	Agriculture	Industrial sector	Transportation	
			Passengers	Cargo
2020	2.72	585.30	140.71	213.57
2021	3.84	771.61	333.51	303.23
2022	5.10	966.47	571.51	403.25
2023	6.32	1169.12	835.22	517.93
2024	7.67	1374.89	1082.20	650.52
2025	9.02	1591.29	1353.87	800.19
2026	10.54	1815.20	1651.22	953.51

Table 8 - Forecasts of fuel savings by sector, in 1,000 toe, in the state of São Paulo (cont.)

Year	Agriculture	Industrial sector	Transportation	
			Passengers	Cargo
2027	11.99	2047.85	1967.49	1093.21
2028	13.57	2290.07	2307.61	1239.30
2029	15.09	2543.47	2665.19	1397.58
2030	16.79	2826.73	3071.01	1572.22

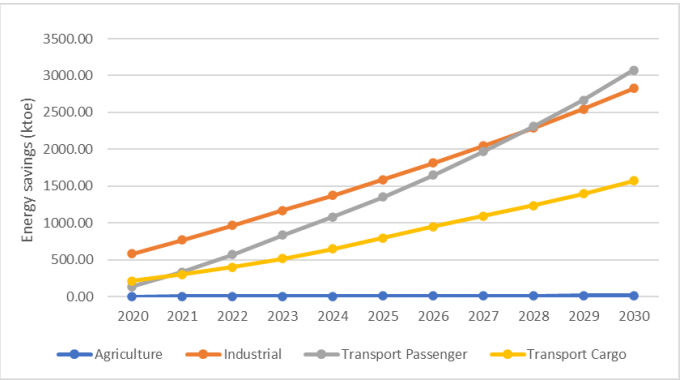

Figure 2 - Forecasts of fuel savings by sector in the state of São Paulo

Tables 9 and 10 and Figures 3 and 4 illustrate all sector's forecasts divided into three groups of actions: Current Programs and Policies (CPP); Additional Programs and Mechanisms (APM); and São Paulo government's Programs and Policies, which refers to existing and envisaged policies at the state level. Part of the savings come from Autonomous Actions, which are initiatives of the agents directly involved (owners and managers of companies and institutions).

Table 9 - Electricity savings forecasts for the state of São Paulo, year by year, in GWh, for all sectors, by type of actions

Year	Electricity savings (GWh)					Current programs and policies (CPP)					Additional programs and mechanisms (APM)			
	Total	Autono mous actions	CPP	APM	São Paulo government's envisaged programs and policies	LEE	PBE	Procel	PEE	Other government programs and policies	Auctions	Labeling	Minimum energyperformance Standards (MEPS)	Additional policies and mechanisms in some sectors
2020	2616.81	351.34	1988.33	0.00	277.13	262.28	465.39	1214.04	42.21	4.40	0.00	0.00	0.00	0.00
2021	3164.53	778.65	2093.94	0.00	291.94	269.42	478.52	1294.55	44.67	6.78	0.00	0.00	0.00	0.00
2022	3768.43	1254.87	2206.00	0.00	307.55	276.84	491.98	1380.48	47.35	9.34	0.00	0.00	0.00	0.00
2023	4508.92	1803.63	2359.08	22.20	324.00	341.17	519.65	1432.23	54.05	11.98	0.00	0.01	0.03	22.16
2024	5263.83	2067.22	2506.61	348.65	341.34	349.64	533.82	1551.03	57.31	14.81	251.31	0.01	0.03	97.30
2025	6169.68	980.37	2652.38	2177.31	359.62	358.14	548.61	1667.03	60.87	17.72	783.65	28.07	0.03	1365.56
2026	7037.45	1548.55	2802.95	2307.06	378.88	366.92	563.74	1786.66	64.76	20.87	795.39	33.05	0.03	1478.58
2027	7964.96	2221.80	2985.60	2358.37	399.19	376.27	579.48	1936.74	69.02	24.08	806.94	38.13	0.03	1513.27
2028	8936.11	2858.30	3163.37	2493.84	420.59	385.65	595.57	2080.88	73.67	27.60	819.96	43.72	0.03	1630.14
2029	9975.41	3628.88	3349.54	2553.84	443.15	395.31	612.00	2232.39	78.76	31.07	834.21	48.31	0.03	1671.29
2030	11171.46	4530.12	3558.32	2616.09	466.94	405.23	628.92	2404.87	84.33	34.96	848.74	53.39	0.03	1713.94

Table 10 - Fuel savings forecasts for the state of São Paulo, in 1,000 toe, year by year, for all sectors, by type of actions

