Atlas of Energy Efficiency

Brazil | 2020

Indicators Report

Empresa de Pesquisa Energética

MINISTÉRIO DE MINAS E ENERGIA

PÁTRIA AMADA BRASIL
GOVERNO FEDERAL

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This report has two special chapters...

The first refers to a more detailed analysis of the cement industry in Brazil, and is the result of a cooperation between EPE, the International Energy Agency (IEA) and the National Union of the Cement Industry (SNIC). This chapter presents a national and an international analysis of the cement industry, with a special focus on advances in energy efficiency and carbon emissions mitigation.

The second chapter explores the impacts of the Covid-19 pandemic crisis and measures related to energy consumption and efficiency in different economic sectors in Brazil. It is also the result of detailed cooperation on data and policies between EPE and the IEA.

SNIC
SINDICATO NACIONAL DA INDÚSTRIA DO CIMENTO

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Contents

Objective

Objective

The main objective of this document is to monitor the progress of energy efficiency in Brazil, through the use of indicators. In 2020 the first "Atlas of Energy Efficiency in Brazil - Indicators Report" was published - with analysis up to the year 2018. This document updates and complements, in a more condensed way, the first report with data up to the year 2019. This document consolidates the fourth cycle of EPE's work in the development of the database of energy efficiency indicators.

Definitions

ODEX

ODEX is an indicator that determines the progress of energy efficiency. It can be aggregated by sector (industrial, residential, services and transport) or for the economy as a whole. ODEX is used by the European Union in the ODYSSEE database program for monitoring efficiency gains.

ODEX by sector (e.g. industry) is based on unit consumption indexes by sub-sector (cement, ceramics, textiles, etc...), weighted by their share in the total energy consumption of the sector. The unit consumption per sub-sector can be expressed in different units in order to provide the best proxy for the evaluation of energy efficiency, be it the consumption per household, physical production, or number of vehicles, for example.

For the present report, 2005 was considered as the base year (value = 100), essentially due to the availability of data for most sectors from that year on. The decrease in the unit consumption index from 100 in 2005 to 80 in 2019, for example, represents an energy efficiency gain of 20% over the analyzed period. In contrast, if ODEX increases from 100 to 120, there will have been a deterioration in energy efficiency over the years in question.

In the case of global ODEX, the same method is applied with weighting factors, based on the shares of the total final energy consumption of each sector.

For the purposes of this technical note, the industrial, residential and transportation sectors were considered. The other sectors (energy, services and agriculture and livestock) were not included due to the unavailability of data.

Energy Intensity

Energy intensity refers to the amount of energy required to produce one unit of final product or service. It is the ratio between an energy indicator (ton oil equivalent [toe], Joule, calorie, Btu, among others) and an activity indicator (U$, R$, m^2, ton-kilometers, passenger-kilometers, among others).

Hypothetical examples:

- Industrial Energy intensity: 100 toe/U$ ppp 2010
- Energy intensity of residential building: 0.5 toe/m^2
- Energy intensity of commercial building: 200 KJ/m^2
- Energy intensity in the transport sector: 1,000 toe/tkm

The energy intensity of an economy corresponds to the ratio of the Total Energy Supply divided by the Gross Domestic Product of the country. This indicator is usually used to measure a country's energy efficiency. Nevertheless, it is important to consider that this ratio does not necessarily express energy efficiency, since a country can have a low energy intensity and be inefficient from an energy point of view. Just consider the case of a small country that has its economy based on the tertiary sector, which may have a lower energy intensity than another large nation whose economy is based on industrial production. However, the second country can use energy for its industries more efficiently than the first uses it to develop its economy based on trade and services.

Thus, the energy intensity should not be analyzed alone. Efficiency gains are only one component of this analysis, which must also take into account the structure (structural effect) of a country's economy (presence of energy-intensive industries, developed services sector, etc.) and changes in activity (activity effect), which are influenced by the size of the country (implying higher demand from the transport sector, for example).

In this report, the indicator will be calculated in two ways: from the perspective of total energy supply (TES), identified as Primary Intensity (i), and from the perspective of final energy consumption, denoted as Final Intensity (ii).

- Total Energy Supply (thousand toe)/GDP (M$[2010])
- Final Energy Consumption (thousand toe)/GDP (M$[2010])

Final Consumption

This is the energy that reaches end-use sectors for energy and non-energy purposes (raw material, for example). The sources used as input or raw material for transformation into other energy products are not included in this concept. These activities are classified, according to the Brazilian Energy Balance, as Transformation Centers (examples: water used to generate electricity or oil that will be transformed into gasoline, diesel oil, etc.).

In general, the sectors in this report were classified according to the Brazilian Energy Balance, with the exception of some energy-intensive sectors, for better representation of energy efficiency progress in Brazil.

Final consumption can be calculated in the following ways:

- **Final consumption** = primary final consumption (+) secondary final consumption, or;
- **Final consumption** = non-energy final consumption (+) final energy consumption

Where:

- **Primary final consumption** is the consumption of primary energy, i.e. consumption from sources coming directly from nature. Examples: natural gas, mineral coal, solar, wind, hydro and sugar cane products, among others
- **Secondary final consumption** is the consumption of secondary energy, that is, consumption from sources coming from the different transformation centers, which have as a destination different sectors of the economy. Examples: electricity, gasoline, diesel oil, ethanol, among others.
- **Non-energy final consumption** corresponds to the consumption of sources that, although they have energy content, are used as raw materials for other purposes. Example: use of naphtha for the manufacture of thermoplastics.
- **Final energy consumption** corresponds to the use of sources by economic sectors as energy.

Transport Sector

Light Duty Vehicles (by size)

Automobile

Motor vehicle for passenger transport, with passenger capacity of up to eight people (excluding the driver);

Light commercial vehicles

- **Utility Vehicle** – vehicle for freight transportation with GCVW of up to 3,500 kg
- **Medium Duty Passenger Vehicle** – mixed vehicle for passenger transport;
- **SUV** – Mixed vehicle characterized by its versatility of use, even off road.

Heavy duty vehicles

Trucks

- **Semi-light** – 3,5 t. < GCVW < 6 t.
- **Light** – 6 t. ≤ GCVW < 10 t
- **Medium** – 10 t. ≤ GCVW < 15 t.
- **Semi-heavy** – GCVW ≥ 15 t. e MTC ≤ 45 t.
- **Heavy** – GCVW ≥ 15 t. e MTC > 45 t.

GCVW– Gross combined vehicle weight
MTC – Maximum Traction Capacity

Introduction

Share of renewables in the energy mix

Historically, Brazil stands out for being a country with a high percentage of renewable sources in its total energy supply when compared to the rest of the world. Over the last 20 years, the share of renewables in the Brazilian energy mix has remained stable at over 40%, a level that has been challenging to maintain. More recently, between 2011 and 2014, there was a reduction in the share of renewables in the energy mix due to a drop in hydropower supply. As of 2015, renewable sources have resumed their growth trajectory with the expansion of the supply of sugarcane products, wind and biodiesel, reaching 46.1% in 2019.

Figure 1 – Share of renewable sources in the Total Energy Supply (TES): international comparison
Source: EPE (2020a)

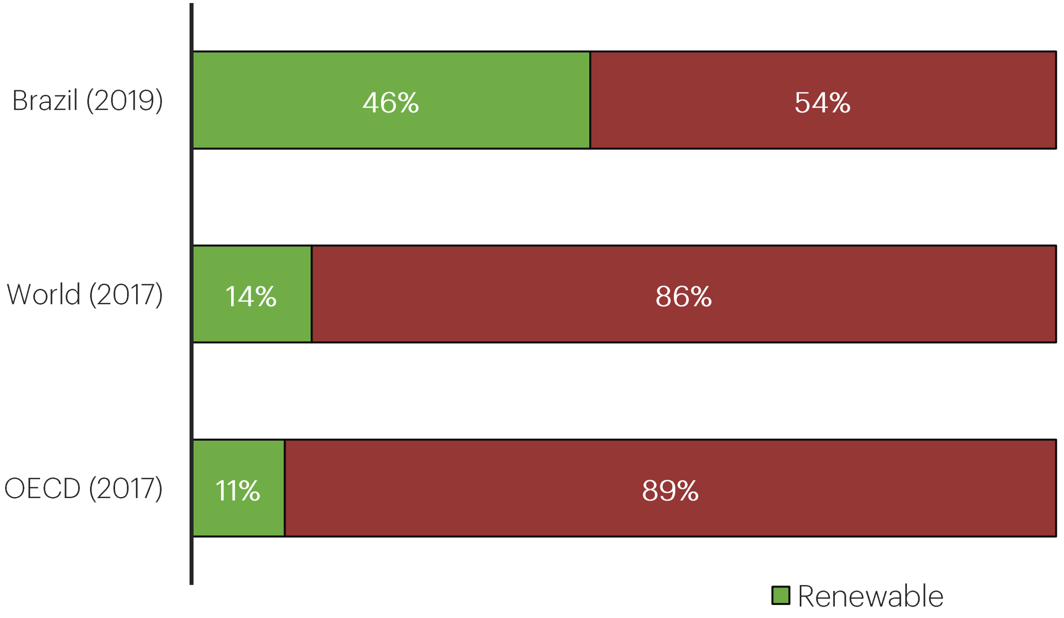
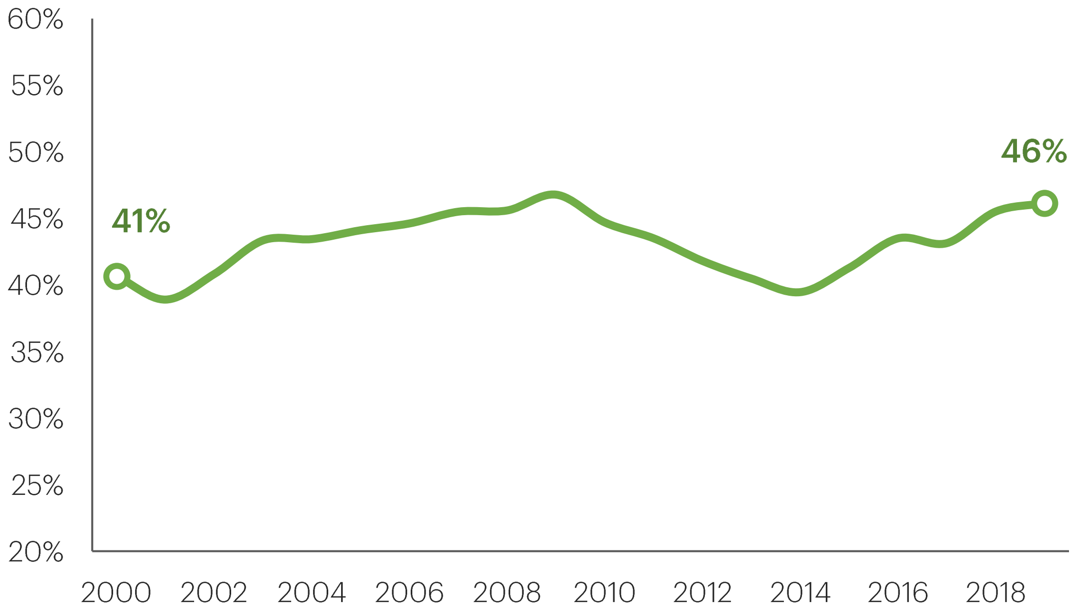


Figure 2 – Share of renewable sources in the Total Energy Supply (TES) – 2000 to 2019
Source: EPE (2020b)

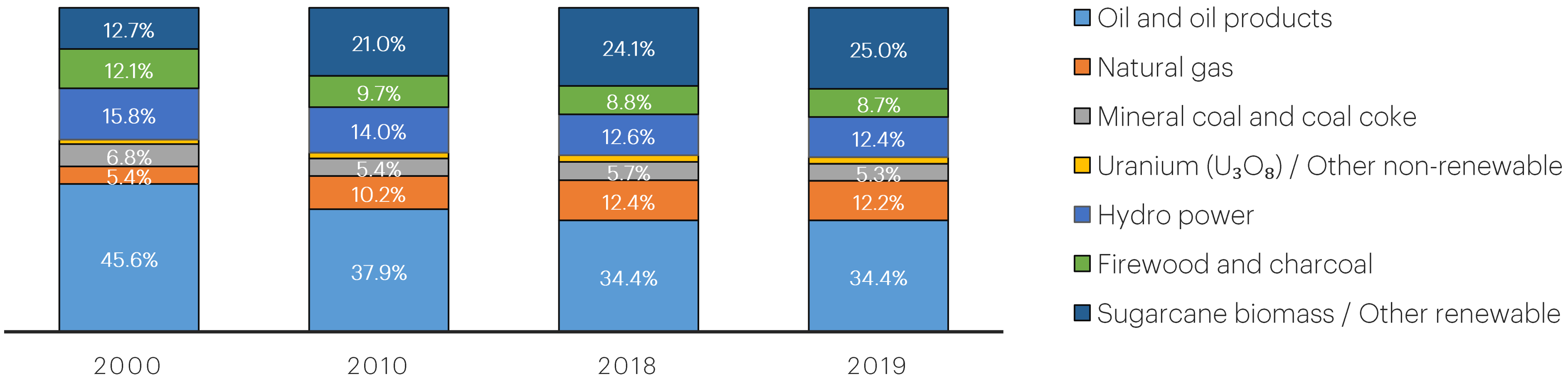


Evolution of final energy consumption by source

For non-renewable sources, oil and its products maintain the largest share. However, natural gas was the standout category, significantly increasing its share of the energy mix from 5% in 2000 to 12% in 2019 due to its use in thermoelectric power plants and extension of the pipeline network, which enabled its use both in industries and in residential, commercial and public buildings.

Figure 3 – Energy consumption by source – selected years

Source: EPE (2020b)

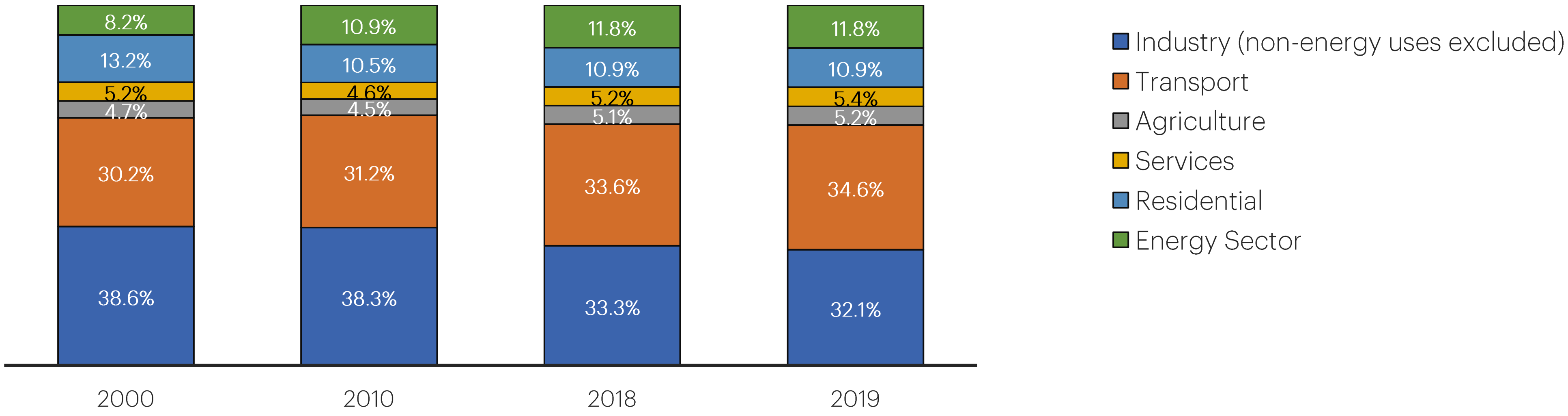


Renewable sources, on the other hand, developed at a faster pace, due to the expansion of the sugar-ethanol sector, and the strong expansion of other renewable sources, notably wind power, black liquor and biodiesel. From a negligible share in 2000, wind energy grew to the point that it contributed 4.8 million toe to the energy mix in 2019, while black liquor, which is directly associated with the pulp and paper industry, contributed another 8.9 million toe in 2019. Biodiesel has been favored by the policy of adding this fuel to fossil diesel. In 2019, the percentage reached 11%. The most used raw material for its manufacture in the Brazil is soy oil. Brazil is the second largest producer of biodiesel in the world, only behind the United States.

Final energy consumption by sector

The main change observed in this period was the decline of industry's share alongside an increase in that of the transport and energy sectors. Aside from a gradual reduction in the clinker/cement ratio from 73.2% in 2000 to 69.5% in 2019, the cement industry saw an average annual growth rate of 1.4% in clinker production, which is energy-intensive.

Figure 4 – Energy consumption by sector – selected years
Source: EPE (2020b)



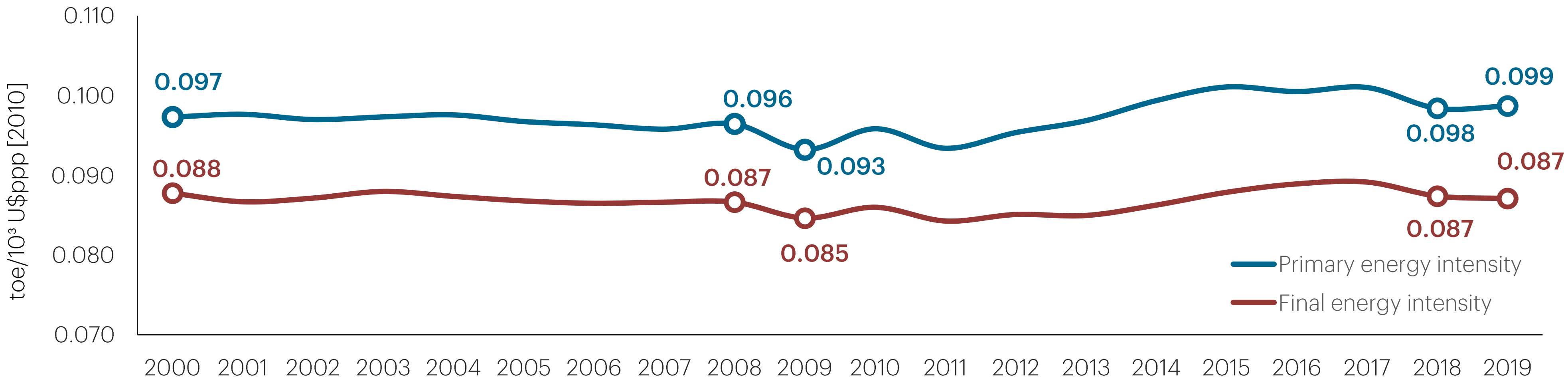
As for metallurgy, this sector expanded its physical output at an average annual rate of 0.6%. In other words, the combined cluster of cement and metallurgy, which consume more than 30% of all the energy used in industry, grew at a slower pace than the transport sector, which saw its energy consumption evolve at an average annual rate of 3.1% over the same period. As for the energy sector, energy consumption expanded by 16.1 million toe in 2019 as compared with the year 2000, driven by the production of oil and ethanol, which grew at annual rates of 4.4% and 6.5% respectively over the period.

Energy Intensity

In 2000-08, primary energy intensity remained stable at around 0.097 toe/10^3 US dollars (USD) at purchasing power parity (PPP) [2010]. Similarly, final energy intensity stabilized at values close to 0.087 toe/10^3 USD PPP [2010]. In 2009, the effects of the international crisis on industry contributed to a reduction in primary energy intensity to 0.093 toe/10^3 USD PPP [2010]. In that year in particular, it was possible to observe the shutdown of more inefficient (less competitive) units with higher energy intensities.

Figure 5 – Energy intensity

Source: EPE (2020b)



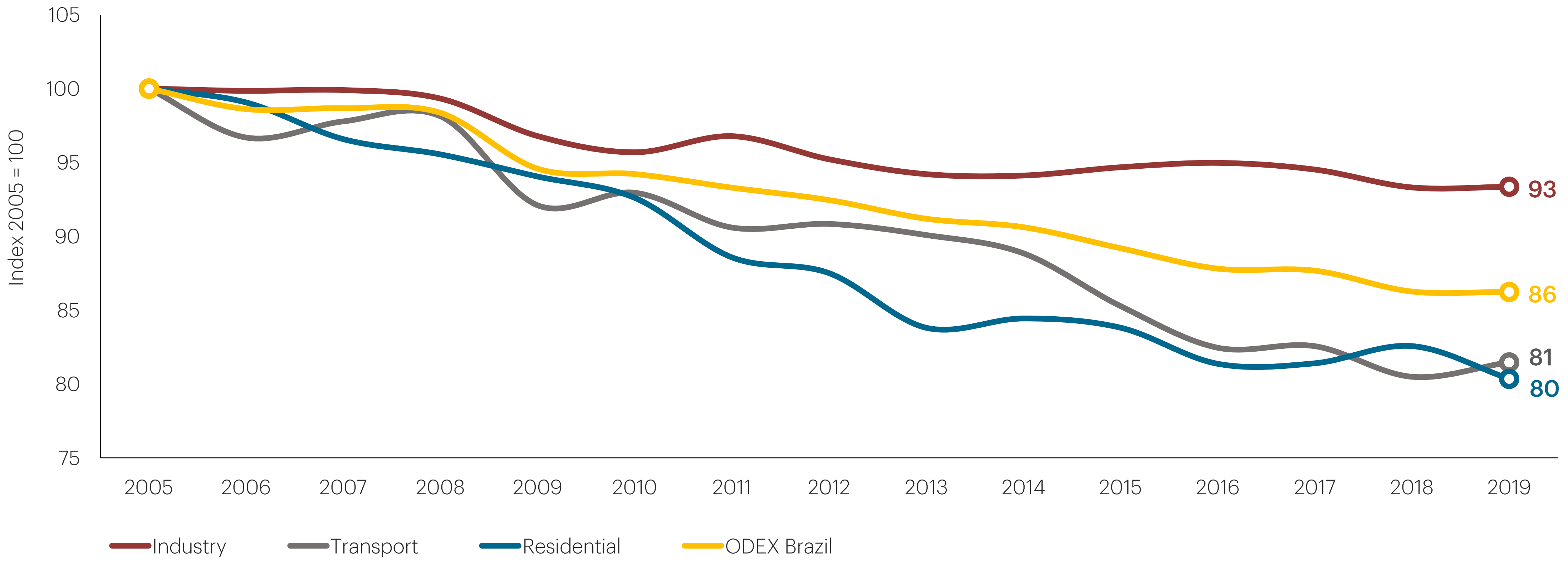
Between 2010 and 2013, primary and final intensities grew at rates of 1.0% and 0.1% per year respectively, reflecting growth in Total Energy Supply that outpaced growth in GDP. Between 2014 and 2019, primary energy intensity grew by 0.3% per year, even with the economy in recession (an average contraction of -0.4% per year). In the same period, final energy intensity grew by 0.4% per year. This upward trend in energy intensity may be associated with the growth in production of low value-added, energy-intensive items aggregated together in the production schedule, as compared to other manufactured products.

ODEX

In this report, 2005 was set as the base year (100), covering the industrial, residential, transport sectors and Brazil as a whole. In this period, all sectors analyzed showed efficiency gains, with the largest gains occurring in the residential (20%) and transport (19%) sectors. The ODEX calculated in 2019 shows that the country became 14% more energy efficient in the period.

Figure 6 – ODEX by sector and for Brazil

Source: Compiled by EPE



Buildings

Evolution of consumption in buildings: residential, commercial and public sectors

The main energy source used in the buildings is electricity. Households use 46% electricity, 26% LPG and 24% firewood. Commercial and public buildings, on the other hand, use electricity with a 92% share.

Figure 7 – Total Energy demanded by buildings

Source: EPE (2020b)

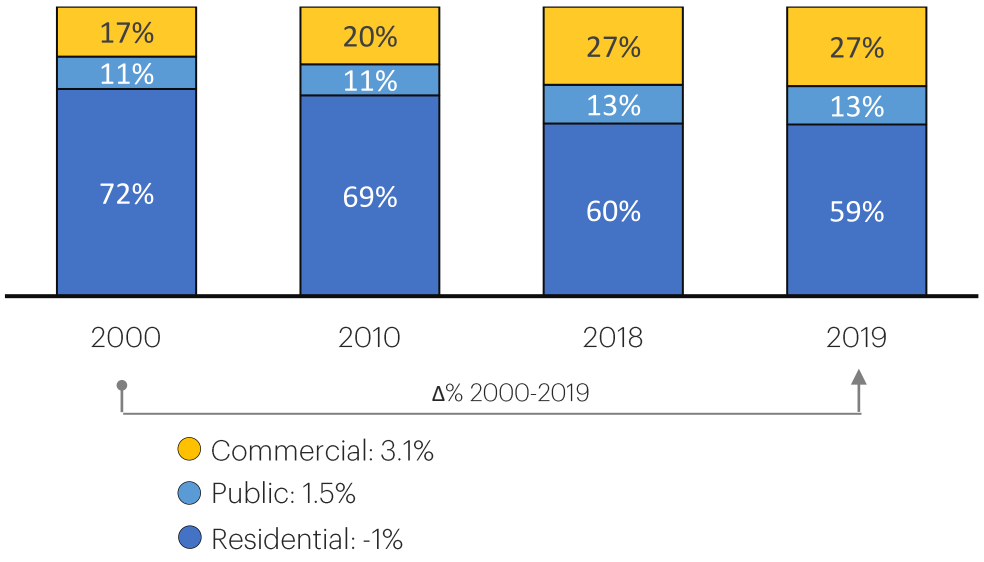
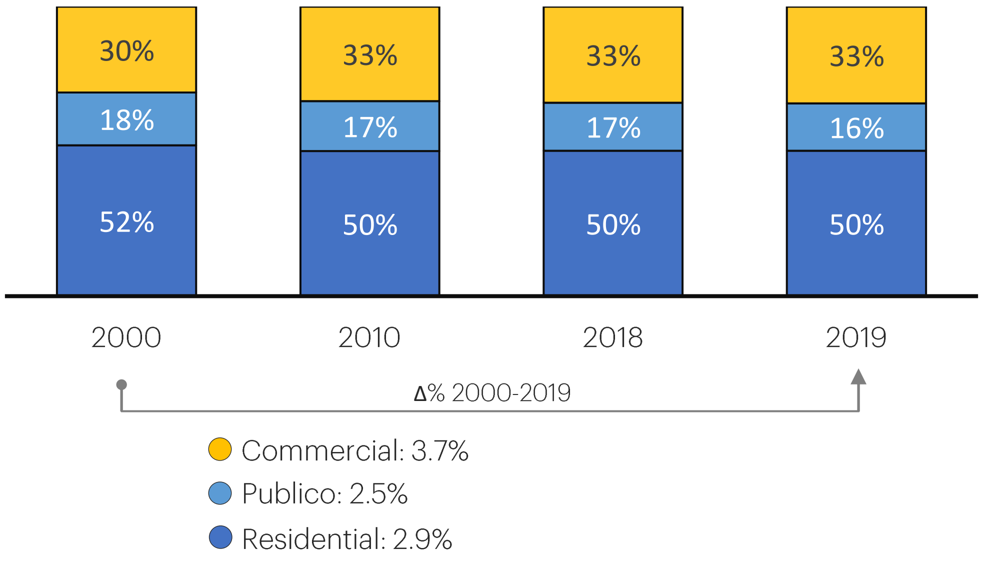


Figure 8 – Eletcricity demanded by buildings

Source: EPE (2020b)



Buildings consume 52% of the country's electricity and because they have a large consumption of electricity it is in this segment that the greatest potential for electrical efficiency lies. PROCEL estimates that the Procel Buildings Label avoided consumption of about 24 GWh in buildings built between 2015 and 2019. (Procel, 2020).

Note: the public sector includes public lighting and sanitation.

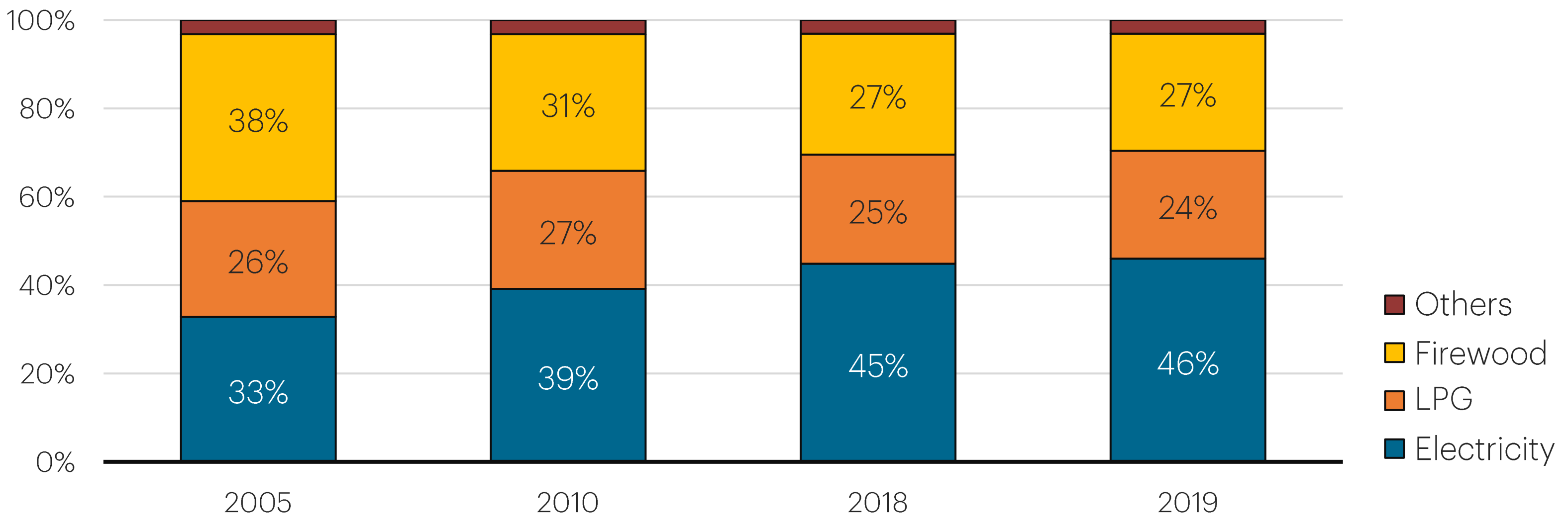
Residential Sector

Evolution of energy consumption by source in households

Electricity continues to be the most widely used energy source in Brazilian households, with a 13% increase between 2005 and 2019. Electricity is widely used in households, and can be used for air-conditioning, food conservation and cooking, electrical and electronic equipment and water heating.

Figure 9 – Energy consumption by source in households – selected years

Source: EPE (2020b)



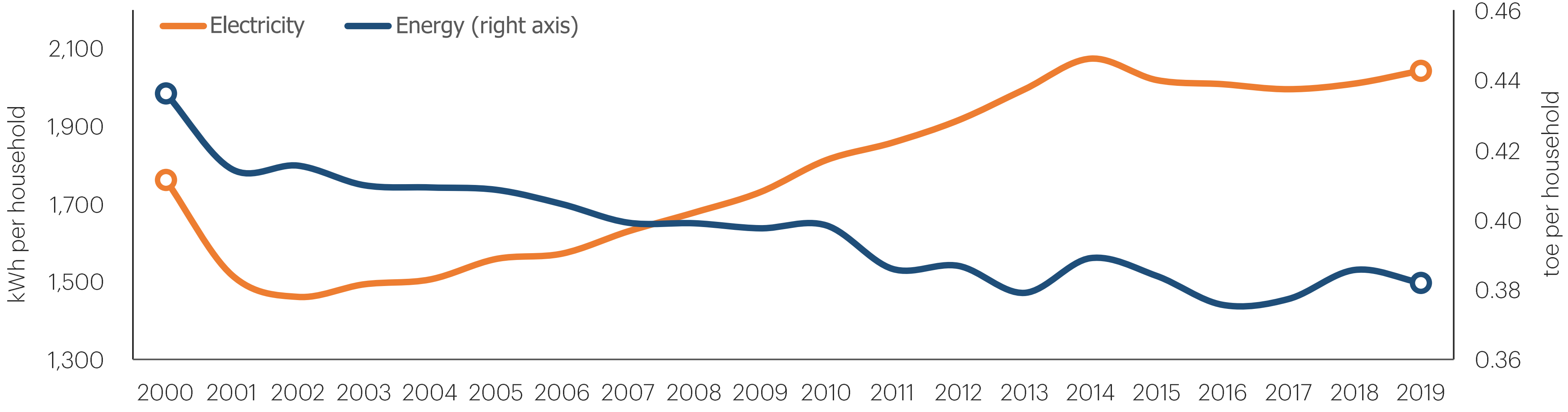
LPG (liquefied petroleum gas) maintains an intermediate share (24% in 2019), and its main use is associated with cooking. Natural gas is used predominantly for cooking and water heating, mainly in the most developed regions of the country that are supplied with this source. The share is still very low in total consumption. The decrease in the consumption of biomass (firewood and coal) as an energy source in households occurred due to the improvement in economic conditions of families, especially between 2002-2014.

Evolution of electricity and energy consumption in households

While energy consumption per household fell 12.4% (decreasing 0.7% annually) from 2000 to 2019, electricity demand per household grew 15.9% (increasing 0.8% by year). In this period, demand for electricity increased as a result of economic progress among families, the advance of credit for the purchase of household appliances, government policies on access to electricity, especially in rural areas, and housing programs and incentives to reduce Brazil's housing deficit.

Figure 10 – Electricity and energy consumption by household

Sorce: EPE (2020b)



Final energy consumption fell in the period as a result of the reduction in the use of less energy-efficient sources (traditional biomass - firewood and charcoal) and the consequent substitution by more efficient sources (LPG, natural gas, electricity). Total energy and electricity consumption fell sharply in 2001 due to the country's electricity rationing. This stimulated a change in habits and promoted energy efficiency measures in Brazilian households.

Políticas vigentes de eficiência energética nas residências

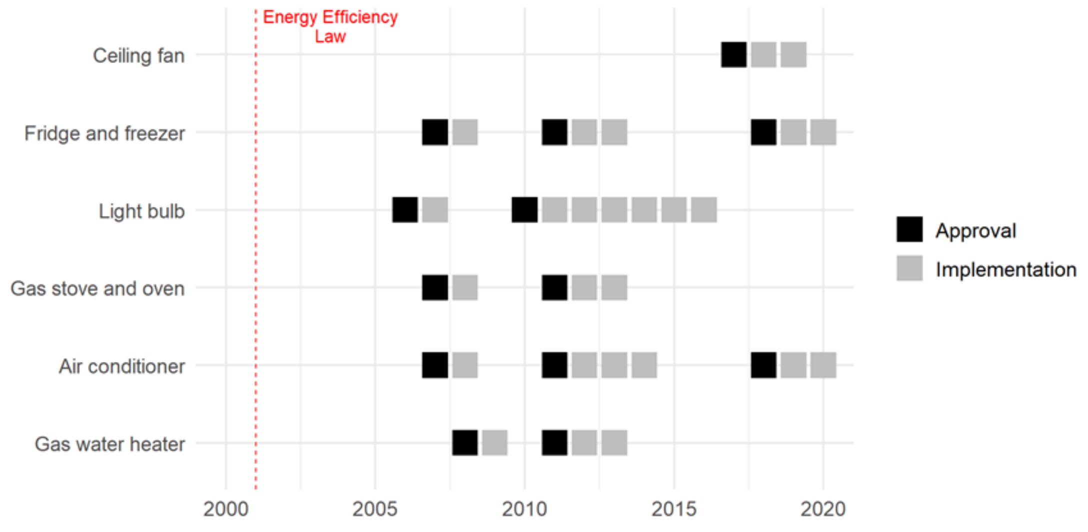
The main energy efficiency measures in households are implemented through policies of mandatory or voluntary standards and labelling on equipment and appliances. These policies include: Minimum energy efficiency indexes (or maximum consumption), comparative labelling (mandatory or voluntary) and endorsement labels.

The Brazilian Labeling Plan (PBE) has been evolving since the 1980s, based on the voluntary participation of appliance suppliers, especially those targeting households. Gradually, compliance has become compulsory for some appliances. With the publication of the Energy Efficiency Law (Law 10,295/2001), in the early 2000s, the PBE began to require, also compulsorily, appliance performance criteria based on minimum energy efficiency indexes (or maximum consumption).

In addition to standards and labeling policies, there are complementary initiatives in the country that seek to promote energy efficiency through norms, certifications and programs, which include not only electricity-consuming appliances, but also the thermal performance of buildings, their relations with the residents and the encouragement for the use of alternative energy generation systems in social interest housing (HIS).

Figure 11 – Period of approval and implementation of policies for minimum energy efficiency standards for residential appliances

Source: Compiled by EPE based on MME data



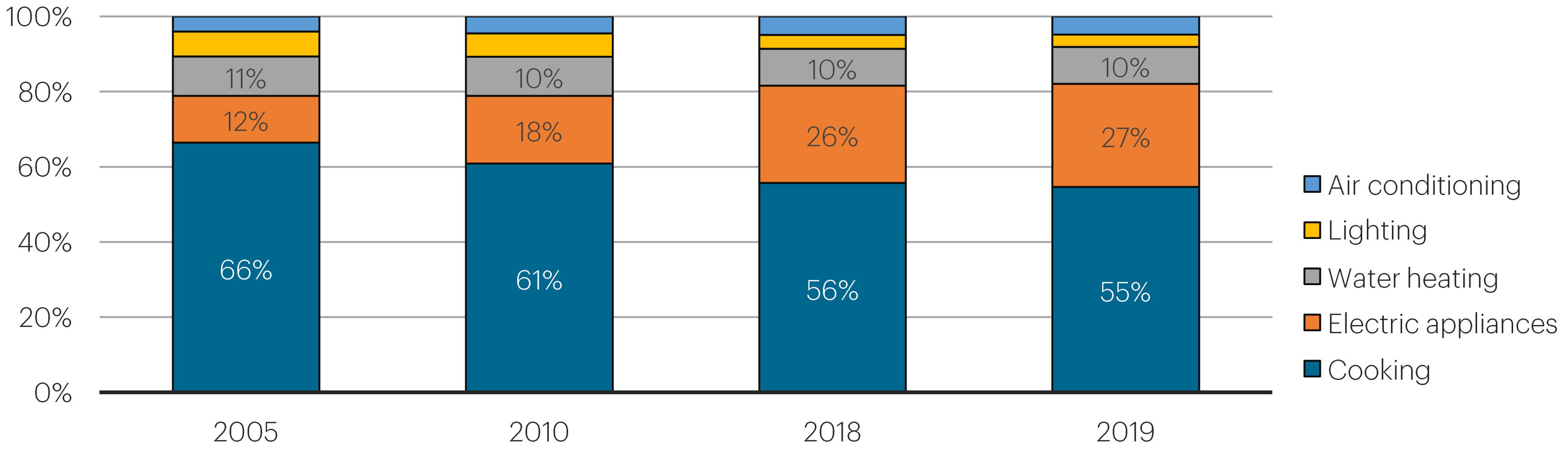
Note: Dates contained in specific regulations and target plans are considered. For lighting data, the specific regulations and target plans for incandescent and compact fluorescent lamps are considered.

Evolution of energy consumption by final use in households

Cooking represents the main energy end-use in households, followed by electrical appliances, water heating, space cooling and lighting. The reduction in consumption for cooking during 2005-2019 can be explained by the replacement of traditional biomass with modern fuels as families make economic progress.

Figure 12 – Residential energy consumption by end use

Source: Compiled by EPE



The growth in the share of electrical and electronic appliances in the period can be explained by an increase in ownership by families due to increased income, the ease of access to credit and reductions in appliance prices.. Space cooling has been gaining ground over time due to the increased use of air conditioners, fans and air circulators in homes. Lighting has been losing its share over time due to the increasingly widespread use of more efficient lamps, especially compact fluorescent and LED technology (light-emitting diode).

Electricity – Final uses, ownership and average annual consumption by appliance

Figure 13 – Residential electricity consumption by end use
Source: Compiled by EPE

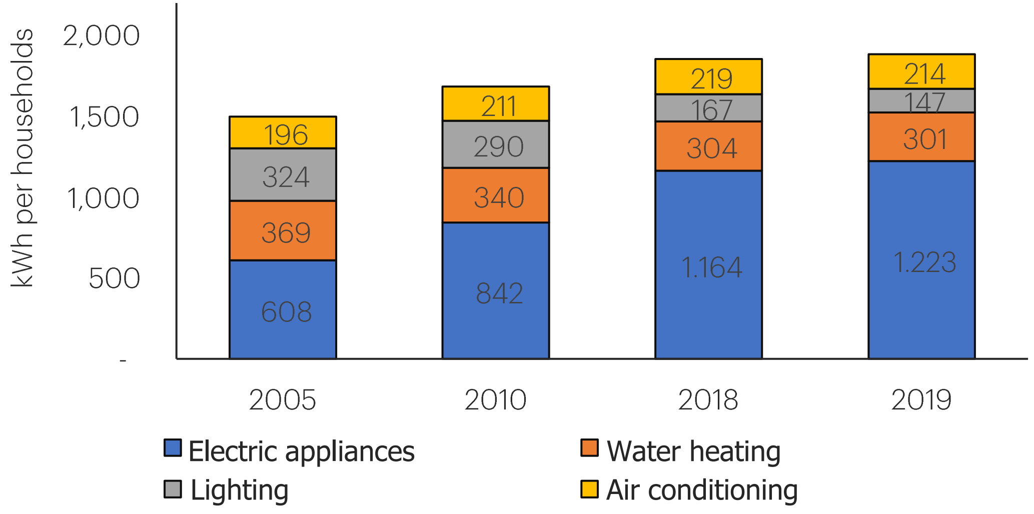
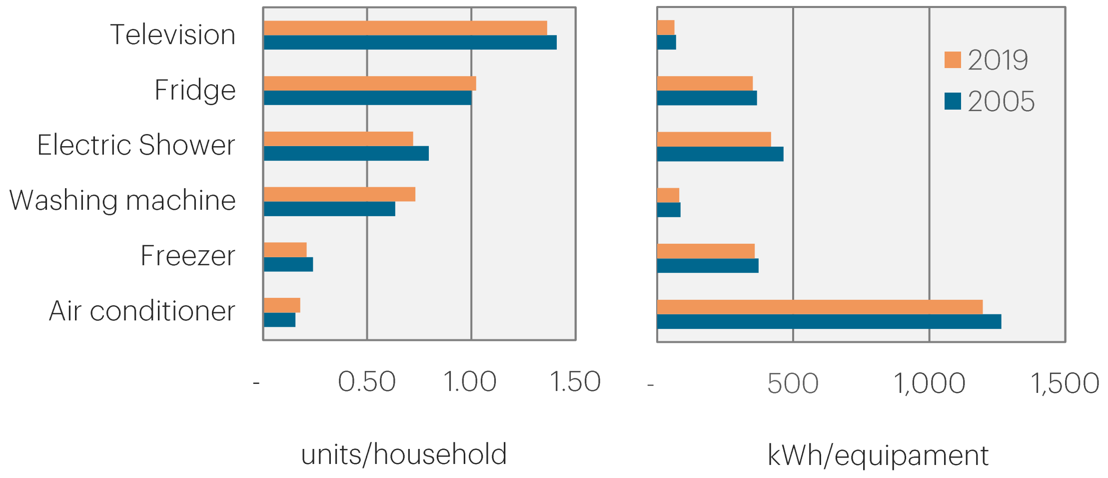


Figure 14 – Ownership and average annual consumption by equipment type
Source: Compiled by EPE



The share of electricity used for cooking is very small and is related to the use of electric ovens and stoves. Cooking is predominantly fueled by sources such as LPG, natural gas and traditional biomass. The reduction in the use of electricity for water heating is due to the increased penetration of solar water heating systems (SAS), especially in dwellings of social interest (HIS), and the expansion of the natural gas network over the period 2005-2019.

The penetration of new and more efficient appliances tends to reduce the average energy consumption of the existing stock in the country. Air conditioners and washing machines were the devices with the greatest advances in ownership in the period 2005-2019, growing by about 1.0% per year. The ownership of freezers and electric showers fell in this period. Regarding freezers, the reduction is largely a result of a change in household habits in recent decades, with households scrapping and no longer replacing appliances that have reached the end of their useful life.

Effects of the evolution of electricity consumption by appliance

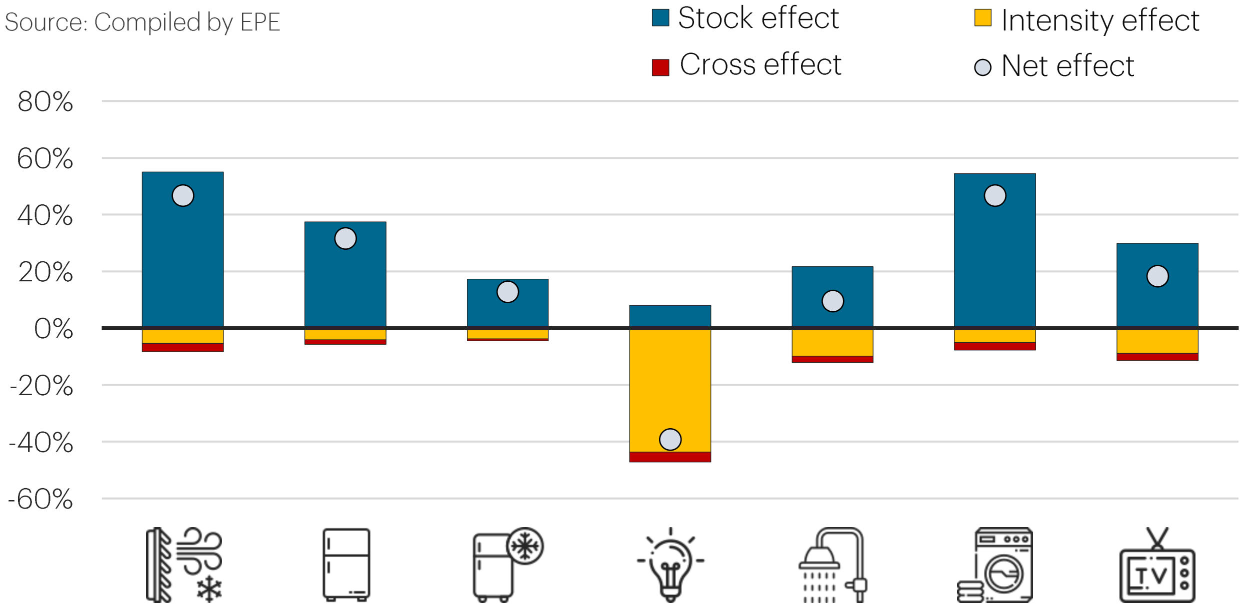
Each appliance displayed a variation in electricity consumption between 2005 and 2019, which can be broken down into 3 effects: the Stock effect corresponds to the variations in the stock of each appliance influenced by the sales of new devices and the scrapping of devices at the end of their useful life or made unusable in each year, by the progress in the number of households and by the variation in the ownership of the appliances per household.

The Intensity effect represents the variations in the specific consumption of each appliance, that is, how much energy each one consumes in its operation. This effect is a proxy for energy efficiency gain and can be understood as the relative gain of replacing technologies or changing usage habits for appliances.

The Cross Effect corresponds to the relationship between the Stock and Intensity effects, since the specific consumption of an appliance in a given year is calculated by the weighted average of the specific consumption of the stocks of appliances with different ages within that year.

Figure 15 – Decomposition of electricity consumption variation by equipment between 2005 and 2019

Source: Compiled by EPE



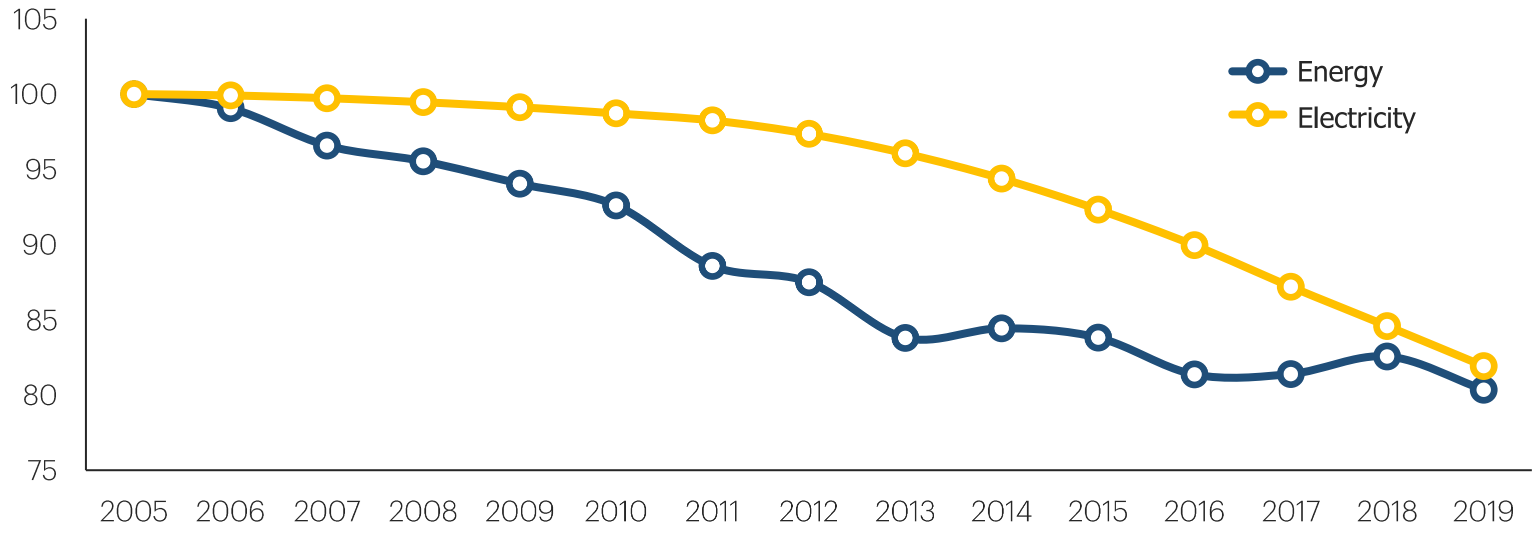
The Stock effect was mainly responsible for the increase in equipment electricity consumption in the period 2005-2019, especially for air conditioners and washing machines. For lighting, the Intensity effect was higher due to the banning of incandescent lamps and the higher penetration of more efficient lamps, especially those with LED technology.