Year	Fuel savings (1.000 toe)					Current programs and policies (CPP)					Additional programs and mechanisms (APM)			
	Total	Autono mous actions	CPP	APM	São Paulo government's envisaged programs and policies	LEE	PBEV	Procel	Conpet	Other government programs and policies	Auctions	Labeling	MEPS	Additional policies and mechanisms in some sectors
2020	942.31	303.86	106.60	0.00	531.85	0.00	14.97	9.04	0.00	82.58	0.00	0.00	0.00	0.00
2021	1412.20	472.68	268.04	0.00	671.48	0.00	39.32	13.76	0.00	214.96	0.00	0.00	0.00	0.00
2022	1946.32	649.09	485.39	0.00	811.85	0.00	71.81	18.87	0.00	394.71	0.00	0.00	0.00	0.00
2023	2528.88	831.75	456.84	287.29	952.99	0.00	119.10	24.77	0.00	312.97	0.00	0.00	0.00	287.29
2024	3115.06	934.37	622.78	462.95	1094.95	0.00	158.97	38.92	0.00	424.90	45.05	0.00	0.00	417.90
2025	3754.80	464.95	808.62	1243.47	1237.76	0.00	204.81	46.78	0.00	557.03	229.82	1.95	0.00	1011.70
2026	4429.73	617.78	1010.22	1420.28	1381.46	0.00	255.60	54.64	0.00	699.98	234.63	2.28	0.00	1183.37
2027	5120.82	797.63	1226.19	1570.90	1526.10	0.00	308.56	71.54	0.00	846.08	239.71	2.59	0.00	1328.60
2028	5850.37	964.47	1451.33	1762.85	1671.72	0.00	366.39	80.98	0.00	1003.96	244.78	2.93	0.00	1515.14
2029	6620.35	1169.07	1694.68	1938.24	1818.36	0.00	428.45	91.20	0.00	1175.02	250.10	3.25	0.00	1684.89
2030	7486.74	1400.86	1979.03	2140.77	1966.09	0.00	501.03	102.71	0.00	1375.29	255.53	3.61	0.00	1881.63

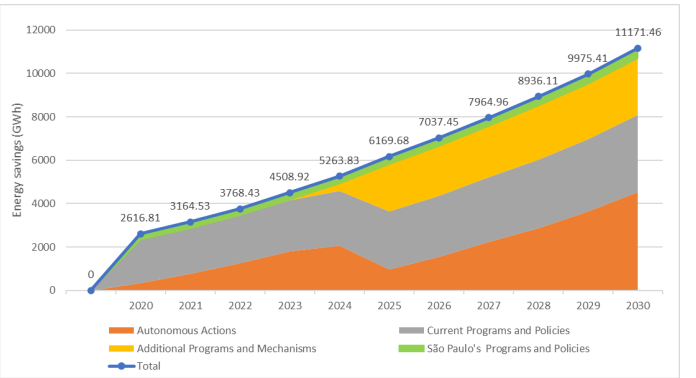

Figure 3 - Electricity savings forecasts for the state of São Paulo, year by year, for all sectors, by type of actions

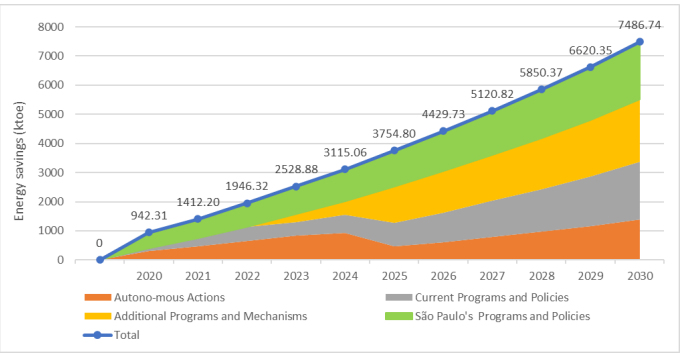

Figure 4 - Fuel savings forecasts for the state of São Paulo, year by year, for all sectors, by type of actions

4. POLICY PROPOSITIONS AND FINAL CONSIDERATIONS

This paper took into account the existing and envisaged policies and mechanisms at the federal government and state government levels related to the promotion of energy efficiency in order to produce forecasts up to the year 2030 in the state of São Paulo. According to these forecasts, electricity savings of 11,171.46 GWh and fuel savings of 7,486.74 ktoe are expected by 2030. These values represent 5.1% of the electric energy consumption and 11% of the fuel consumption projected for São Paulo in 2030. It was found that these energy savings

rates are higher than those estimated from the PDE 2030 forecasts, which are 4.19% for electricity savings and 5.59% for fuel savings (shown in Table 2). These differences occur because the forecasts based on the PDEf take into account several envisaged new actions, which are not considered in the forecasts based on PDE 2030.

Since the sectors with the most significant potential for energy savings in São Paulo are the industrial and the transportation sectors (passengers), this paper proposes additional approaches to promote EE in these sectors. Concerning the transportation sector, the first proposal is called “Vehicular EE”, which is a program that was introduced in the European Union in 2009. This program sets sequential goals that facilitate the adaptation of the automotive industry concerning GHG emissions and energy consumption. Companies that do not comply with the stipulated limits must pay a “premium” corresponding to the remaining amount to fulfill their objectives. Another measure adopted in several European countries refer to tax incentives that can impact the ownership levels of vehicles, annual mileage traveled and specific energy consumption of each vehicle (MARIANO, 2014). Finally, for the industrial sector, regular energy audits, even in companies not having energy management systems, have been a successful instrument in several countries. They have been used to identify energy conservation opportunities, quantify the energy and cost reductions savings, and inform the managers of the companies about possible profitable actions producing energy and cost savings (ANDREI et al., 2021).

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