Residential ODEX

ODEX is an efficiency indicator that, for households, aggregates the consumption trend of the different end uses, or appliances, based on their share in total consumption.

Figure 16 – Evolution of residential ODEX calculated for total energy and electricity

Source: Compiled by EPE



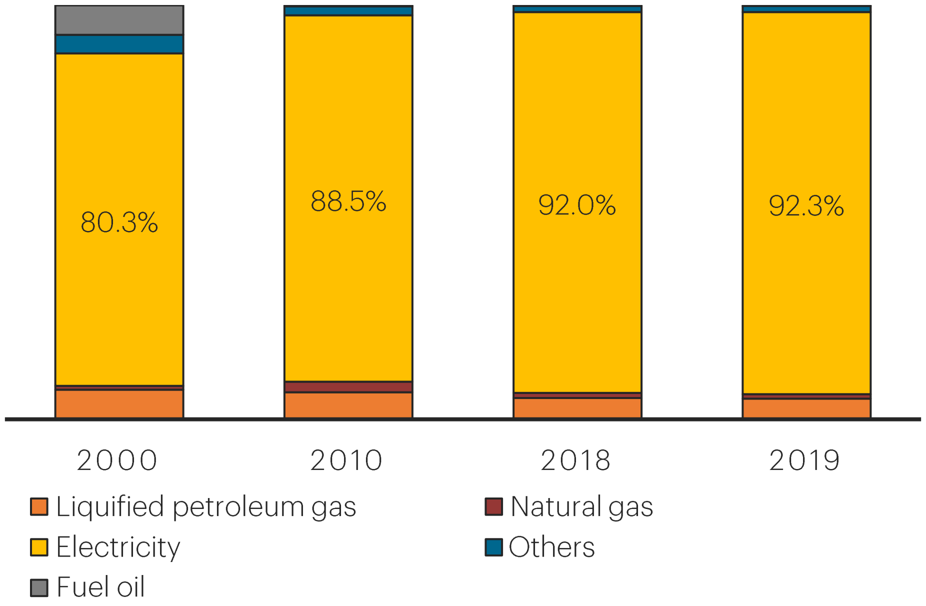
While ODEX calculated for total energy fell approximately 20% between 2005 and 2019, the decline of ODEX for electricity consumption fell somewhat short of this level. It is observed that in recent years the retraction of the indicator is more significant for electricity, suggesting the importance of this source in residential energy conservation in the Brazil.

The indicators associated with energy consumption in households analyzed in this document suggest that when we consider the main end uses, as well as the main electric appliances, we observe a trend of energy efficiency in the Brazilian residential sector between 2005 and 2019. In addition to public policies to induce energy efficiency, this phenomenon is the result of complex interactions that include economic, social and behavioral factors in households.

Services
(commercial and public services)

Overview: evolution of final energy consumption by source in the services sector [1]

Figure 17 – Final energy consumption in the services sector
Source: EPE (2020b)



Natural gas supplied by pipelines grew 3.5% from 2010 to 2019, however its final consumption in the sector fell. This occurred because part of the natural gas is destined for electricity generation, which is not accounted for, according to BEN's methodology, as final consumption. In this period, there was an increase in the installed capacity for electricity generation in the sector (9.0%), either through self-production or cogeneration.

LPG consumption has stagnated since 2005, influenced by ANP resolution nº22/2005 Art.30 prohibiting the use of LPG in:

- Saunas
- Boilers
- Swimming pool heating, except for medicinal purposes
- Engines of any kind, including for automotive purposes, except for forklift trucks and industrial cleaning equipment powered by internal combustion engines.

Electricity continues to gain importance in the sector's final consumption and may be associated with several factors such as increased ownership of electrical equipment and appliances, increased automation and process control, and substitution of the use of secondary sources, among others. Natural gas consumption peaked in 2007 at 332 ktoe and in 2019 reached 147 ktoe, a decrease of 6.2% in the period 2010-2019. LPG maintained its consumption level, with a drop of 0.4% in the 2010-2019 period.

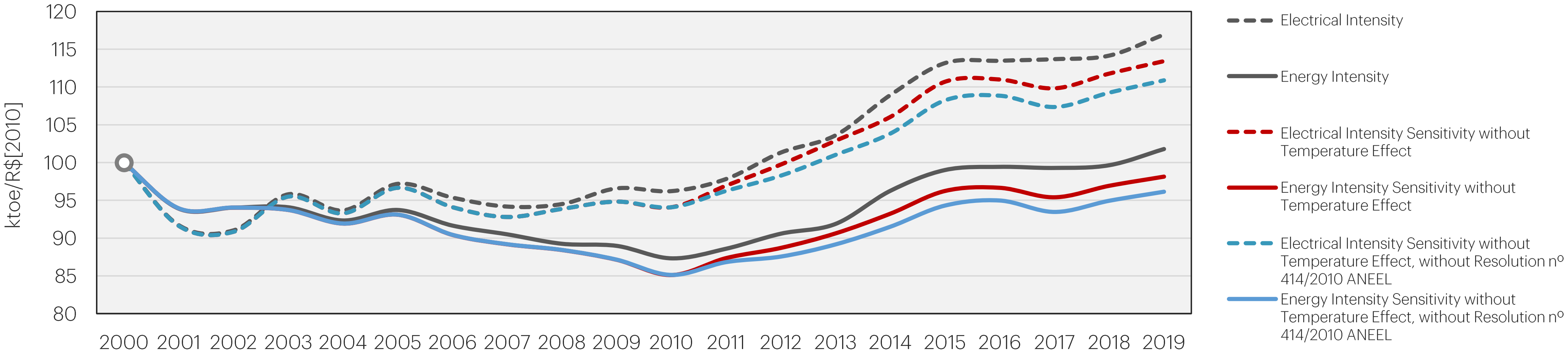
[1] Commercial and public sectors according to the Brazilian Energy Balance classification.

Analysis of sector-level indicators: evolution of the energy demand profile of the commercial and services sectors

The indicators of electrical and energy intensity suffered an impact in 2001, caused by electricity rationing. As of 2010, the increase in intensities may not reflect an inefficiency, since ongoing efficiency policies act to mitigate consumption growth. There are segments strongly linked to population growth, that are less sensitive to economic oscillations, which may raise the indicators.

Figure 18 – Electrical and Energy Intensity

Source: Compiled by EPE

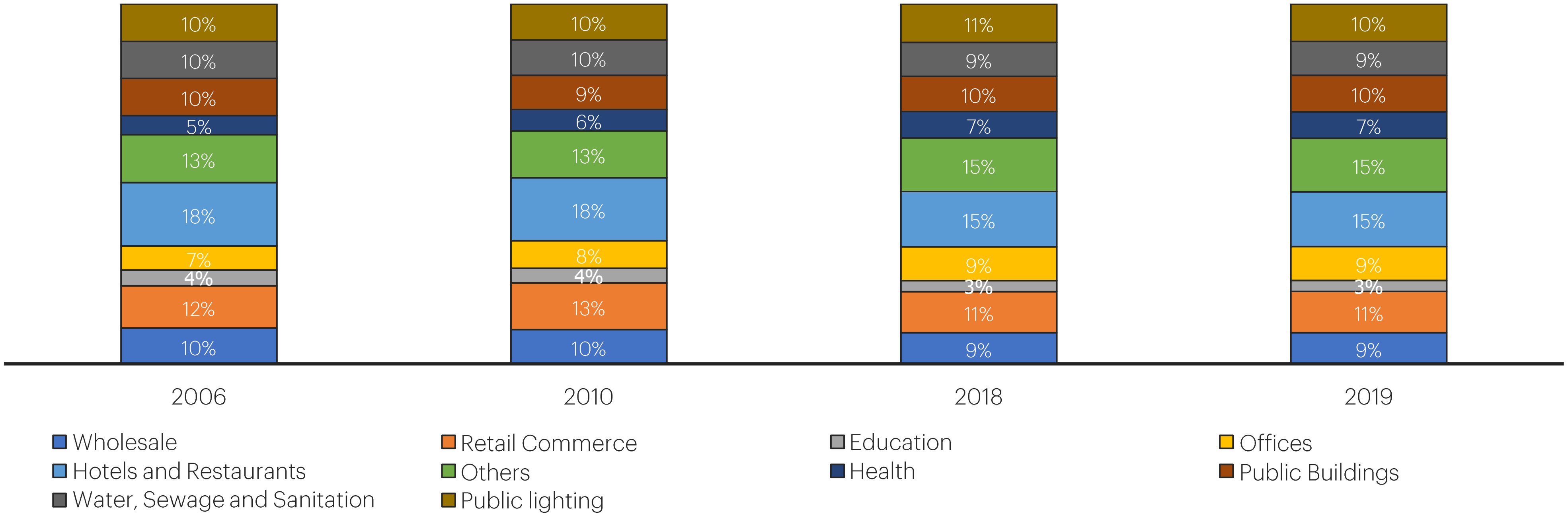


The electrical intensity moves away from the other indicator because of the growth of electricity compared to other sources, reflecting the increase in the use of useful energy of some energy services such as air conditioning for environmental thermal comfort and also by the expansion of electricity in the energy mix of the services sector.

Energy consumption by segment 2006-2019

Figure 19 – Energy consumption by segment in the services sector

Source: Compiled by EPE



The services sector, intrinsically heterogeneous, presents a certain homogeneity in the annual energy amounts consumed per segment throughout the period. Current energy efficiency policies are driving greater market penetration of efficient equipment.

Some current energy efficiency policies

For the services sector, important energy efficiency policies drive the penetration of more efficient equipment and buildings, and in particular:

- Brazilian Labeling Program - INMETRO, created in 1984;
- PROCEL RELUZ - National Program for Efficient Public Lighting and Signaling, created in 2000;
- Energy Efficiency Program – PEE (Portuguese) regulated by ANEEL , created in 2000;
- Technical Group for Energy Efficiency in Buildings – created in 2001 Grupo Técnico para Eficientização de Energia em Edificações – criado em 2001;
- Procel Edifica, Energy Efficiency Program in Buildings - Eletrobrás/Procel – created in 2003;
- PROCEL SANEAR - Energy Efficiency Program in Environmental Sanitation, created in 2003;
- PROCEL Annual Resource Plan, Law No. 13,280/2016;
- Procel Label for appliances/equipment (1993) and buildings (2020);
- ABNT/NBR 15220/2005 - Brazilian Thermal Performance Standard for Buildings;
- ABNT/NBR 15575/2013 - Performance for residential buildings, residential buildings of up to five floors;
- INMETRO, Technical Regulation for Quality (RTQ, in Portuguese) for Energy Efficiency of Commercial, Services and Public Buildings, Technical Regulation of Quality for Energy Efficiency Level of Residential Buildings - RTQ-R, RAC - Requirement of Conformity Assessment for Buildings and its Complementary Ordinances;
- SLTI Normative Instruction no. 02/2014 of MPOG.

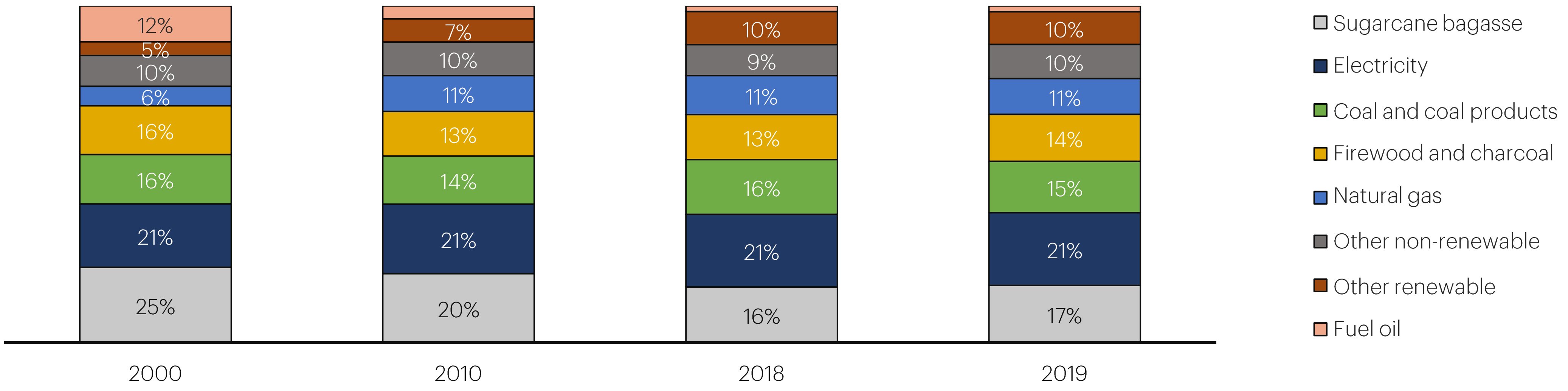
Industry

Industrial sector overview: evolution of energy consumption by source

The industrial sector consumes approximately a third of total final energy consumption to meet the needs of its productive processes. Until 2017 it was the sector with the highest level of consumption. However, as industrial economic activity declined between 2014 and 2017, and as sugar production fell in 2018, it was surpassed by the transport sector.

Figure 20 – Final energy consumption by source

Source: EPE (2020b)



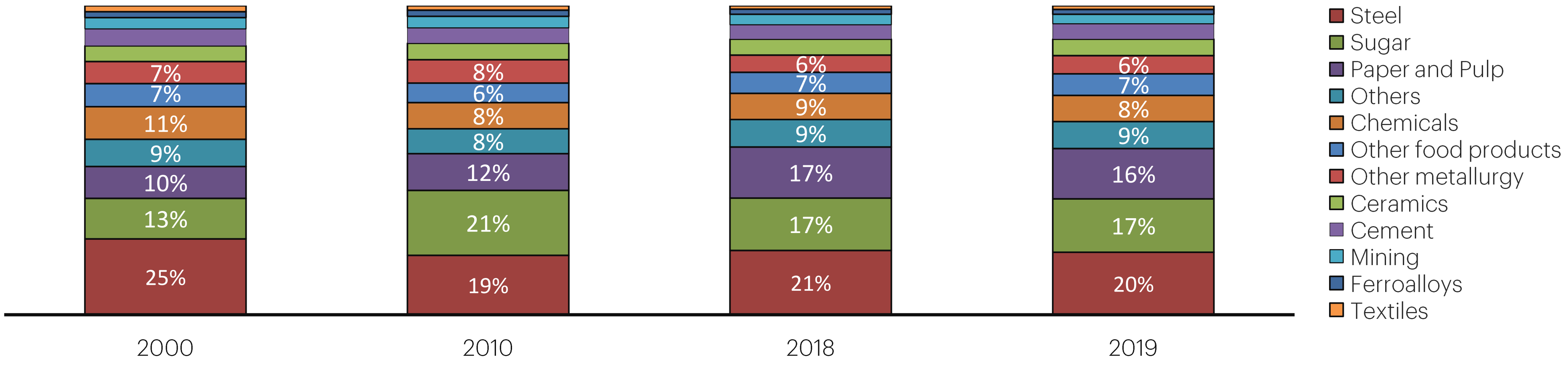
In the year 2000, industry's main energy sources were, in order of importance, electricity, coal and its products, firewood and charcoal, sugarcane bagasse, and fuel oil. By 2019, sugarcane bagasse stood in joint second place in the table of most-consumed energy sources, along with coal and its products, and second only to electricity

Industrial sector overview: evolution of energy consumption by subsector

The increase in the share of sugarcane bagasse and other renewables in industrial consumption is related to the increase in the shares of the sugar and pulp sectors. A reduction can be observed in the share of fuel oil, which has gradually been displaced by petroleum coke (notably in cement production), and in natural gas and other renewables (in paper and pulp production).

Figure 21 – Sectorial shares of final energy consumption in industry

Source: EPE (2020b)



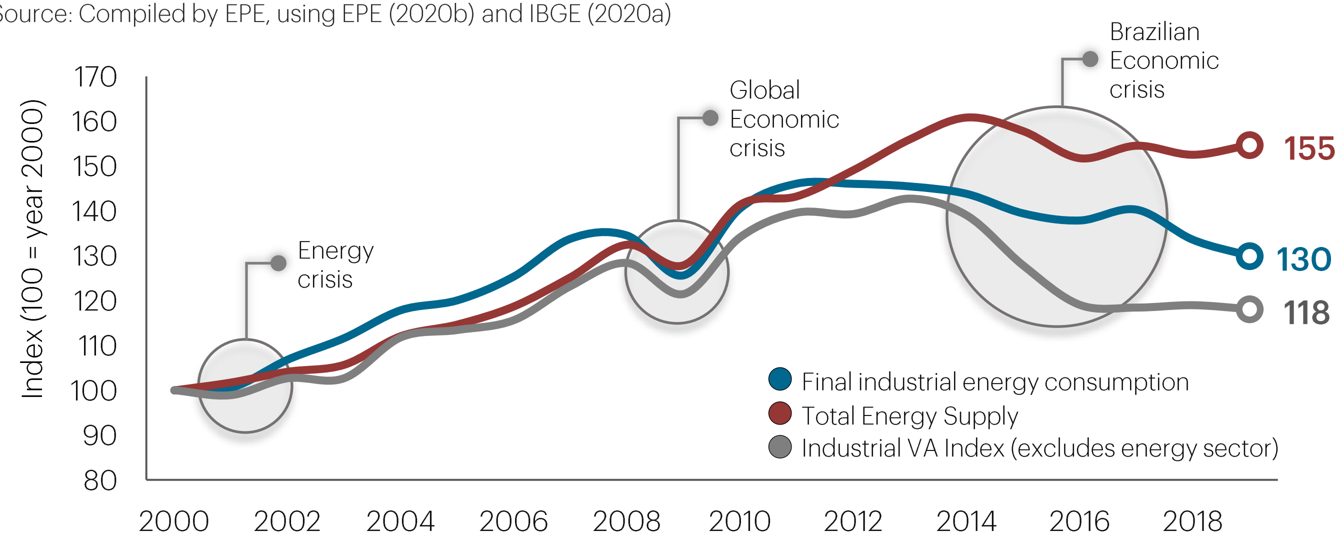
Industry's largest consumers of energy are the steel, sugar, and paper and pulp sectors, which together accounted for 48% of the total in 2000 and 53% 2019. Over this period, there was a reduction in the steel industry's share (-5%) and in that of chemicals (-3%), while the share of the paper and pulp (+6%), and sugar (+4%) sectors increased.

Evolution of total energy consumption in industry and value added in Brazil

Between 2001 and 2005, industrial energy intensity grew at a rate of 1.2% per year, due to increasing consumption in more energy-intensive sectors. The period that ran from 2006 to 2010 was marked by strong economic growth, with industrial GDP and final energy consumption both growing at a rate of 3.3% a year. Between 2014 and 2017, the industrial GDP per capita shrank by 5.4% per year and the energy intensity increased by 3.9% per year.

Figure 22 – TES, final industrial energy consumption and industrial value-added

Source: Compiled by EPE, using EPE (2020b) and IBGE (2020a)



Reduction of industrial GDP per capita and energy intensity of industry, respectively, in the order of 1.9% and 7.6% between 2018 and 2019. Based on a record of greater participation of energy-intensive sectors as of 2013, there has been an increase in the degree of idleness of industries, and a reversal in the trajectories in terms of indicators due to subsequent falls in sugar production (in 2018 and 2019), linked to a decrease in intensity in other energy intensive subsectors, such as ferroalloys, pulp and paper, mining and pelletizing and other metallurgy, justified by structural changes and efficiency gains in various segments in recent years.

Chronologically, the main movements were as follows:

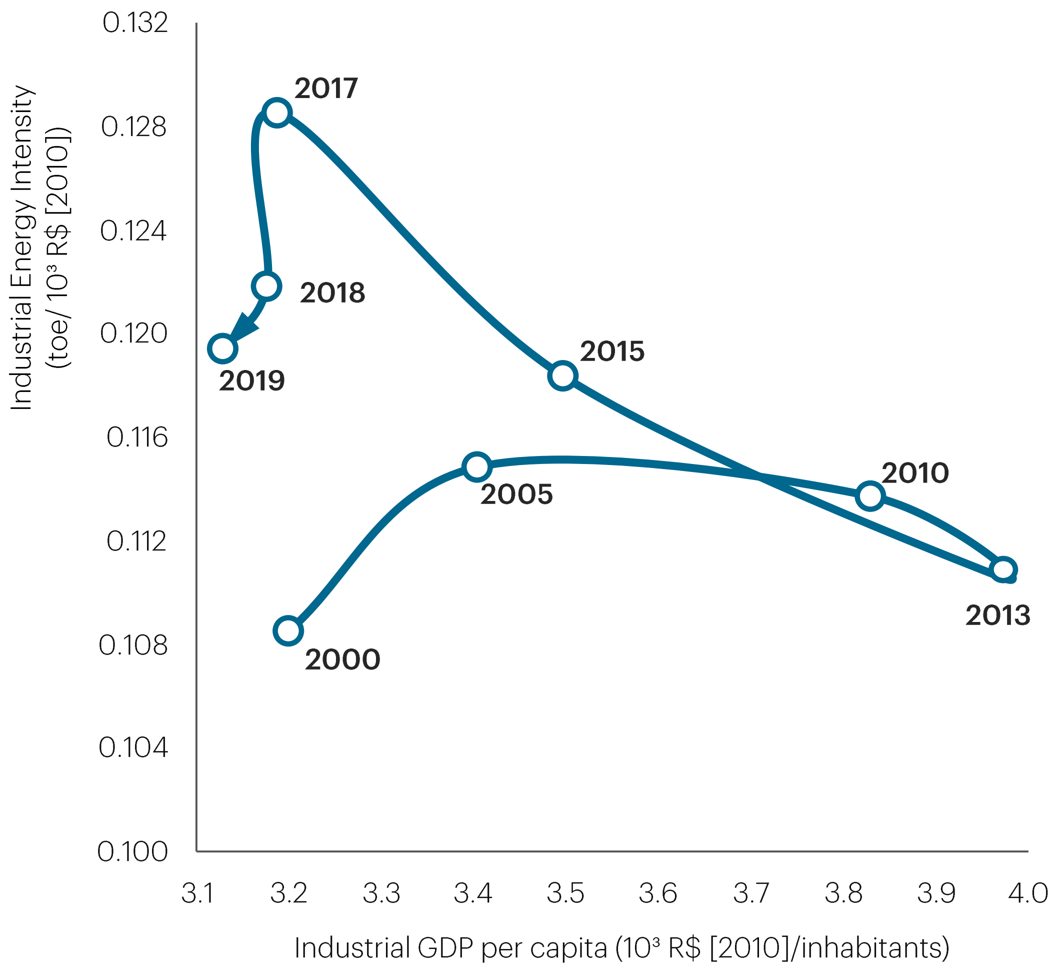
- A growth trend can be observed over the period, interrupted only occasionally in the years of the rationing crisis (2001) and the international financial crisis (2008-09). From 2014, however, the outbreak of a national crisis began to reverse this trend.
- Between 2001 and 2005, industrial energy intensity grew at a rate of 1.2% per year, due to increasing consumption in more energy-intensive sectors such as sugar, chemicals, ferroalloys and steel.

In the following years...

- The period that ran from 2006 to 2010 was marked by strong economic growth, with industrial GDP and final energy consumption both growing at a rate of 3.3% a year. As a result, the energy-intensity indicator remained stable (-0.1% per year) (EPE, 2020c).
- The global financial crisis of 2008-09 caused a recession in the major world economies, with a climate of generalized instability and a reduction in external demand for Brazilian products. As a result, there was a negative impact on the basic metallurgy sector, and the paralysis and even the decommissioning of less efficient industrial units, which in turn reduced energy consumption. This adverse scenario did not last long, however, and in 2010 industrial GDP grew by 10.9% while final energy consumption increased by 12.3% (EPE, 2020c).
- From 2014, the outbreak of a national economic crisis interrupted the growth trajectory of industrial GDP that had been observed since 2010. Combined with a weaker world economy, a degraded domestic scenario that featured a sharp fall in consumption as well as increases in unemployment, inflation and interest rates, reduced the domestic production of industrial goods in a manner that was almost universal, resulting in a decline in industrial GDP per capita of 3.9% per year between 2014 and 2019. During this period there was an increase in energy intensity of 1.3% per year. This came about because of structural changes in industry, with a higher share of energy-intensive activities, and an increase in the degree of idleness in the manufacturing industry as a whole, which began operating at non-optimal levels.

Figure 23 – Path of energy intensity and GDP per capita in industry

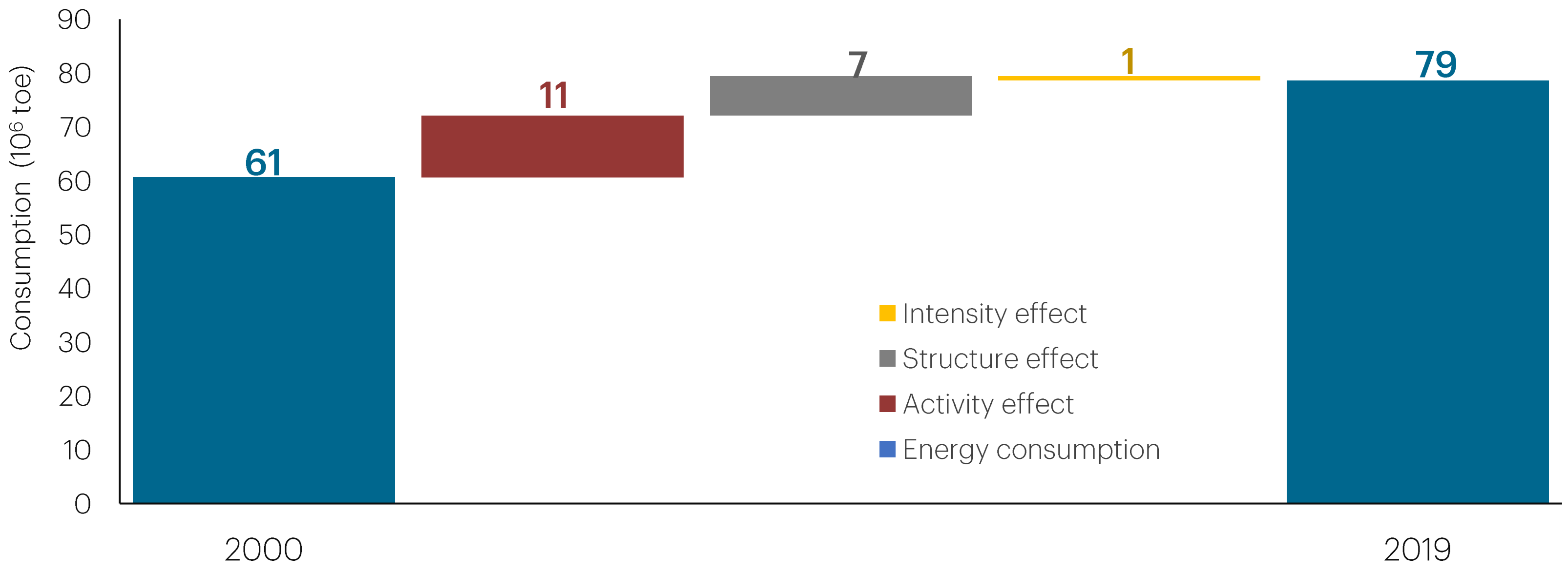
Source : Compiled by EPE, using EPE (2020b) and IBGE (2020a)



Decomposition analysis: between 2000 and 2019 industrial energy consumption increased by 1.4% per year...

Figure 24 – Breakdown of changes in industrial energy consumption

Source: : Compiled by EPE, using EPE (2020b) and IBGE (2020a)



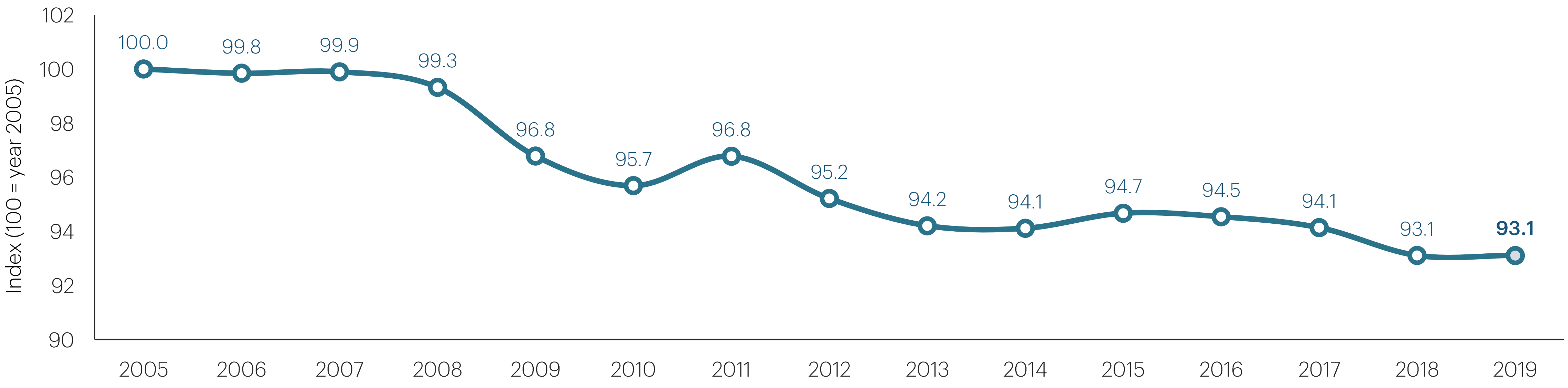
The activity effect (increase in industrial activity, reflected in value added) was the main contributor to this growth, followed by the structure effect (change in the relative participation of sub-sectors within the industry), which in the period, was characterized by an increase in the participation of the energy-intensive segments of sugar and paper and pulp.

Industrial ODEX

Specific consumption was examined for the steel, paper and pulp, cement, and sugar sectors, while energy intensity was examined for 'other food', textiles, chemicals, ceramics, ferroalloys, 'other metallurgy', mining, and 'other industries', based on available information.

Figure 25 – Industrial ODEX

Source: Compiled by EPE

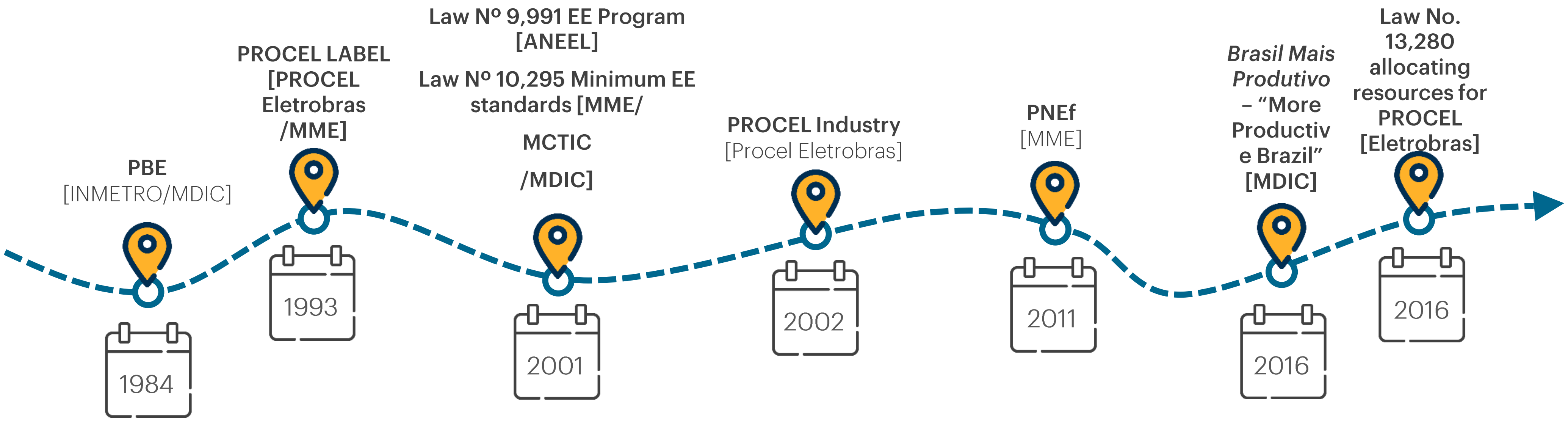


In 2019, ODEX for industry was 93,1, which is to say it was 6,9% lower than the ODEX for 2005, with an average reduction of 0.6% per year. This represents an average gain in energy efficiency.

Timeline: current energy efficiency policies

Figure 26 – Main highlights of energy efficiency policies related to the industrial sector

Source: EPE. Images; Icons made with Freepik - www.flaticon.com



For the industrial sector, important policies have boosted gains in technological innovation, both in the use and in the production of products related to the energy efficiency market. These policies have driven the penetration of more efficient equipment and processes and also take advantage of energy efficiency opportunities, besides representing a driver for gains in competitiveness.

Update on Energy Efficiency and Carbon Abatement in the Cement Sector in Brazil and Globally

Introduction

Energy efficiency is a critical tool to cut carbon emissions and air pollution, and part of a package of decarbonisation strategies that also includes (i) the increase in the use of cement additions, replacing clinker, (ii) switching to lower-carbon fuels, promoting material efficiency through the use of alternative materials and the reduction of total demand for materials, and advancing process and technology innovations such as carbon capture use or storage (CCUS).

Since the 1970's, the efficiency and carbon emissions profile of the Brazilian cement industry have improved markedly through implementation of best practices in technologies, expanding the use of clinker substitutes, and promoting the use of alternative fuels.

In 2019, the cement industry in Brazil, in cooperation with several international organisations including the IEA, developed a Technology Roadmap 2050[2]. The Roadmap lays out a trajectory to further cutting emissions to align with the objectives of the Paris Agreement. The Roadmap includes a range of priority actions, including:

- Strenthening national and international cooperation;
- Enhancing the energy recovery of urban and industrial waste;
- Promoting energy efficiency by sharing best practices;
- Promoting research and development in emerging and innovative carbon-mitigating technologies.

In early 2020, the IEA and EPE published a benchmarking analysis as part of the Atlas of Energy Efficiency that included key indicators for the cement sector (EPE and IEA 2019).

This chapter builds on continuing cooperation between the IEA and EPE to present a national and international analysis of the cement sector, with a particular focus on advancements in energy efficiency and carbon mitigation. It begins with an analysis of the evolution of the sector in Brazil, including key technologies and strategies adopted over the past several decades. This is followed by a global chapter that benchmarks Brazil with other countries along key indicators, and offers examples of leading technology and policy options to advance energy efficiency and carbon mitigation of the sector.

[2] The Brazilian roadmap was developed by the national industry with the International Energy Agency (IEA), the Cement Sustainability Initiative (CSI) of the World Business Council for Sustainable Development (WBCSD), the International Finance Corporation (IFC) of the World Bank and a group of academics led by José Goldemberg. .

1. Brazil Country Analysis

1.1. Brazilian overview

The Brazilian cement industry currently stands out internationally as one of the best positioned in terms of low carbon emissions, energy efficiency and use of alternative fuels and raw materials. This outstanding position was achieved due to actions begun decades ago, which have been expanding and consolidating over the years.
In the 1970's, the oil crises that resulted in the rise of international prices led the Federal Government to seek solutions to contain the import of oil and oil products, on which Brazil was highly dependent.

Among the proposed solutions, by determination of the Presidency of Brazil, the National Union of the Cement Industry (SNIC in Portuguese) and the Ministries of Industry and Commerce, Mines and Energy and Transport signed a protocol that aimed to create conditions and introduce measures to reduce fuel oil consumption in the energy-intensive cement industry as much and as soon as possible.

The commitments then assumed by the industry resulted in the modernization of the industrial infrastructure, with the conversion of wet to dry kilns in almost the entire industrial fleet in less than 15 years - a practice pursued in the world years later – reducing fuel consumption by almost half and, consequently, lowering CO2 emissions.

In addition to the installation of equipment to reduce energy consumption, other results obtained in the search to optimize energy use by the sector included: the increased use of cement additives such as blast furnace slag and ash from thermoelectric plants, the use of alternative energy sources through the pioneering use of biomass, and the development of ecological burners for various types of fuels, with 100% national technology.

The 1980s and 1990s were characterized by market stagnation and consolidation of these more efficient practices in the production process, with a less pronounced but constant evolution. During this period there were significant advancements in the use of higher levels of additives to replace clinker, resulting in lower final energy consumption per ton of cement produced and reduction in CO2 emissions in the Cement sector.

The production boom and the increase in installed capacity seen from mid-2000s to 2015 resulted in a new transformation and update of the Brazilian cement sector. More than 99% of the sector started to operate with dry process. Multi-stage pre-heaters and precalciners, which reuse the hot gases from the furnace to preheat the raw material, have become predominant, as well as more efficient clinker coolers. Modern vertical mills, with lower electrical consumption, have gradually replaced more obsolete ball mills.

It was also in the 2000s that the consolidation of the co-processing activity in Brazil took place. This practice is widespread throughout the world and allows the thermal reuse of waste in cement production furnaces, replacing non-renewable fossil fuels.

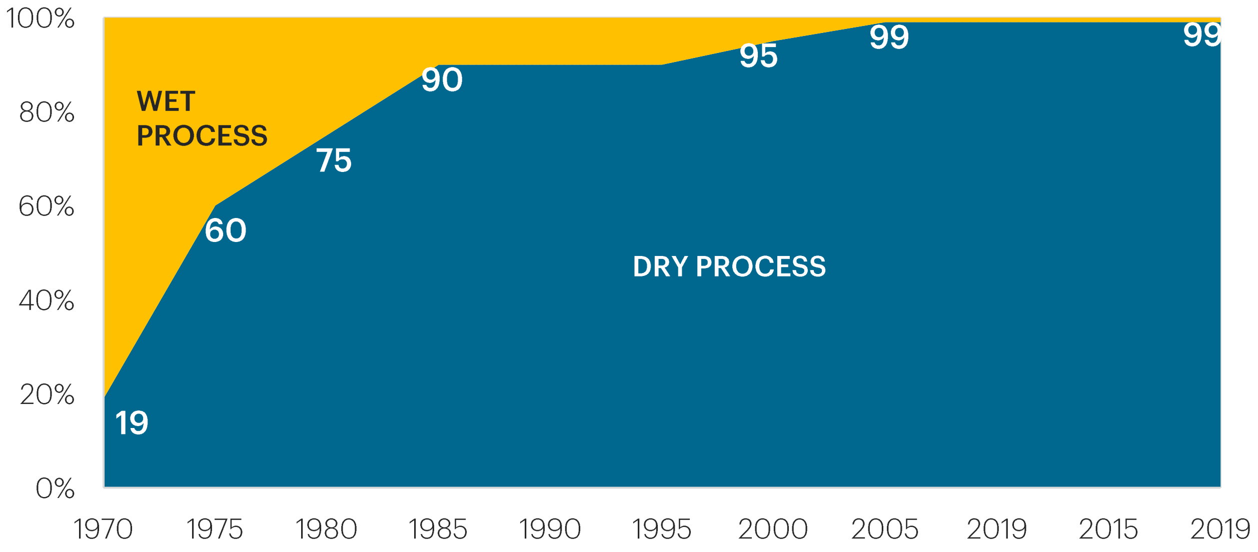
More recently, two milestones have led the drive for greater efficiency in the sector: the updating of the ABNT Cement Standard (ABNT NBR 16697), in 2018, and the Conama Resolution on Coprocessing, in 2020 (RESOLUÇÃO CONAMA/MMA Nº 499, DE 6 DE OUTUBRO DE 2020), lagging almost 30 and 20 years, respectively. These updates allow greater use of alternatives to substitute clinker, and waste to substitute fossil fuels, in the cement production process. These shifts align with the patterns of more advanced standards and norms, such as the European ones.

1.2. Technological developments

The cement industry in Brazil has a modern and efficient industrial infrastructure, which is constantly being updated. The almost total replacement of wet kilns by dry kilns the 1970s and the 1980s (today more than 99% of facilities use dry kilns), the significant increase in capacity in the last ten years, with facilities operating with the best available technologies (BAT), and the constant investments in retrofits and equipment modernization mean that the sector's energy consumption is today below that of most countries (SNIC, 2019a).

Figure 27 – Shift of Furnaces from Wet process to Dry process

Source: Compiled by EPE, using SNIC (2020).



At present, approximately 40% of plants are less than 15 years old and more than 70% of furnaces are equipped with 4 to 6 stage preheating towers and pre-calciners. Modern grate coolers equip 80% of the Brazilian kilns. Approximately 50% of the raw material mills are vertical, which is the technology considered to have the lowest electric consumption.

With these measures, the sector has managed to reduce its thermal specific consumption by 45%, going from 6.4 GJ/t of clinker to 3.5 GJ/t of clinker from 1970 to 2019. In terms of electrical specific consumption, the improvements were less significant during this period, from 115 kWh/t of cement to 111 kWh/t of cement, since this value was close to the benchmark.

1.3. Indicators

The decreasing share of clinker in the composition of cement over the period 2000-2019 resulted in a 1.1% reduction per year in specific consumption of cement (Figure 28).

Clinker is a basic component of cement. Its production is energy-intensive and is the most demanding part of the process in terms of thermal energy. In the production of cement, by-products of other activities and alternative raw materials are added to clinker, such as slag from steel mills, ashes from thermoelectric plants, and limestone filler. The use of additional materials reduces the amount of clinker used in cement production and, consequently, reduces energy consumption without necessarily altering the production level. Furthermore, the use of specific additional materials such as pozzolana can reduce production costs and bring advantages such as increasing cement's resistance to water.

Figure 28 – Specific energy consumption in the cement industry

Source: Compiled by EPE, using EPE (2020b).

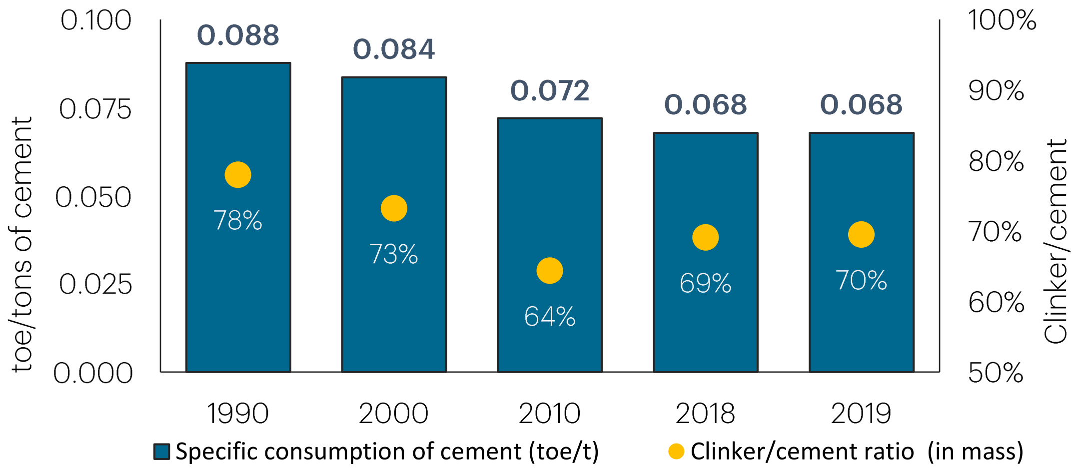


Figure 29 – Specific consumption in the cement industry - clinker and cement

Source: Compiled by EPE, using EPE (2020b).

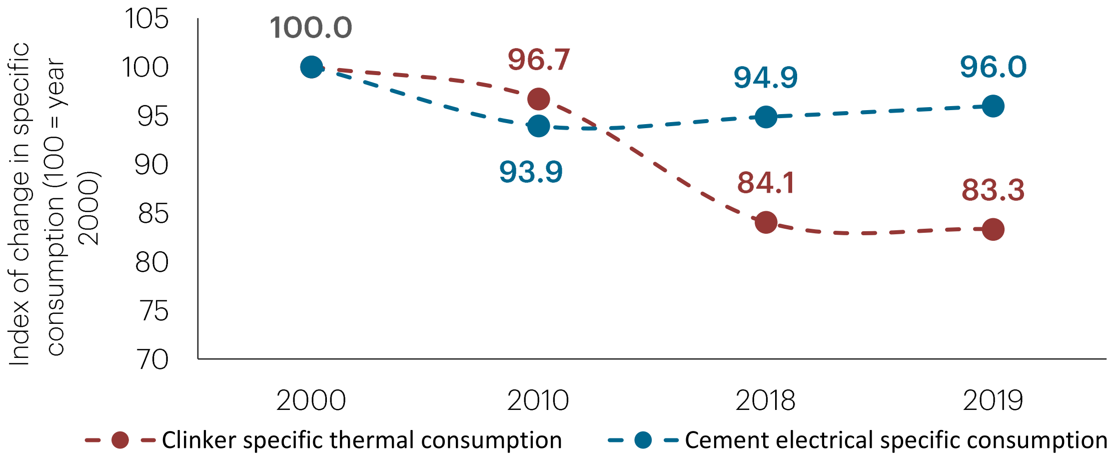


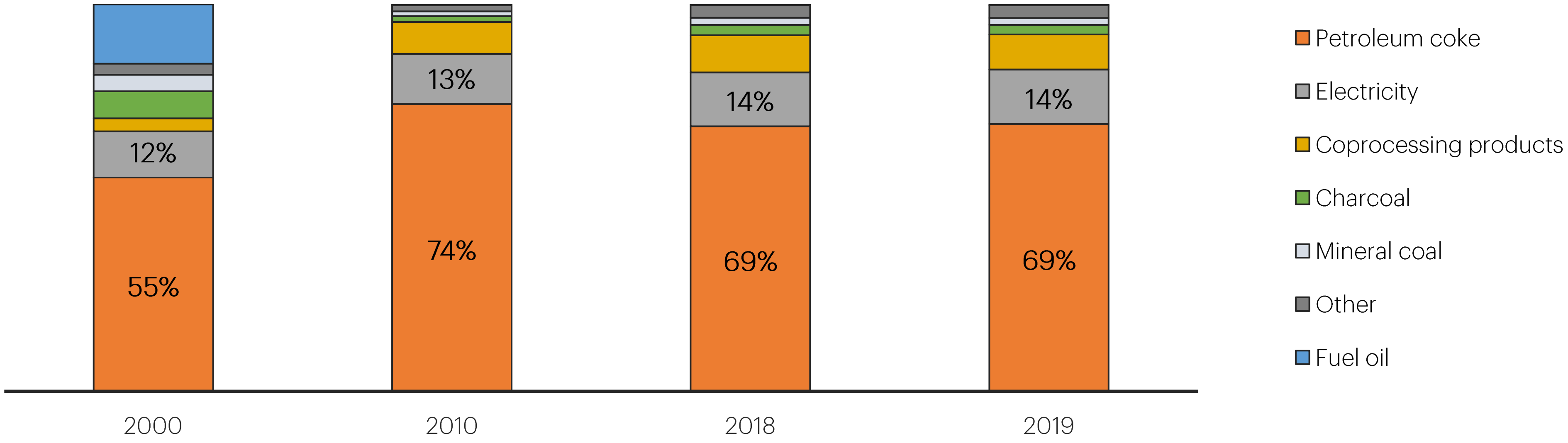
Figure 29 makes possible a separate evaluation of the specific thermal and electric consumption from the production of clinker and cement. Most of the electricity consumption takes place in cement production (grinding), and most of the fuel is used in clinker production (furnace). It can be observed that thermal specific consumption of clinker (which excludes electricity) fell by 17% over the whole period.

When it comes to cement, the continuous reduction in specific energy consumption between 2000 and 2019 is related to improvements made in the sector during this period, through investments in more efficient machines. Thus, it is observed that the specific consumption of cement decreased by 4% over the entire horizon. Both the reduction in the specific thermal consumption of clinker and the decrease in the specific electrical consumption of cement reveal gains in energy efficiency in the analyzed period.

The energy mix of the cement industry, which is illustrated in Figure 30 , has undergone changes over time. The oil crises and the consequent adjustment of the industry had a strong impact on fuel oil consumption, especially in the 1980s, when there was a momentary migration to coal (mineral and vegetable). In the 2000s, it was the entry of imported petroleum coke, more competitive, that made the sector migrate to this energy source, to the detriment of fuel oil. Thus, currently, petroleum coke is the main energy source, due to its low price and guaranteed supply.

Figure 30 – Cement production: final energy consumption by source

Source: Compiled by EPE, using EPE (2020b)



From the 2000s on, a new energy revolution is beginning to gain relevance, which is the use of alternative fuels, featuring the co-processing of waste and the use of biomass. Co-processing has several environmental benefits, offering both an appropriate means of waste disposal and, when from renewable sources, reducing greenhouse gas (GHG) emissions. The co-processing of alternative sources has grown, and represented 9% of consumption in 2019.

The search for energy sources with less carbon intensity than conventional fuels has been an important tool of the Cement sector to reduce its CO2 emissions, besides contributing to the elimination of environmental liabilities represented by the accumulated waste in dumps and landfills. This energy transition has required - and will require even more - investments from the sector in adapting the production process, as well as improvements in monitoring and control.

Today, alternative fuels already represent 15% of the sector's thermal consumption, and grow every day, replacing mostly petroleum coke, which is still responsible for 80% of the total. The other 5% comes from charcoal consumption.

1.4. New technologies and perspectives for the cement industry

Climate change is becoming more and more relevant in the cement industry, which is one of the most carbon intensive industry segments. Globally, it is responsible for about 7% of the CO2 emitted in the world, although the Brazilian cement industry has one of the lowest carbon intensities in the world (per ton of cement produced), due to the actions it has been implementing for decades.

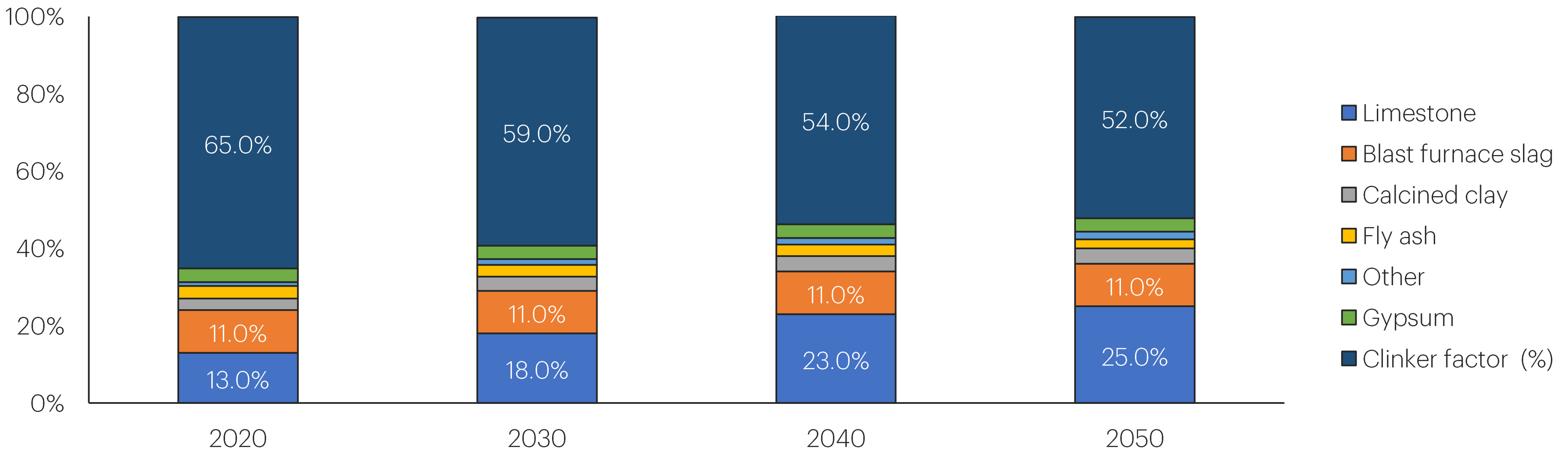
Facing the challenge of reducing, even more, the already low CO2 emissions, the cement industry in Brazil has developed a Technology Roadmap 2050, containing the perspectives and needs to accelerate its transition towards a low carbon economy. These trends are concentrated in four main pillars:

1.4.1. Cement Additions

Regulatory progress, research in cement chemistry, development of new cements, among other actions, would allow the industry to continue advancing in the development of new additions to cement, replacing clinker. With this, the segment aims to reduce the clinker/cement ratio to levels just above 50% by 2050.

Figure 31 – Clinker's Additions and Substitutes

Source: Compiled by EPE, using SNIC (2019a).



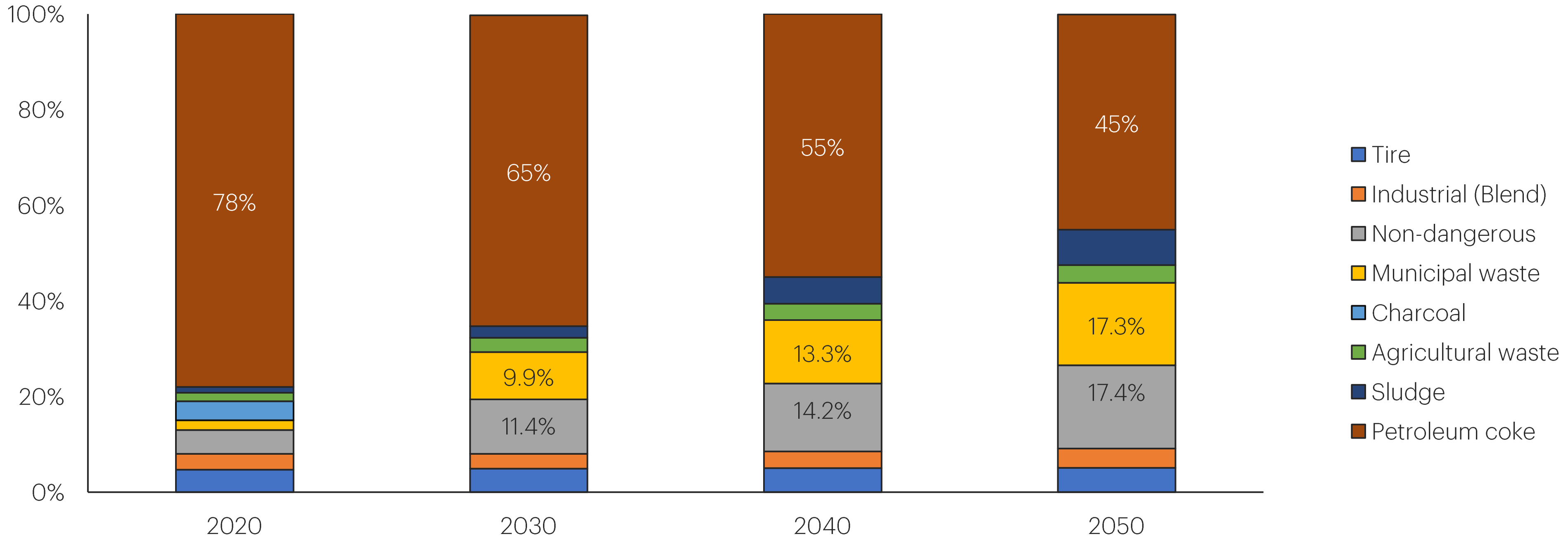
1.4.2. Alternative Fuels

The shift from non-renewable fossil fuels to alternative fuels, mostly represented by co-processing of waste, will be the main transformation of the cement plants in the coming decades.

Following the world trend, it is expected that the sector in Brazil will reach levels of around 55% of alternative fuels by 2050 - values already practiced by some European countries such as Germany. In Europe as a whole, the average replacement rate is 40%.

Figure 32 – Alternative fuels

Source: Compiled by EPE, using SNIC (2019a).



1.4.3. Energy Efficiency

Considering the technological state of the Brazilian industrial fleet, which is modern and efficient, no significant changes are expected until 2030, when the most obsolete factories would begin to be replaced by new units, using state-of-the-art equipment and technology. Thus, the sector is expected to reach thermal consumption values of around 3.2GJ/ton of clinker and 90kWh/ton of cement by 2050.

Figure 33 – Specific thermal consumption of clinker (2014-2050)

Source: Compiled by EPE, using SNIC (2019a).

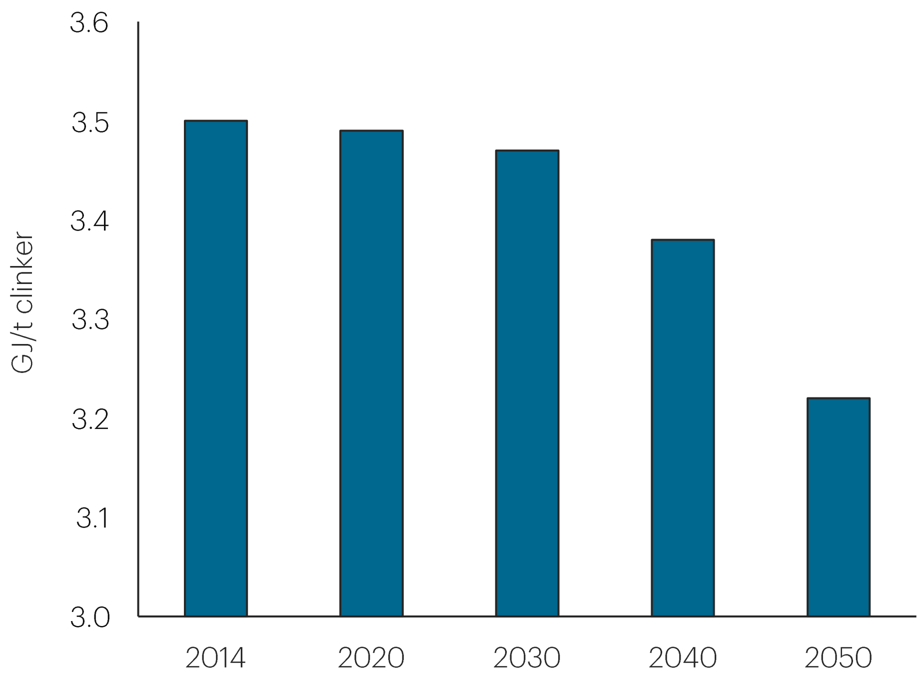
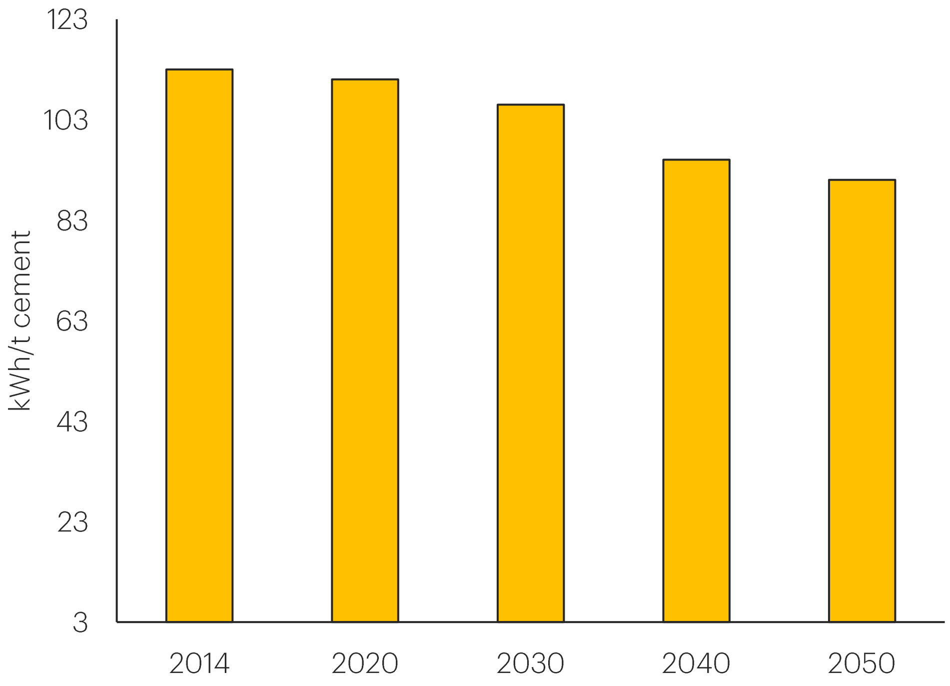


Figure 34 – Specific electrical consumption of cement (2014-2050)

Source: Compiled by EPE, using SNIC (2019a).



1.4.4. Innovative and Emerging Technologies [3]

The three alternatives traditionally used and known to the sector for the mitigation of its emissions, previously described, present a technical and operational limitations. Hence, it is necessary to seek long-term disruptive solutions that allow the sector to advance further towards a less carbon intensive and consistent production process. Brazil has already implemented one of the key recommendations to support development of these kinds of solutions by developing a roadmap for the sector to 2050. Additional suggestions include encouragement of joint international scientific and research projects.

Consequently, innovative and emerging technologies gain importance, particularly Carbon Capture Utilization and Storage (CCUS), which is being studied around the world.

Under this perspective, the sector relies on the viability of CCUS at industrial scale in Brazil starting in 2040. Realizing this vision will require significant investments in R&D.

[3] More suggestions can be found at IEA 2020, IEA e CSI (2018), e SNIC (2019a).

2. International benchmarking analysis

2.1. Cement Industry trends

Energy efficiency is a critical tool to cut carbon emissions and air pollution, and part of a package of broader decarbonisation strategies including sourcing renewable energy and CCUS. While some strategies, and particularly CCUS, will require decades to reach commercial maturity, the advantage of energy efficiency is that it is available today, is the most cost-effective option, and has multiple benefits. All countries, including Brazil, show the potential to bring the specific consumption of cement production down to the level of best available technology (BAT) – that is, technology that is efficient, technically feasible and economically affordable[4]. The most cost-effective opportunities to implement BAT capital expenditures predominantly come at the time of construction of a new cement facility or during refurbishment. For this reason, it is particularly important to ensure that policies and incentives are aligned to deploy BAT at these critical junctures. At the same time, other energy efficiency measures can be implemented during the operational phase, including control, maintenance and operator training, and are important to ensure the multiple benefits that continual improvement can bring.

This section begins with a global benchmarking analysis of key efficiency indicators in the cement sector that compares the performance of the cement industry in Brazil with other countries. This is followed by a discussion of global trends and opportunities to reduce emissions. Finally, the chapter provides several examples of good policy practices that are driving emissions reductions and improved efficiency in the sector around the world.

[4] More broadly good/best practice is a technique and/or technology that, through experience and research, has been proven to reliably lead to a desired result with the minimum use of resources.

Modelling emissions abatement pathways[5]

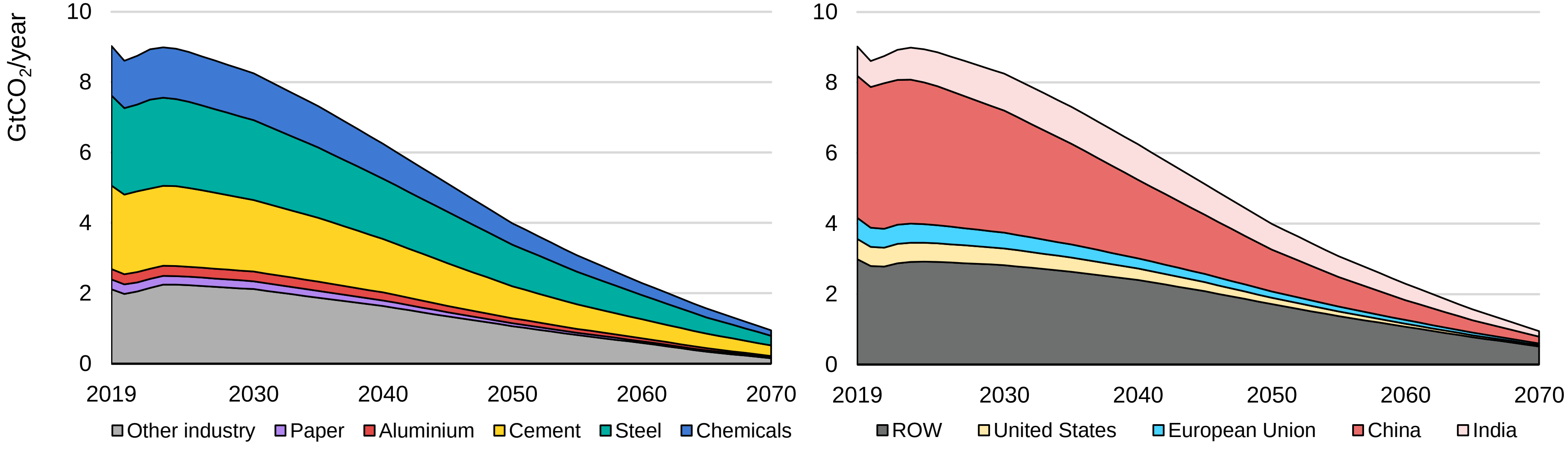
Based on existing and announced policies – as described in the IEA Stated Policies Scenario (STEPS) – the world is not on course to achieve the outcomes of the UN SDGs most closely related to energy: to achieve universal access to energy (SDG 7), to reduce the severe health impacts of air pollution (part of SDG 3) and to tackle climate change (SDG 13).

The IEA's Sustainable Development Scenario (SDS) outlines a major transformation of the global energy system, showing how the world can change course to deliver on the three main energy-related SDGs simultaneously.

The SDS scenario is also consistent with the Paris Agreement, which has an objective of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels".

Figure 35 – Global direct CO_2 emissions in industry by sub-sector and region in the Sustainable Development Scenario, 2019-70

Source: IEA (2020a)



Notes: Includes energy-related and process emissions. Other industry includes less energy-intensive industries such as food and beverage, mining and textiles.

ROW = Rest of the World

[5] A more detailed description of the IEA's modelling approach and scenarios is available at: https://www.iea.org/reports/world-energy-model

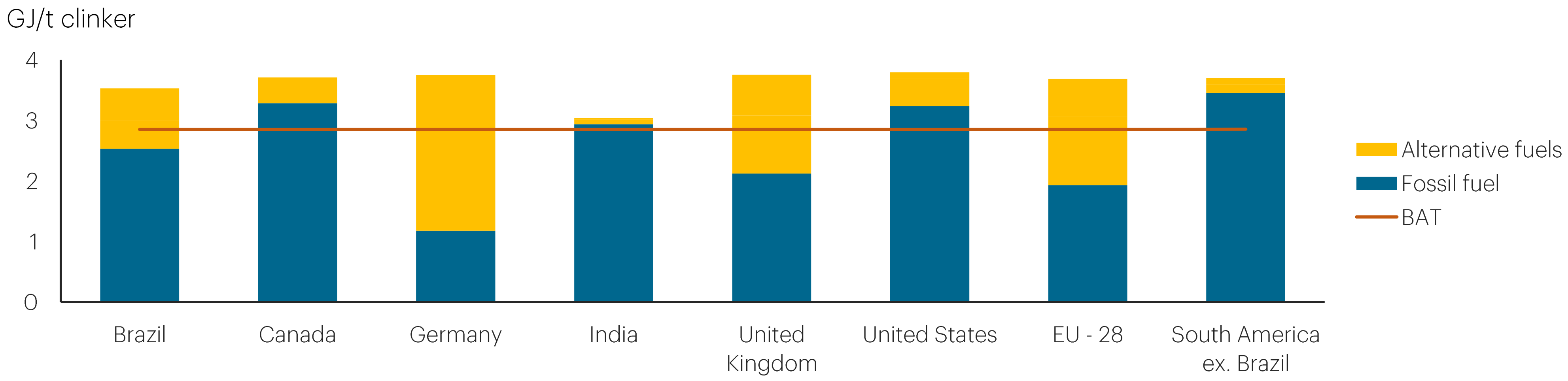
2.1.1. Energy consumption and efficiency

Thermal specific consumption of clinker production is a key indicator of energy efficiency and emissions levels. The mix of fossil fuels to alternative fuels in the process is an important indicator of emissions levels. In 2018, only India came close to achieving the level of best available technology (BAT) in terms of thermal specific consumption across its cement sector. Brazil's specific thermal consumption was slightly below the rest of South America and other major countries and regions presented below. All countries presented have potential to improve their processes to reach the level of BAT.

Brazil has a higher degree of alternative fuels in clinker production than Canada, India, the United States and the rest of South America. Countries and regions with a higher share of alternative fuels include Germany, the United Kingdom and the EU-28[6].

Figure 36 – Thermal specific consumption of clinker, excluding electricity consumption (2018)

Source: CSI (2019)



It is important to note that there can be a tension between reducing CO_2 emissions and improving energy intensity. Some CO_2 reduction measures require more energy inputs, partially offsetting the energy savings from switching to modern kilns and resulting in a higher energy intensity.

[6] EU-28 refers to the 28 member countries of the European Union in place in 2019.

For example, using calcined clay requires considerable energy for processing even after recent energy efficiency improvements. Similarly, using bioenergy and waste leads to higher energy needs for pre-treatment to ensure uniform composition and optimum combustion, as well as to minimise the content of potentially problematic substances that can result in additional pollution or emissions. For these reasons, energy efficiency is more important than ever to minimise these increases in energy consumption.

Another indicator of energy efficiency is the specific consumption for electricity in the cement sector. In 2018, Brazil's specific consumption for electricity was slightly higher than for the rest of South America, and lower than other major economies and regions presented, except for India. Nearly all countries presented demonstrate significant potential to improve the level of specific consumption for electricity when compared to that achieved through best available technology.

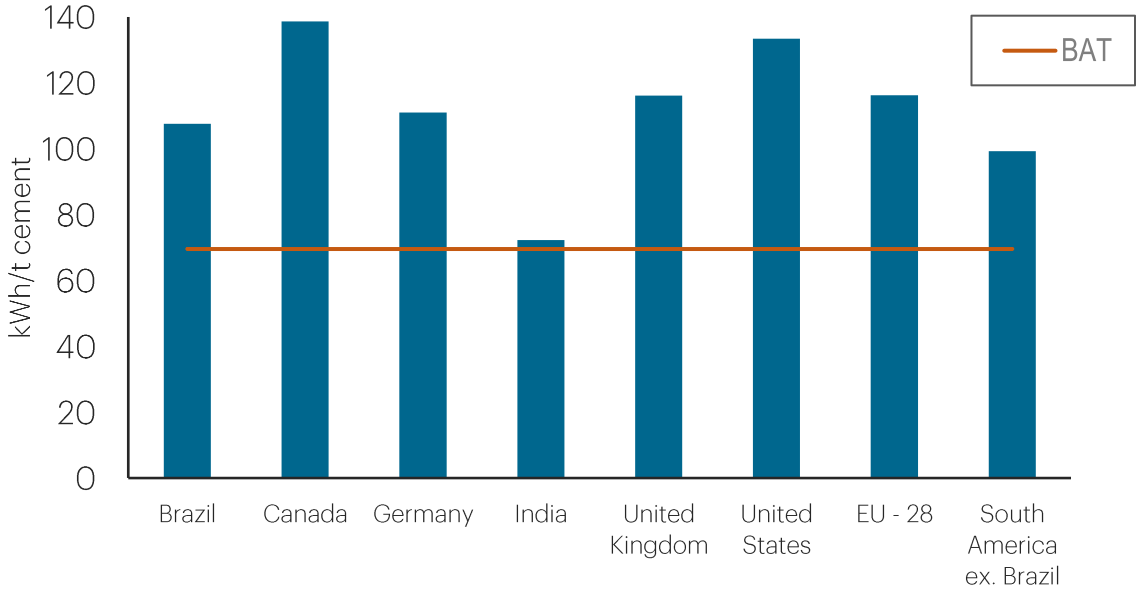
Strategies to improve specific consumption of electricity include switching to more efficient grinding technologies, such as from replacing or selecting ball mills to high-pressure grinding rolls and vertical roller mills, as well as using excess heat recovered from the kiln for power generation. These improvements are part of a package of measures to reduce emissions in the sector, many of which Brazil is already implementing partially or totally. However, one technology with the potential to dramatically reduce electricity consumption in the sector is Waste Heat Recovery (WHR). According to SNIC analyses, this technology can achieve the same levels of savings as all other electrical efficiency measures together, achieving a 25-30% reduction in the plant's electrical consumption.

This is a reality in countries like China and India, where this technology is present. Meanwhile, there is only one unit with WHR in Brazil, which was designed already integrating this equipment.

The high import rates and the absence of instruments to promote the import of energy efficiency and low carbon technologies, without similar national, represents the main obstacle to the viability of this equipment.

Figure 37 – Specific consumption for electricity, 2018

Source: CSI (2019)

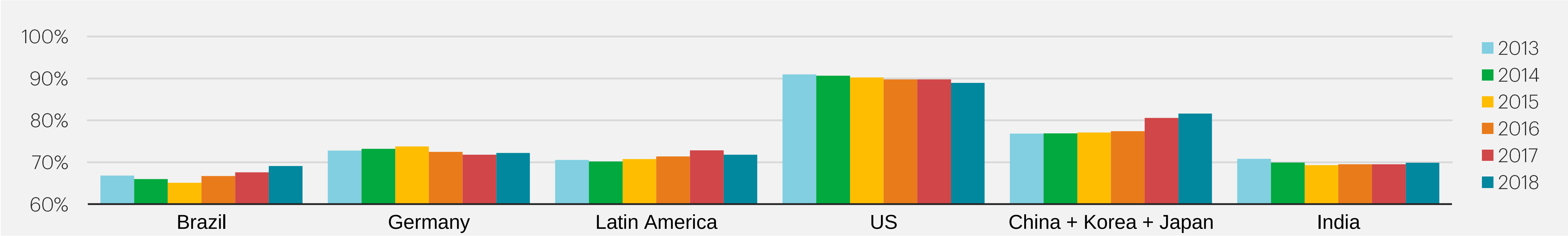


2.1.2. Clinker/cement ratio

One of the most effective measures to reduce the energy demand of cement production is to reduce the ratio of clinker to cement. This can be accomplished by substituting clinker with other less energy-intensive materials to create blended cement mixes. In 2019, clinker made up about 71% of cement on average worldwide, with blast furnace slag and fly ash from coal plants accounting for a significant proportion of the rest. Over time as these alternatives become scarcer, the IEA projects an increasing reliance on alternatives like limestone and calcined clay..

Figure 38 – Clinker/cement ratio

Source: CSI (2019) and EPE (2020b) for Brazil



The deployment of CO_2-reduction technologies in the cement industry is broadly similar across regions. Nonetheless, there are some differences in the contribution made by reductions in the clinker-to-cement ratio as its potential is highly dependent on the local availability of clinker substitutes, as well as on the required properties of the final concrete product, which are determined by local standards and end-use applications. The potential also varies according to the extent to which it has already been exploited.

For example, China already has a comparatively low clinker-to cement ratio (65% in 2019), and based on raw material availability and current building standards, its ratio is expected to remain relatively low. Brazil is expected to remain a leader in calcined clay production, having produced about 2 Mt per year since the 1970s. Regions like Italy that have good availability of natural pozzolana – an alternative cement constituent – rely more on that to lower cement-related emissions. Regions that move to concrete standards that are not prescriptive and do not require pre-specified amounts of clinker could facilitate increased uptake of blended cements without compromising safety and performance.

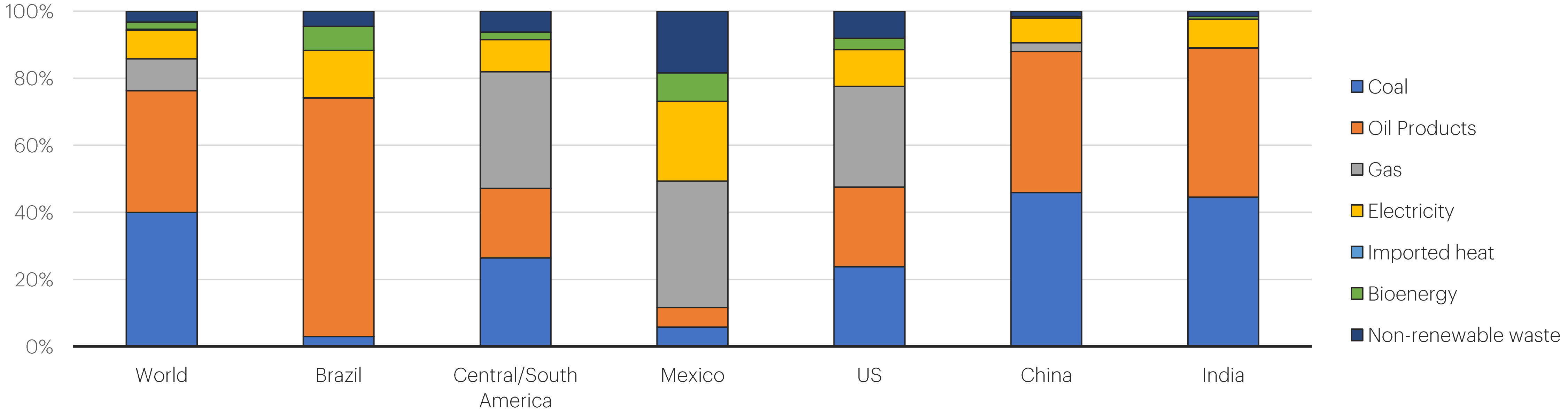
2.1.3. Energy sources for clinker production

Another important part of the package of policy measures to decarbonize the cement sector is to encourage and put in place policy frameworks supporting the use of alternative fuels in clinker production. At the same time, improving the efficiency of fuel combustion remains an important goal.

The clinker production process is highly energy intensive and tends to rely heavily on coal, notably in the largest global cement markets: China and India. However, as Figure 39 illustrates, there is a significant portion of natural gas, oil and biofuels deployed in different jurisdictions. The EU-27 deploy a significant share of biomass, while Brazil, Mexico and India rely heavily on oil for cement production. While natural gas is one of the lesser fuels in the cement sector in Brazil, it plays an important role in Argentina, the United States, the EU-27, and to a lesser extent Mexico and Colombia.

Figure 39 – Fuel use in the cement sector, select countries (2019)

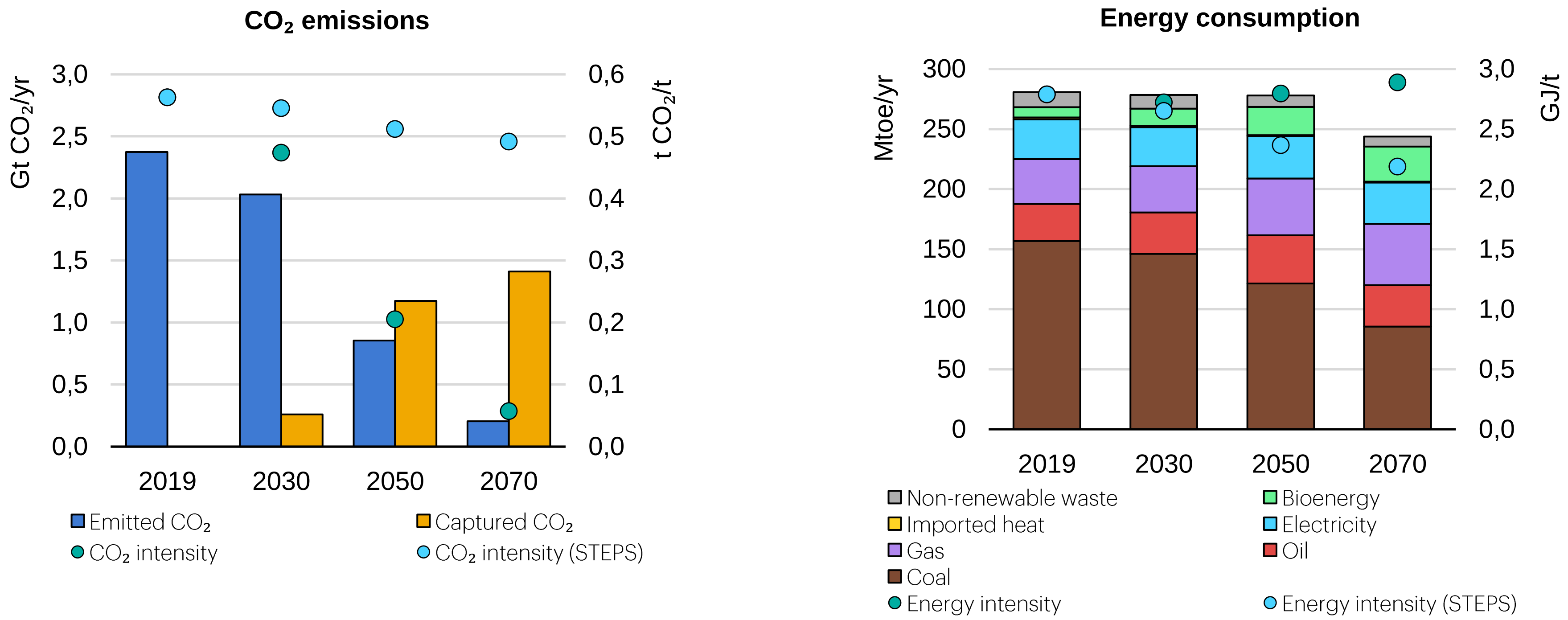
Source: These are estimates rather than directly reported data. They are informed by: production data from USGS (United States Geological Survey); clinker ratios, fuel shares and thermal intensities from the GCCA (Global Cement and Concrete Association); and fuel shares in the non-metallic minerals sector reported to IEA.; and EPE (2020b) for Brazil



While the fuels used in clinker production are often highly carbon-intensive, fuel switching makes a relatively minor contribution to emissions reductions in the Sustainable Development Scenario. Fuel switching – mainly from coal to natural gas, hydrogen, biomass and renewable waste (including waste wood, sawdust and sewage sludge) – accounts for about 1% of cumulative emissions reductions. Given the high temperatures, the large quantities of energy needed and the technical requirements of kilns, switching to direct electrification, hydrogen or direct heating from concentrated solar power would be technically challenging and very costly. Work on some of these switching options is underway, but it is at an early stage of development. To reduce emissions from fuels used in clinker production, much more emphasis is placed on carbon capture and storage and on other areas already discussed, such as clinker substitutes.

Figure 40 – Global cement sector direct CO_2 emissions and energy consumption in the Sustainable Development Scenario (SDS), 2019-70

Source: IEA (2020a)



Notes: STEPS = *Stated Policies Scenario*. Energy intensity here includes all energy used per tonne of cement, including additional Energy needs for some strategies deployed in the SDS – chemical absoption carbono capture and storage, calcined clay use and alternative fuel use. This explains the increasing overall Energy intensity by 2070.
CO_2 emissions from the cement sector fall by around 90% between 2019 and 2070 in the SDS, largely due to material efficiency and large-scale deployment of CCUS.

2.2. Examples of technology and policy options

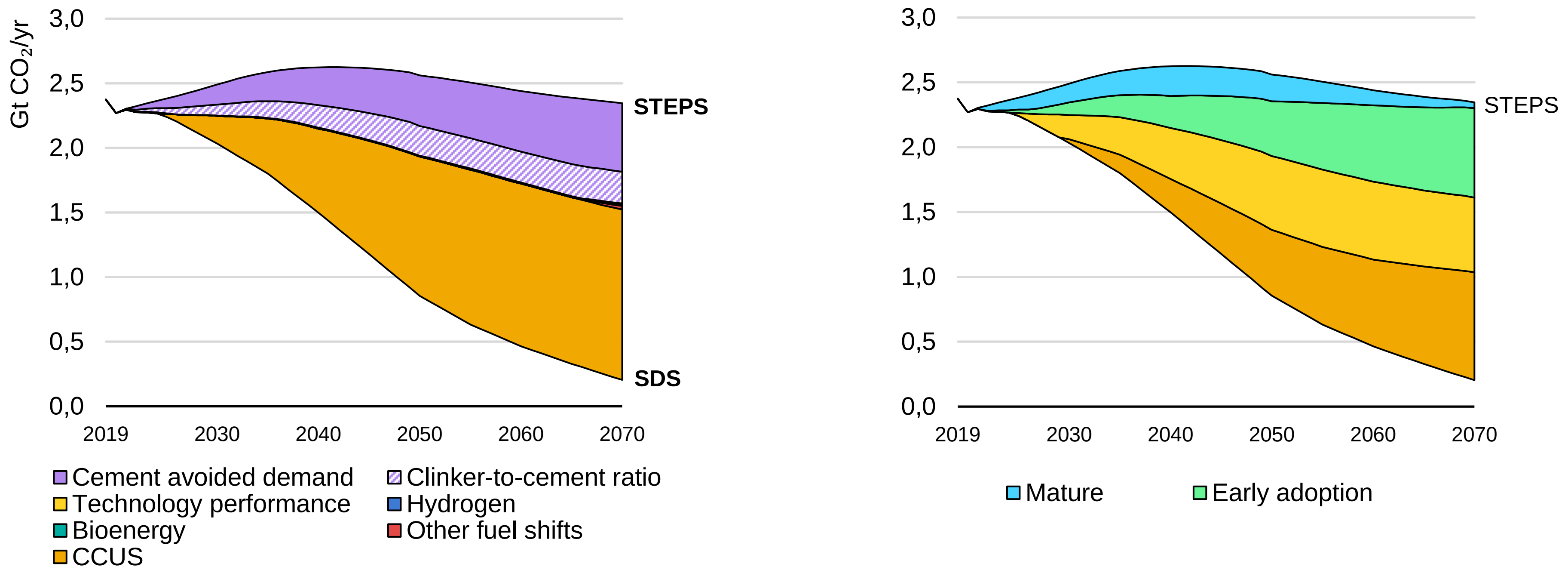
2.2.1. Technological developments

In its recent report on "Energy Technology Perspectives 2020", the IEA models a pathway to decarbonising the cement sector globally to 2070. This view presents a package of measures to achieve the Sustainable Development Goals. This package prominently features CCUS, avoided demand, and a reduction in the clinker-to-cement ratio as key mitigation options. Energy efficiency continues to play an essential role in ensuring that best available technologies are in place, and that as solutions emerge, cement plants are as energy efficient as possible.

As illustrated in Figure 41, the IEA's analysis shows that CCUS may need to account, in a global scale, for 60% of emissions reductions required to reach the SDGs in the cement sector to 2070.

Figure 41 – Global CO_2 emissions reductions in the cement sector by mitigation strategy and current technology maturity category, 2019-70

Source: IEA (2020a)



Note: Cement avoided demand and the clinker-to-cement ratio both fall within the broader category of material efficiency. The thermal energy used by the chemical absorption CCUS deployment is subtracted from the CCUS contribution, and therefore does not impact the efficiency contribution. Material efficiency and the CCUS together play the leading role in reducing cement sector emissions in the SDS. Over 60% of cumulative reductions come from technologies that are not yet commercially available.

Avoided demand for cement makes up the next-largest portion of emissions reductions. The main measures that yield these gains are higher renovation rates to extend the lifetime of existing buildings, lower levels of waste on construction sites, the optimisation of building designs to reduce the materials needed to construct the same floor area, and material efficiency in other cement infrastructure.

A reduction in the clinker-to-cement ratio comes in as the third major source of emissions reductions.

According to Figure 41, many of the technologies needed to achieve the SDS are in demonstration or prototype phase. For this reason, technology advancement will play a significant role in decarbonising the cement sector. In the meantime, there is an opportunity for cement plants to continue to improve energy efficiency by optimising plant operations and installing more efficient equipment when it is economically viable to do so. This will be particularly important in the near-term as new technologies are tested and mature.

Globally most of the potential has been exploited in recent decades for technology improvement, mainly due to the phase-out in most regions of wet kilns and traditional vertical kilns. Notably, the world's biggest cement producers – China and India – have already deployed the most efficient kiln commercially available today – the dry kiln with a precalciner and a staged cyclone preheater.

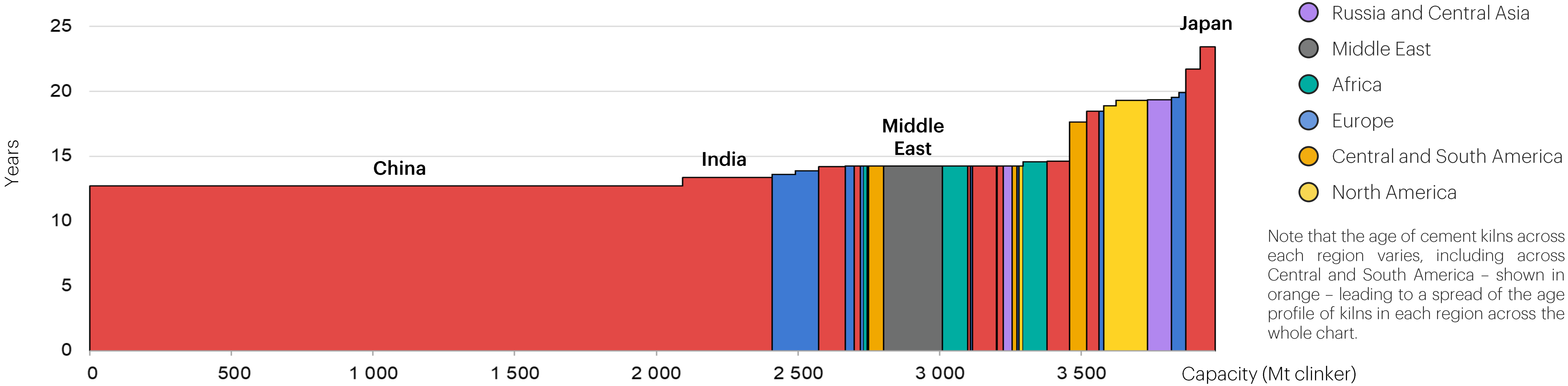
In Brazil, over the last ten years, in response to the growing demand from the construction sector, the industry has doubled cement production and increased its installed capacity by 50%, reaching 71 million and 100 million tons/year, respectively. The most modern technologies available (BATs) were used for this purpose (SNIC, 2019a).

Nowadays, about 40% of the industrial park is less than 15 years old and more than 70% of its furnaces are equipped with 4 to 6 stage preheating towers and pre-calcinators. Grid coolers equip 80% of the Brazilian ovens and approximately 46% of the raw material mills are vertical, considered to have the lowest electric consumption (SNIC, 2019a).

The fact that cement factories last a long time hinders the pace at which they can be replaced with new ones using lower emission technologies without early retirement. Retrofits of existing capacity with CCUS technologies are therefore likely necessary, perhaps together with conversion of some assets to enable them to process alternative lower emission raw materials like calcined clay.

Figure 42 – Age profile of cement kilns

Source: IEA (2020a)



Note that the age of cement kilns across each region varies, including across Central and South America – shown in orange – leading to a spread of the age profile of kilns in each region across the whole chart.

Many of these plants often need a major refurbishment before the end of their typical lifetime, with investment needs being the same order of magnitude of those for a brand new plant. A typical investment cycle is about 25 years, which offers a window of opportunity to change course and significantly reduce emissions from existing heavy industry infrastructure. But if this window of opportunity is missed and key technologies such as hydrogen or CCUS are not available, then these plants could continue to emit a high level of greenhouse gas emissions for another couple of decades to come.

Additional technological improvements are listed in the IEA's ETP Clean Energy Technology Guide. They are ranked according to a series of parameters including: readiness level, their importance to reach net zero targets, and the step in the value chain. Table 1 provides a selection of key technological improvements, chosen both according to their readiness level and importance for net-zero emissions.

Table 1 – Technology opportunities to achieve net-zero emissions, readiness and importance

Source: IEA (2020a)

Readiness level (TRL)[7]	Technology	Step in value chain	Importance for net-zero emissions	Details
6 to 9	Grinding > Advanced grinding technologies	Production	Moderate	A range of more efficient raw material and fuel grinding technologies for cement production are under research and development. They include contact-free grinding systems, ultrasonic-comminution, high voltage power pulse fragmentation, low temperature comminution.
9	Raw materials > Alternative cement constituents > Calcined clay	Production	High	Calcined clay is an alternative cement constituent that can be used instead of clinker in blended cements.
9	Raw materials > Alternative binding material > Alkali-activated binders (geopolymers)	Production	Moderate	Alkali-activated binders are produced by the reaction of an alumino-silicate (the precursor) with an alkali activator. They rely on materials similar to those used in blended cement to reduce the clinker to cement ratio.
9	Unhydrated cement recycling	End-of-life	Moderate	In the process of concrete curing, some portion of cement does not come in contact with water and is left unhydrated (some estimates suggest that up to 50% of cement could remain unhydrated). New concrete crushing technologies are under development that would enable recovering this unhydrated cement from end-of-life concrete for direct reuse as new cement.
9	Curing > CO2 sequestration in inert carbonate materials (mineralisation	Production	Moderate	CO_2 from industrial emitters can be used as a raw material in the production of building materials. The most mature applications involve the replacement of water with CO2 during the formation of concrete, called CO2 curing, and the reaction of CO2 with waste materials from power plants or industrial processes (e.g. iron slag, coal fly ash), which would otherwise be stockpiled or stored in landfill, to form construction aggregates (small particulates used in building materials). The CO2 used in building materials is permanently stored in the product. CO2-cured concrete can deliver lower costs compared to conventionally-produced concrete, while building materials from waste and CO2 can be competitive in some cases as it avoids the cost associated with conventional waste disposal. Producing building materials from waste can be energy intensive, in particular the pre-treatment and post-treatment steps. For structural applications of building materials (e.g. building, bridges, etc), multi-year trials projects are required to demonstrate safe and environmental-friendly performance

Table 1 – Technology opportunities to achieve net-zero emissions, readiness and importance (continuation)
Source: IEA (2020a)

Readiness level (TRL)[7]	Technology	Step in value chain	Importance for net-zero emissions	Details
8	Cement kiln > CCUS > Chemical absorption, partial capture rates (less than 20%)	Production	Moderate	Chemical absorption of CO_2 is a common process operation based on the reaction between CO_2 and a chemical solvent (e.g. amine-based). The CO_2 is released at temperatures typically in the range 120°C to 150°C and the solvent regenerated for further operation. It can be applied to kilns, the main unit producing clinker for cement production
8	Raw materials > Alternative binding material > Carbonation of calcium silicates	Production	Moderate	Cements based on carbonation of calcium silicates can sequester CO_2 as they cure. Therefore, even if they are based on similar raw materials to PC clinker, these types of cement can yield zero process CO_2 emissions in net terms, as the emissions would essentially be re-absorbed during the curing process.
7	Cement kiln > CCUS > Chemical absorption (full capture rates)	Production	Very high	Chemical absorption of CO_2 is a common process operation based on the reaction between CO_2 and a chemical solvent (e.g. amine-based). The CO_2 is released at temperatures typically in the range 120°C to 150°C and the solvent regenerated for further operation. It can be applied to kilns, the main unit producing clinker for cement production.
7	Cement kiln > CCUS > Calcium looping	Production	Very high	Calcium looping is a technology that involves CO_2 capture at high temperature using two main reactors. In the first reactor, lime (CaO) is used as a sorbent to capture CO_2 from a gas stream to form calcium carbonate ($CaCO_3$). The $CaCO_3$ is subsequently transported to the second reactor where it is regenerated, resulting in lime and a pure stream of CO_2. The lime is then looped back to the first reactor. Nearly pure oxygen is typically used (oxyfuel combustion) to supply a large heat flow to the second reactor. A main benefit of calcium looping is potentially lower overall process energy consumption compared to other capture technologies. The technology is well suited for application to the flue gases from kilns, the main unit producing clinker for cement production

[7] Technology readiness is based on a scale of 1 to 9, with 1 representing the lowest level of readiness and 9 representing the highest. For a full list of technologies, see https://webstore.iea.org/download/direct/4165 e https://www.iea.org/articles/etp-clean-energy-technology-guide

As Table 1 shows, much stronger efforts are still needed for technology promotion. For instance, at a CO_2 price of about USD 80/tCO2, CCUS starts to become a cost-competitive option for cement production in countries such as Canada and Australia, where the price of cement reaches the level of USD 140/t (SNIC 2019b). In these countries, this would only affect consumers marginally (around 3% increase in cost for a 500K house)[8]. In the case of Brazil, where the price of cement is USD 60/t (SNIC, 2019b), the CO_2 value of around USD 80/tCO2 would have an extremely negative impact, which could make the country's cement industry unfeasible.

Moreover, there are still large opportunities to produce cement through green alternatives. The CemZero project currently being developed in Sweden by the joint efforts of cement producer Cementa (a subsidiary of HeidelbergCement) and energy producer Vattenfall has proven that electrification of the cement process is feasible and might be competitive. The next phase will develop a pilot. Considering that concrete is the second most consumed material in the world, after water, and that it represents 7% of global emissions, much more similar projects should be pursued across the world. Global partnerships and data sharing will be essential to save time and resources, which are in very limited amount if we are to meet the objectives laid out in the SDS scenario.

[8] For more information, visit: https://www.energy-transitions.org/wp-content/uploads/2020/08/ETC-sectoral-focus-Cement_final.pdf

2.2.2. Public and private policies

It is clear that a policy package for the cement sector will need to address the main emissions reductions opportunities and continuous improvements in efficient technologies and operations. Underpinning each of these strategies is an energy reporting policy/framework that provides accurate and reliable data to improve the validity and usefulness of the benchmarking being undertaken. Leading emissions reduction opportunities include CCUS and alternatives for clinker (materials efficiency). Policies to reduce demand for cement in the buildings sector and other infrastructure will also be crucial, though they fall outside the scope of this chapter.

The IEA's recent analysis – WEO 2020 – shows that energy efficiency and electrification play a central role in the industry sector in the near term. While electrification plays a lesser role, at least for now, in projections for the cement sector, energy efficiency remains crucial. Progress with energy efficiency will make sure that higher levels of efficiency can be locked in new and refurbished industrial assets that will operate for decades to come and existing facilities will continue to improve their efficiency.

The ideal policy packages for energy efficiency consist of the combination of three main types of mechanisms: Regulations, information and incentives. These three elements of a policy package are applicable across the economy, whether countries are looking to improve energy efficiency in industry or transport, appliances or buildings. Each of these tools in the policy toolkit can play an important role in driving energy efficiency improvements, while delivering jobs, energy bill savings, and other benefits.

The following examples of successful cases across the world contain a combination of these three mechanisms. Table 2 lists some examples of policies that have produced improvements in energy use by cement. It is to be noted that these are illustrations, and that specific national and local specificities should be taken into account when setting policy packages. Some measures might produce different results in different places.

Table 2 – Examples of programmes to improve energy efficiency of cement sector

Source: IEA (2020a)

Country or region	Energy efficiency policies	Regulatory	Incentives	Information
China	Top 100 / 1 000 / 10 000 enterprises Programme[9]	Under these programmes consumption targets are set for each enterprise. Compliance with the targets is part of the evaluation of the overall performance of the provincial governments, which is linked to annual evaluation awards and promotions for government officials. Enterprises are expected to carry out: energy audits, training, reporting, action plans, and investments, among other measures.	Companies benefit from financial incentives.	Companies must report quarterly on their progress to the National Bureau of Statistics (NBS)."
	As part of its 13th Five-Year Plan (2016-20), China aims to reduce the thermal energy intensity of clinker production to 3.07 GJ/t clinker on average by 2020, which would shrink the gap between the current level and best available technology thermal energy performance by two-thirds.			
Índia	Perform, Achieve, Trade (PAT) Scheme	PAT sets mandatory energy intensity improvement targets for designated consumers (DCs) in energy-intensive sectors.	PAT provides an incentive for DCs to exceed targets by allowing them to generate energy saving certificates (ESCerts) and sell them to other underperforming DCs. Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) covers 50% of the value of loans to participating financial institutions (PFIs) on energy efficiency projects.	A very thorough data reporting system allows the Government to collect production and energy use from DCs to re-evaluate targets of the PAT every 2 years.
	Between 2011 and 2015, 85 cement plants in India participated in the first cycle of Perform, Achieve, Trade (PAT), a market-based mechanism to improve energy efficiency. They achieved energy demand reductions equivalent to 9% of India's 2014 cement sector energy consumption, and the cement sector is now involved in the second PAT cycle, with higher targets and coverage.			
Global	In 2015 in the private sector, 18 key cement companies developed the shared objective to reduce their CO2 emissions by 20-25% from the business-as-usual level by 2030, equivalent to 1 GtCO2. This initiative, dubbed the Low carbon Technology Partnership Initiative (LTCPi) is very good example of collaborations that could be built on to promote energy efficiency improvements[10].			
Europa	In Europe, the mandate to develop cement standards within the European Committee for Standardisation was recently widened to allow possible low-carbon alternatives to OPC clinker that rely on different raw materials or mixes. This is an example of regional approaches that could be widened to include energy efficiency across sectors.			

Focus on Germany

- Total end-use energy consumption in the cement sector in Germany has been increasing since 2008 due to two factors: increasing demand from the building materials industry for high-performance, and often finely ground, cements and increasing production of cements with other main constituents (blast furnace slag or limestone) in addition to clinker. Such composite cements lead to lower specific carbon dioxide emissions but increase the grinding effort required to achieve the desired product quality;
- Germany's proportion of coal and lignite in the total thermal energy requirement for cement production has dropped from around 87 per cent in 1987 to around 28 per cent in 2018, through increased use of alternative fuels;
- In 2012 German industry entered into an agreement with the government to increase energy efficiency, committing to continually reducing its specific energy consumption between now and 2020;
- In return for energy tax relief, German industry has – in place of the previous climate protection agreement – committed to introducing certified energy management systems and a collective annual reduction in specific energy consumption of 1.3 per cent from 2013 and 1.35 per cent between 2016 and 2020. (Vdz).

Energy efficiency can be further accelerated through collaborative efforts among industry, public sector and research partners to share best practices on state-of-the-art technologies and to develop plant-level action plans that would increase the speed and scale of technology deployment. Ensuring efficient equipment operations and maintenance would also help guarantee optimal energy performance, and digital technologies are creating new opportunities, enabling better control of energy use and lowering the cost of monitoring and optimising industrial processes. The implementation of energy audits will help identify key opportunities for further efficiency gains, and the use of energy management systems will greatly enhance the levels of efficiency.

[9] Para mais informações sobre estes programas, consulte LBNL (2008).
[10] Para maiores informações sobre esta iniciativa, acesse: https://www.wbcsd.org/Sector-Projects/Cement-Sustainability-Initiative/Resources/Low-Carbon-Technology-Partnership-initiative-LCTPi-Cement-full-report

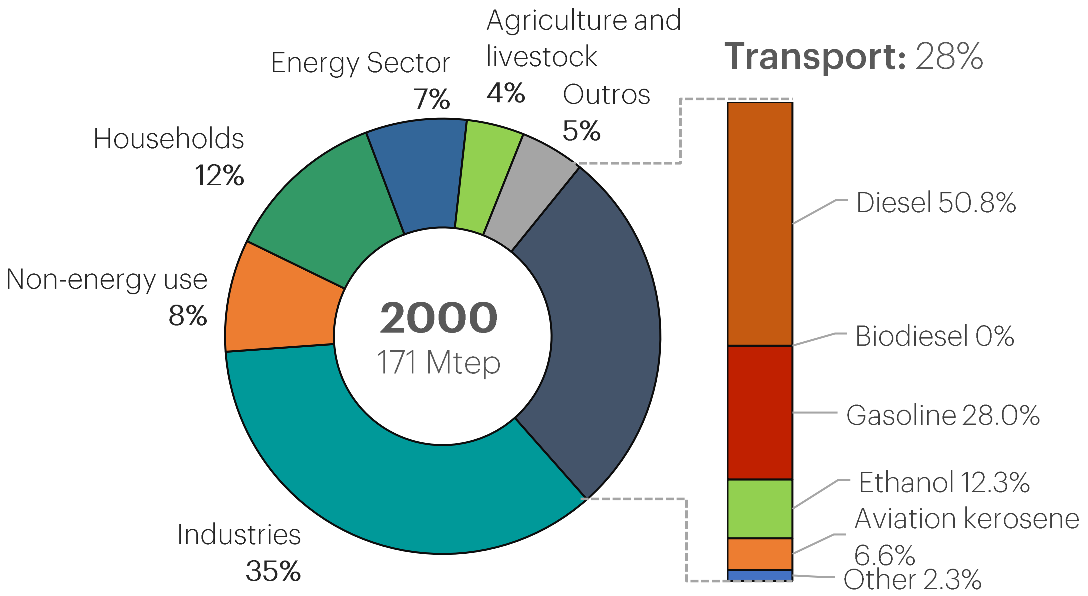
Transport

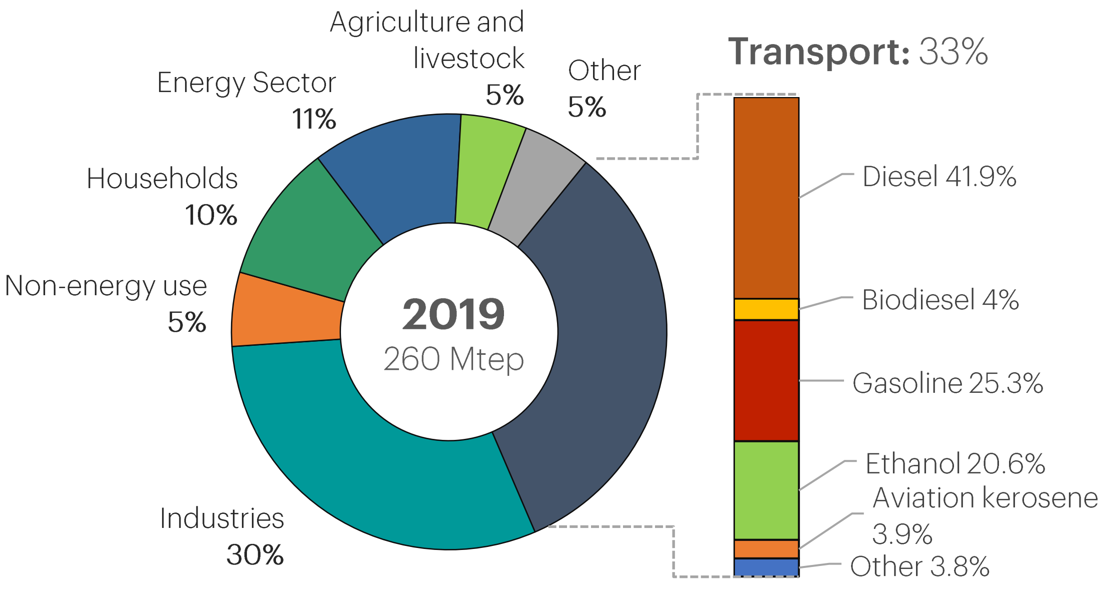
Evolution of energy consumption in the transport sector

National energy consumption grew 2.2% p.a. between years 2000 and 2019, in line with GDP growth, which was 2% per year. Growth in income and the number of private cars has increased energy demand for mobility.

Figure 43 – Final consumption and the transport sector in Brazil in 2000 e 2019 (toe)

Source: Compiled by EPE, using EPE (2020b)





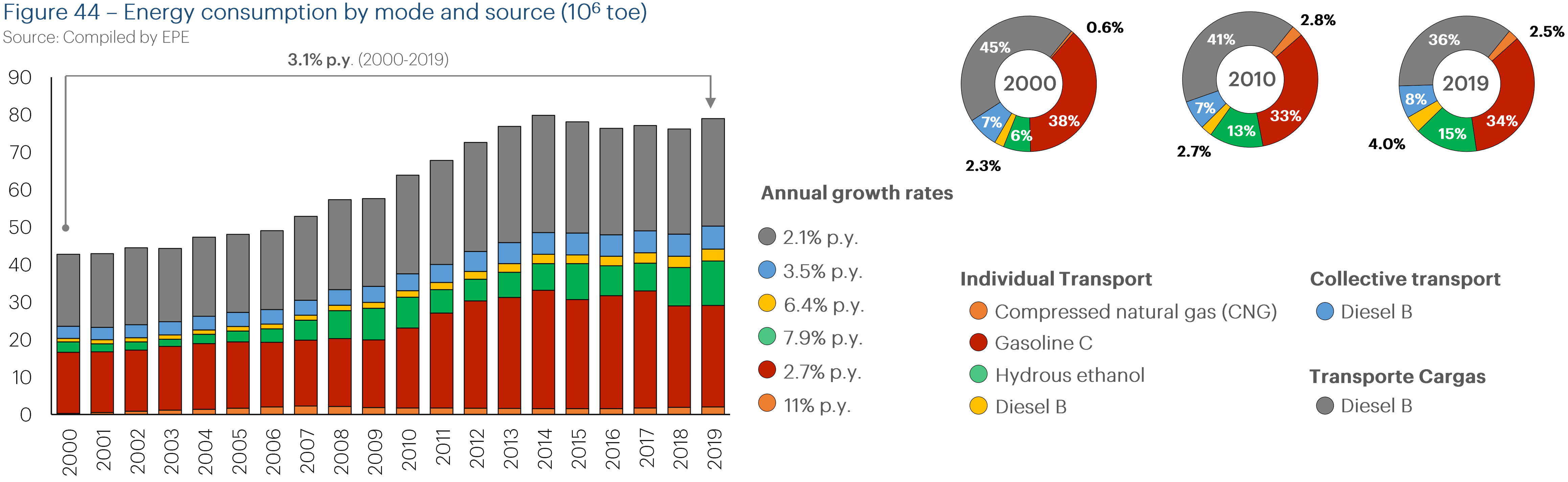
The transportation sector grew 3.1% per year, when an increase in passenger and cargo transportation was observed, due to the increase in the consumption of goods and the agricultural sector.

Evolution energy consumption in road transport

Demand for passenger transport increased by 4.1% per year, while that for freight transport grew by 2.1% per year. Superior progress of individual transport has reduced potential systemic efficiency gains.

Figure 44 – Energy consumption by mode and source (10^6 toe)

Source: Compiled by EPE



The growth of the CNG and hydrous ethanol shares as energy sources in the road transportation mix is noteworthy. Both have a higher specific consumption than gasoline vehicles. Incentives to biofuels influenced the share of biodiesel and hydrated ethanol, which grew 8% p.a. since 2000. Both have limited the sector's efficiency gains.

Passenger Transport

Individual transport has gained importance over the first decade, in line with a greater income distribution, and to the detriment of the sector's total efficiency. Among the modes, some highlights were:

- Air transport has also increased in activity, to the detriment of interstate public road transport. The use of more efficient aircraft and the increase in occupation have promoted a growth in efficiency in this mode.
- Metro-rail transportation has also grown, especially due to infrastructure projects, which were accelerated with the major events of the last decade, replacing individual transportation, and promoting systemic efficiency.
- Public road transport became less efficient due to the introduction of biodiesel, and the increasing use of air conditioning in the fleet of large cities.

Figure 45 – Energy intensity by mode [toe/(10^6 p.km)]

Source: Compiled by EPE

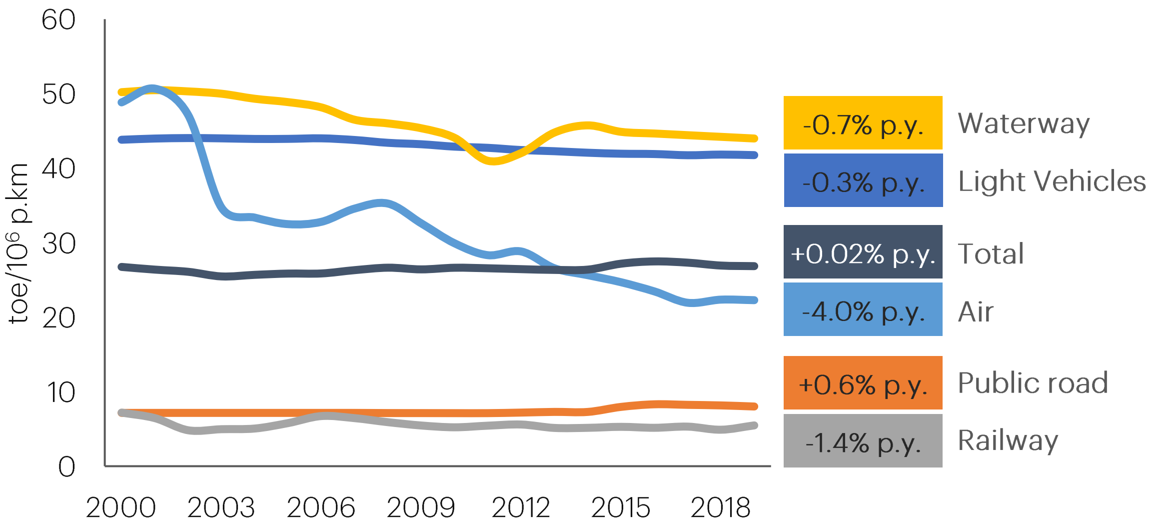
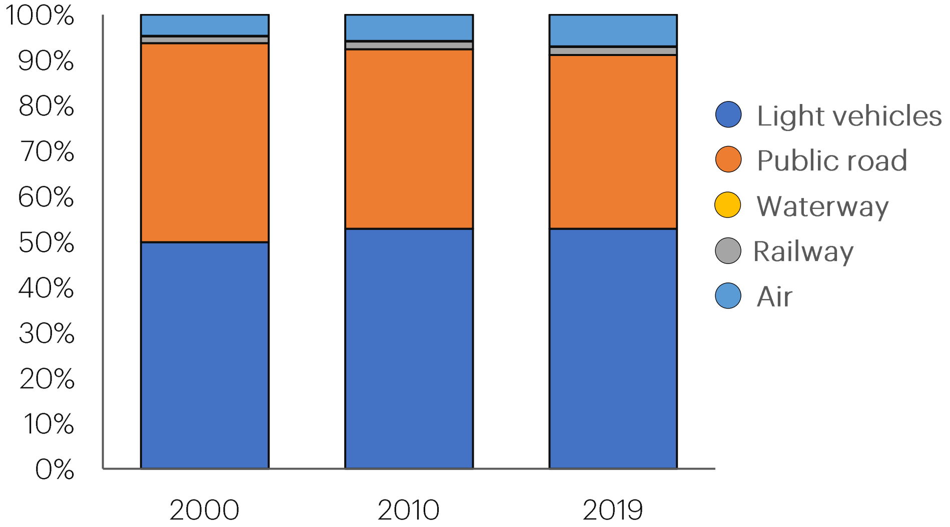


Figure 46 – Activity by mode [p.km]

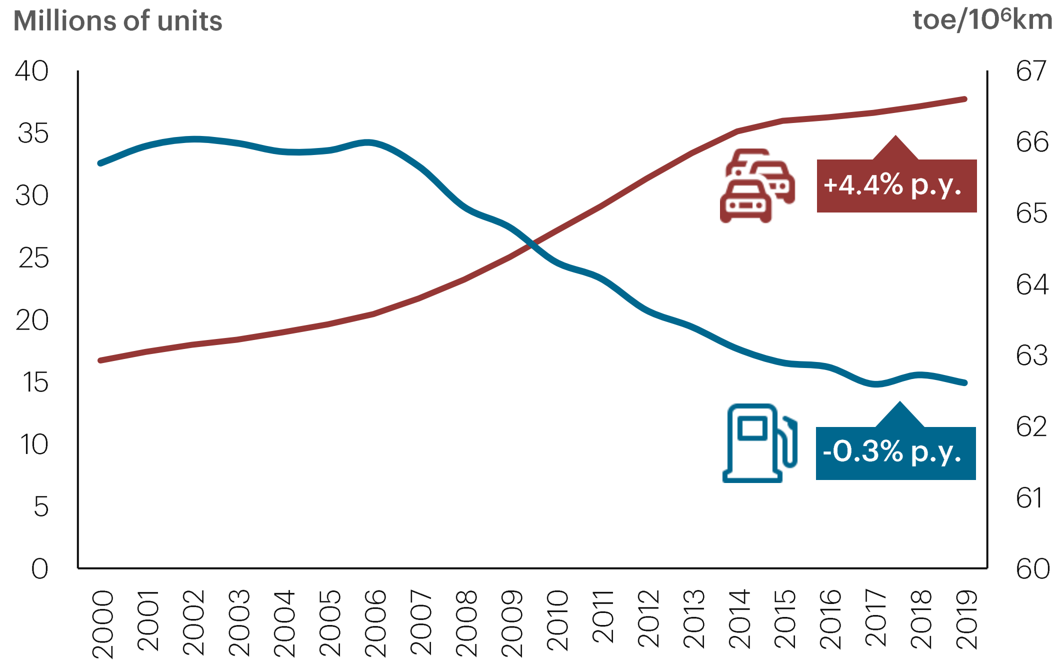
Source: Compiled by EPE



Individual passenger transport

Figure 47 – Light Vehicle fleet and specific consumption - 2000 to 2019

Source: Compiled by EPE

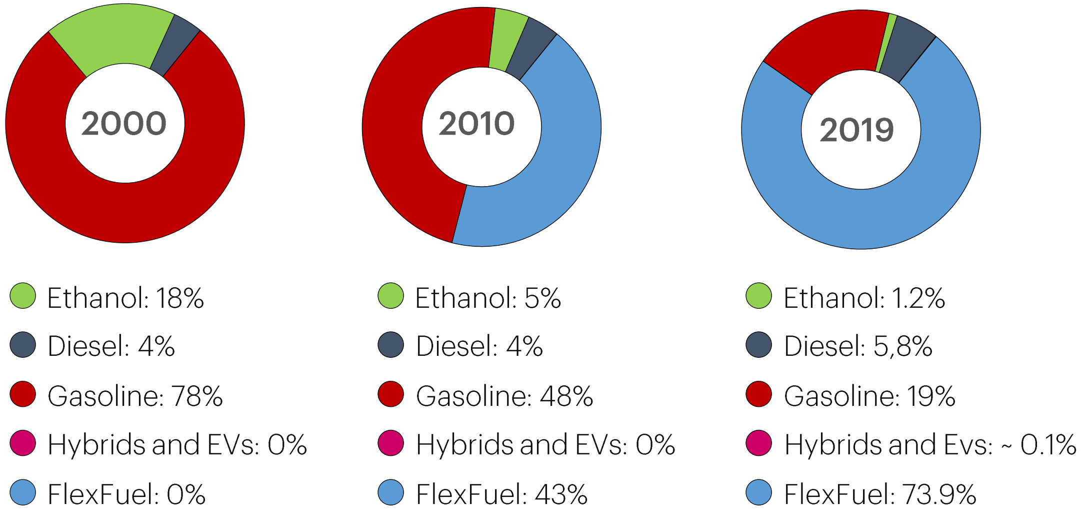


Car sales have followed the growth of Brazilian per capita income from 2000 – 2010

The Vehicle Labeling Program, as well as "Inovar Auto" and "Rota 2030" programs improved energy efficiency.

Figure 48 – Light Vehicles fleet per type of motorization – selected years

Source: Compiled by EPE



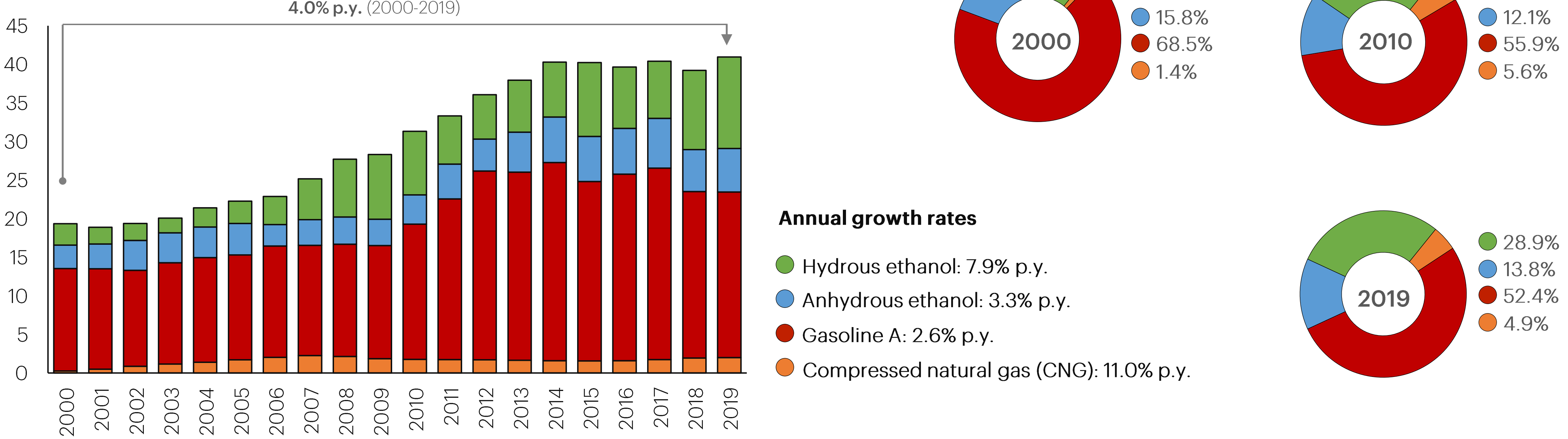
The entry of flex fuel vehicles (gasoline/ethanol) from 2003 brought the possibility of choosing the fuel (hydrous ethanol or gasoline) at the time of refueling. Their share in the fleet advanced rapidly, which influenced the average efficiency of the light vehicle fleet, since flex fuel vehicles have lower efficiency than their dedicated analogues. The increase in the sale of SUVs has also raised the specific consumption of the fleet, because they are less efficient vehicles.

Otto cycle and individual road transport

A The expansion of the flex fuel vehicle fleet has allowed an increase in demand for hydrous ethanol, whose calorific value is lower than that of pure gasoline.

Figure 49 – Energy consumption by source (10^6 toe)

Source: Compiled by EPE



Since 2003, the increase of flex-fuel vehicles in the fleet has influenced the average efficiency of the private vehicle fleet, not contributing to the systemic efficiency of the transport sector. The increase in the mandatory addition of anhydrous ethanol from 20% to 27%, combined with increased sales of hydrous ethanol, allowed ethanol's share to rise from 30% in 2000 to 43% in 2019. The increase in the share of ethanol has reduced the energy efficiency of the fleet, but has significantly reduced carbon emissions.

Freight transport

Waterway and railway transport grew 4.7% per year and 4.5% p.a., respectively, more than doubling their magnitude in the country's activity, improving the efficiency of the sector as a whole (systemic efficiency). Some factors mark out these trajectories:

- Given the growth in consumption of the agricultural and construction sectors, and their reliance on road transport, the mode grew 5.3% per year.
- Energy efficiency of road transport stands out. This results from an increase in the fleet of modern trucks at the beginning of the decade, in addition to highway improvements.
- The increase in the transport of non-mineral or agricultural products and cargo containerization have reduced the energy intensity of rail transport.

Figure 50 – Energy intensity by mode [toe/(10^6 t.km)]

Source: Compiled by EPE

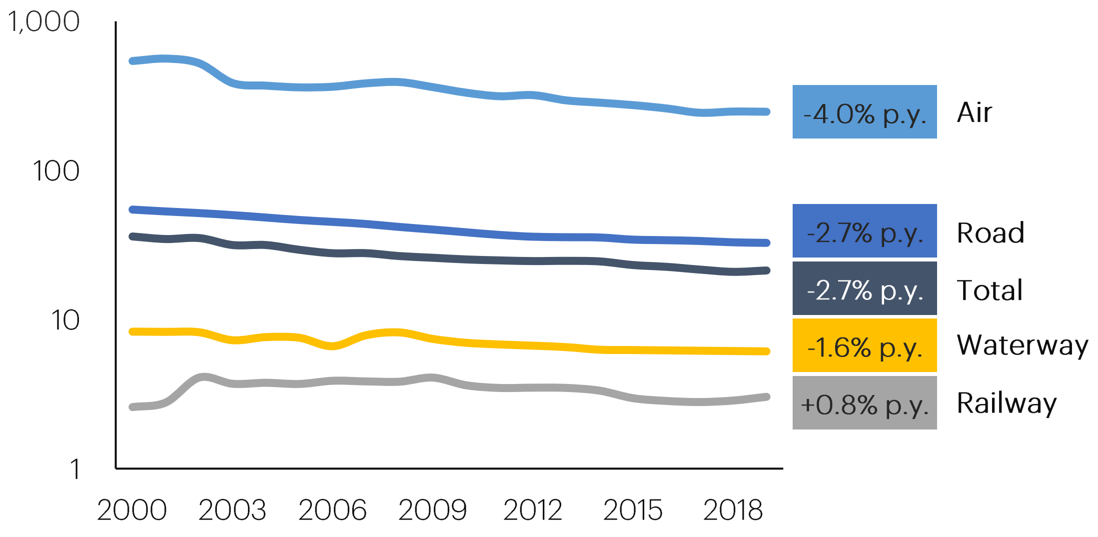
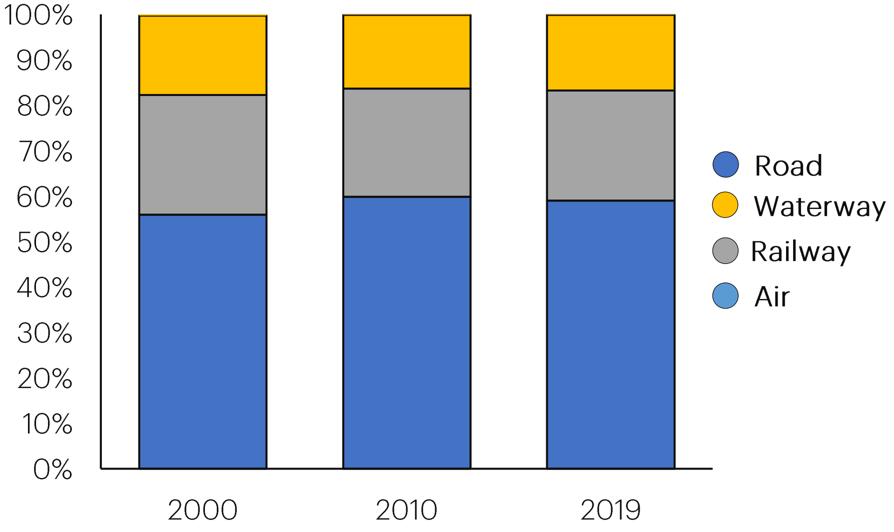


Figure 51 – Activity by mode [t.km]

Source: Compiled by EPE



Road freight

Figure 52 – Truck Fleet by Category (millions of units)
Source: Compiled by EPE

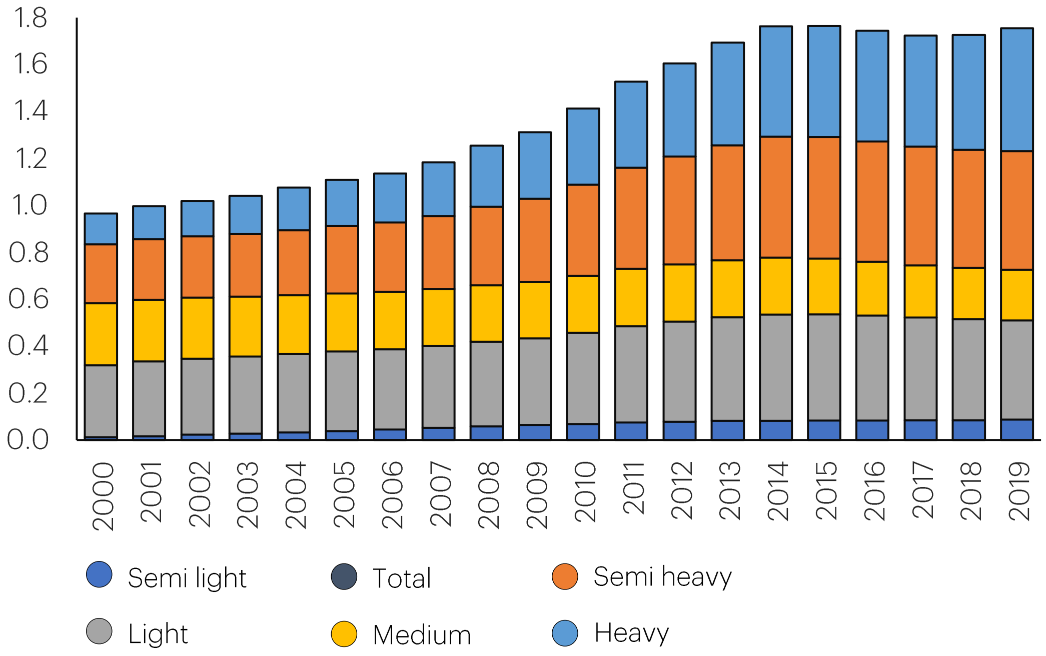
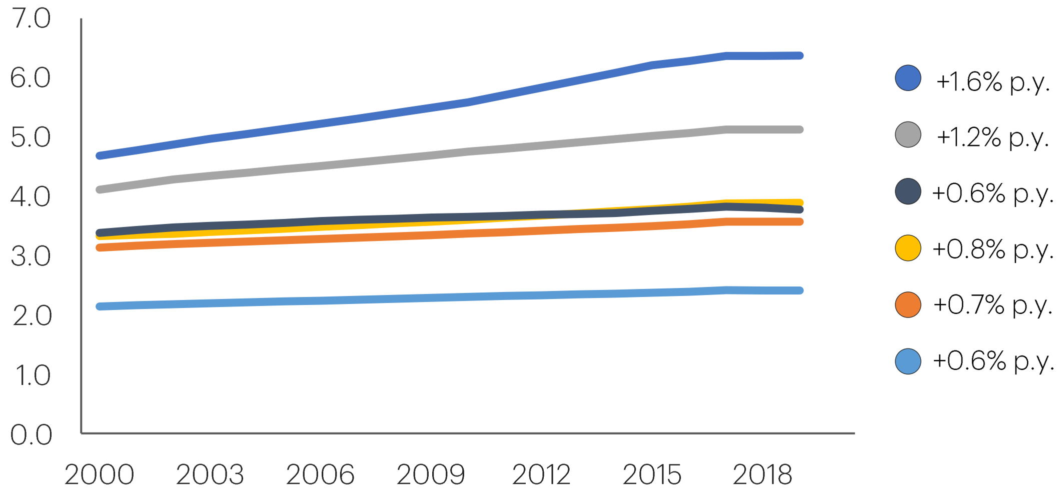


Figure 53 – Average energy efficiency of new vehicles sold (loaded) [km/L]
Source: Compiled by EPE



The truck fleet has grown over the past two decades in order to facilitate the outflow of agricultural production in the new agricultural frontier in the Center-West and North of the country. Long distances to ports and consumption centers increase activity but improve fleet efficiency.

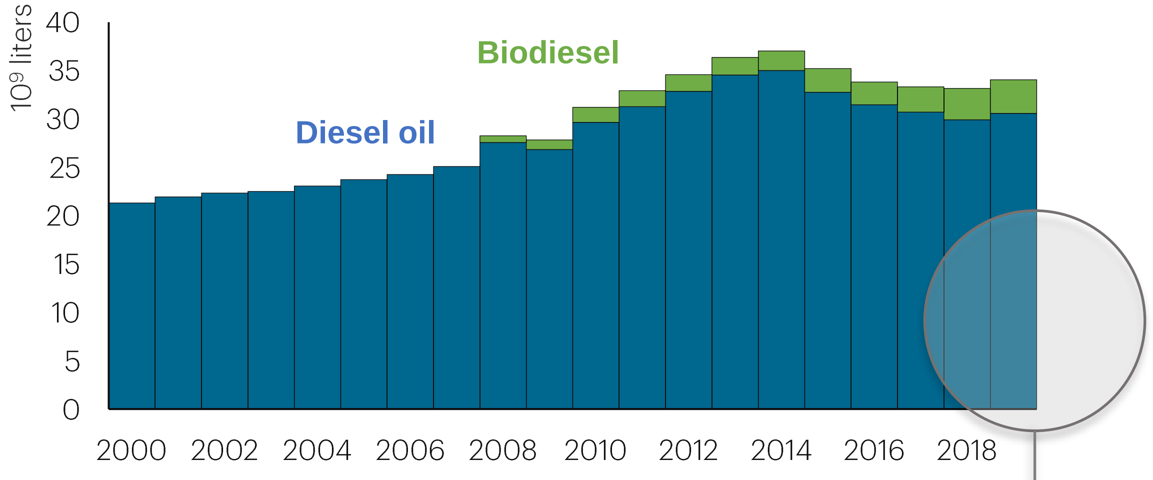
The introduction of new phases of the Vehicle Emissions Control Program (Proconve, in Portuguese) has stimulated the adoption of more efficient engines to reach emission limits.

The increase in the proportion of heavy and semi heavy trucks increased the average efficiency of the fleet by 0.9% per year, although the efficiency of new trucks grew by 0.6% per year.

Diesel and biodiesel consumption

Figure 54 – Consumo de diesel e biodiesel (10^9 liters)

Source: Compiled by EPE using EPE (2020b)



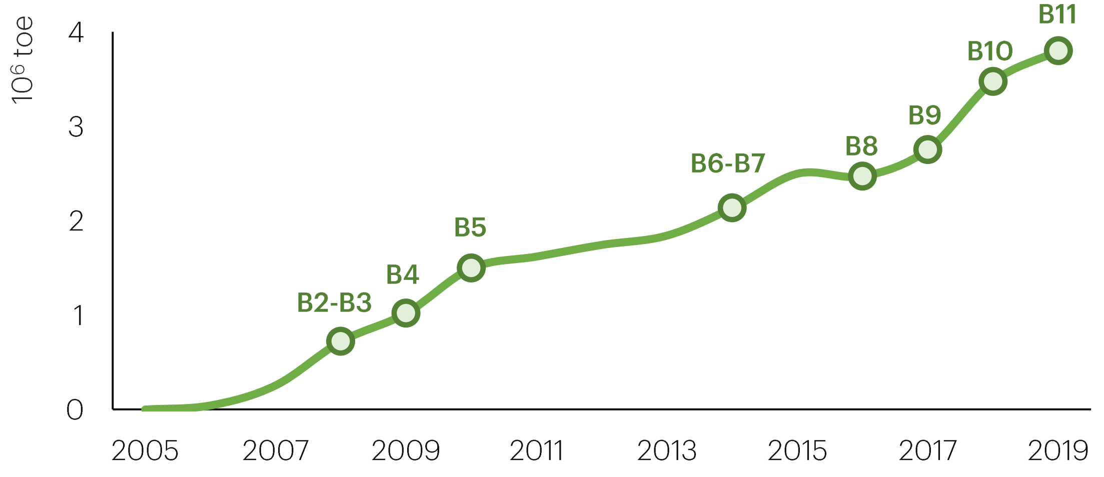
Demand for diesel oil grew 2.6% p.a. between 2000 and 2019, led by growth in demand from the agricultural and transport sectors.

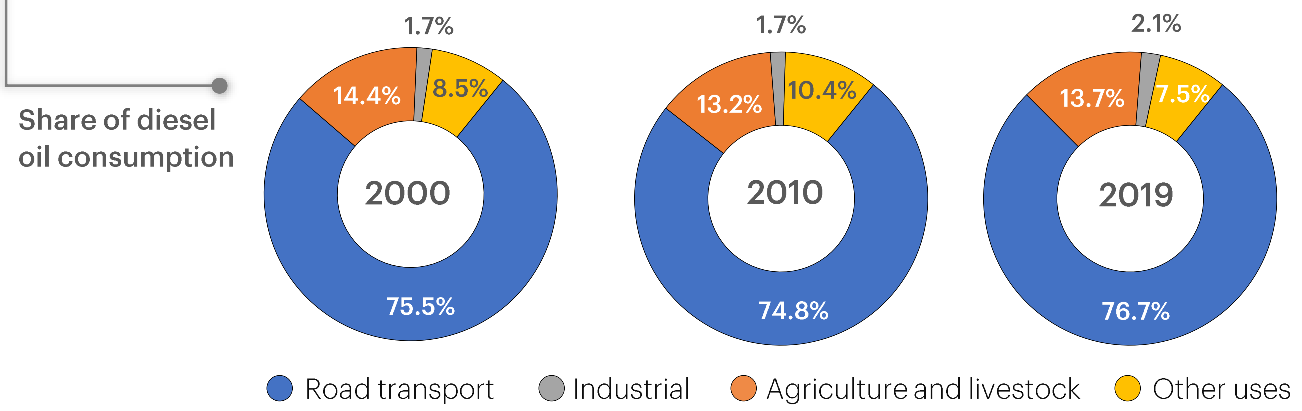
The demand for diesel oil has advanced only 2.0% per year, due to the advance in the use of biofuels, which increasingly displace fossil fuel.

Although there are environmental gains, the energy efficiency of this biofuel is lower than that of its fossil counterpart, increasing the specific consumption of machinery, and reducing the energy efficiency of road freight transport.

Figure 55 – Evolution of biodiesel consumption and its addition percentages

Source: Compiled by EPE using EPE (2020b)





Additional remarks – transport

The transportation sector has recently become the most substantial component of the country's final energy consumption. Within this sector, road consumption is the most relevant.

Energy demand for passenger transport is dominated by car consumption. The increase in per capita income over the last two decades has further increased this segment's share, reducing the systemic efficiency of the transport sector as a whole.

The increase in gasoline demand has not kept pace with the growth of the fleet, due to efficiency gains resulting from new vehicle labeling programs, incentive policies for the sale of flex fuel vehicles and the expansion of ethanol production.

The small relative investment in logistics infrastructure maintained the dependency on road transport. Despite the increase in cargo carried by this mode, the efficiency of new truck engines limited diesel's potential demand growth. In addition, the systemic efficiency gains were relevant, especially due to the increased share of heavy and semi heavy trucks, more efficient for significant distances.

The introduction of biodiesel in the transport mix has contributed to meeting the energy demand for freight and collective transportation, mitigating carbon emissions and fossil diesel imports, although its calorific value is slightly lower than that of fossil diesel.

Impacts of Covid-19

Joint chapter between EPE and IEA.

This chapter is composed of data derived from three types of sources:

1. Data collected by private companies and by Oxford University, which do not correspond to official statistics in Brazil. These data are published by these institutions to assist countries in combatting Covid-19, and have been used in this chapter to help analyze the impact of the pandemic on energy consumption and energy efficiency;
2. Data collected by the International Energy Agency, IEA;
3. Data collected from Brazilian official institutions, such as EPE and IBGE.

Please, go to the end of the chapter for a full list of references.

This chapter includes both official sources of data, and new more novel sources of data. To maximise the relevance for policy makers of the analysis of the unique circumstances surrounding the ongoing pandemic, this chapter focuses on current market trends with possible implications for energy efficiency.

To do so, it draws heavily on a range of frequently updated data from smart phones and web searches, in addition to official energy statistics.

Both EPE and the IEA base our analysis on long-standing work on data collection and quality with official statistical bodies. The new data sources (and methods) leveraged here should be seen as a complement to more traditional survey-based methods, facilitating validation and allowing for preliminary estimates and insights.

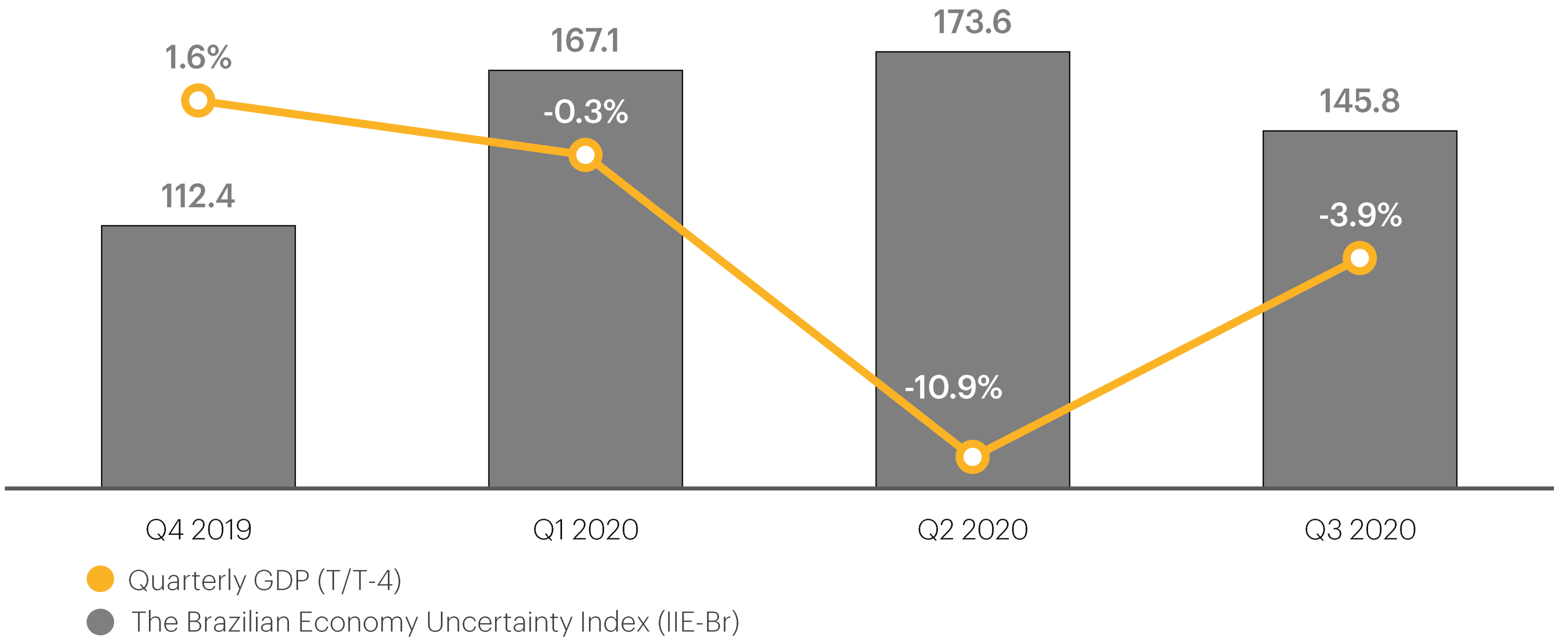
The availability of complementary sources of real-time data in different areas is rising fast, and has come of age in the exceptional circumstances of 2020. We trust that the use of these data in this chapter will serve to inform the reader's understanding of important trends and developments over the past year.

Covid-19 has had a substantial impact on GDP

Covid-19 has had a substantial impact on GDP. In Q3, the economy rebounded from the previous quarter, with a contraction of 3.9%. This has had a profound effect on households and businesses, and significantly impacted energy consumption and efficiency. It reflects severe job losses, many of which affect sectors engaged in energy efficiency such as construction, industry and services.

Figure 56 – Quaterly performed GDP (T/T-4) x Uncertainty (FGV)

Source: Compiled by EPE, using IBGE (2020a) and FGV (2020)



Note: According to FGV (2020), the IIE-Br is an index composed of two components: i) IIE-Br Media, based on the frequency of news with reference to uncertainty in the print and online media; ii) IIE-Br Expectation, built from the average of the variation coefficients of economic analysts' forecasts, reported in the Brazilian Central Bank's Focus survey, for the exchange rate and the Selic rate 12 months ahead and for the accumulated IPCA for the next 12 months.

Ongoing lockdowns of varying degrees continue around the world

Varying levels of lockdowns continue to impact investment, behaviour and consumption patterns. The level of stringency has varied depending on public and private actor decisions, such as city and state governments and employers. While this is a high-end estimate, it illustrates the continuing existence of significant restrictions, which are having impacts on energy demand and consumption patterns.

Figure 57 – Selected countries' response stringency index[11]
Source: Oxford University (2020)

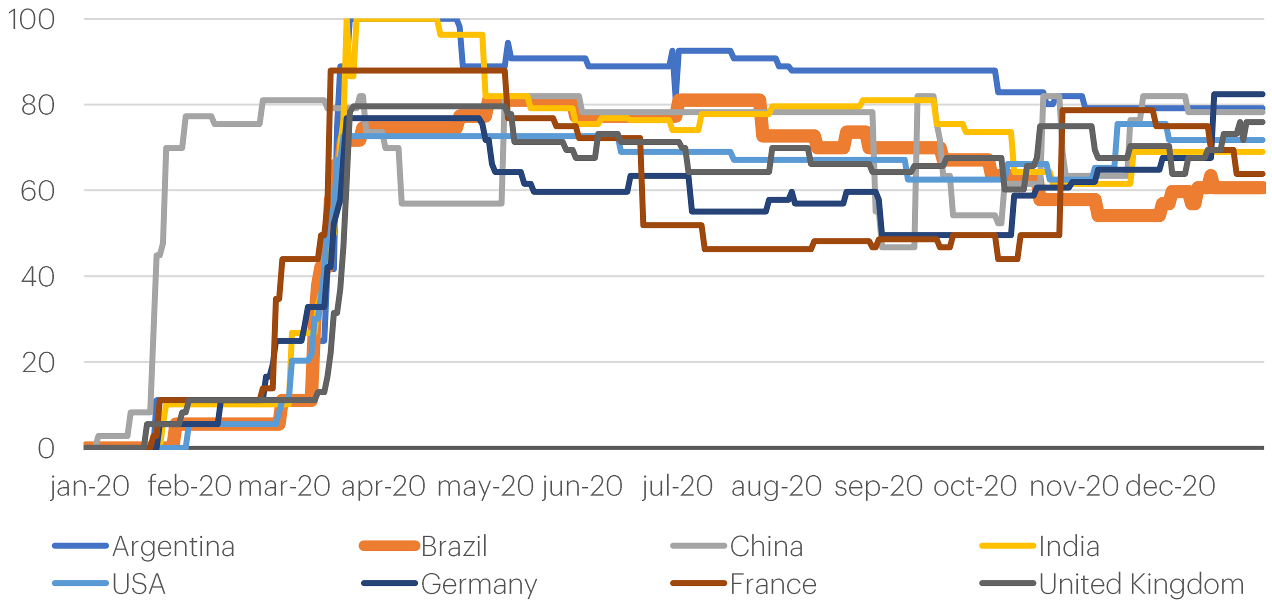
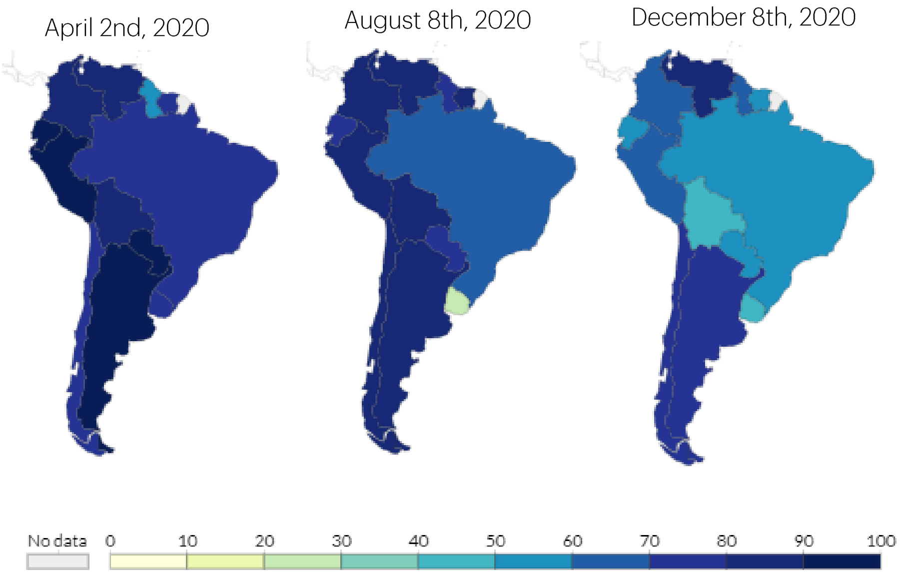


Figure 58 – Stringency index [11] in South America
Source: Oxford University (2020)

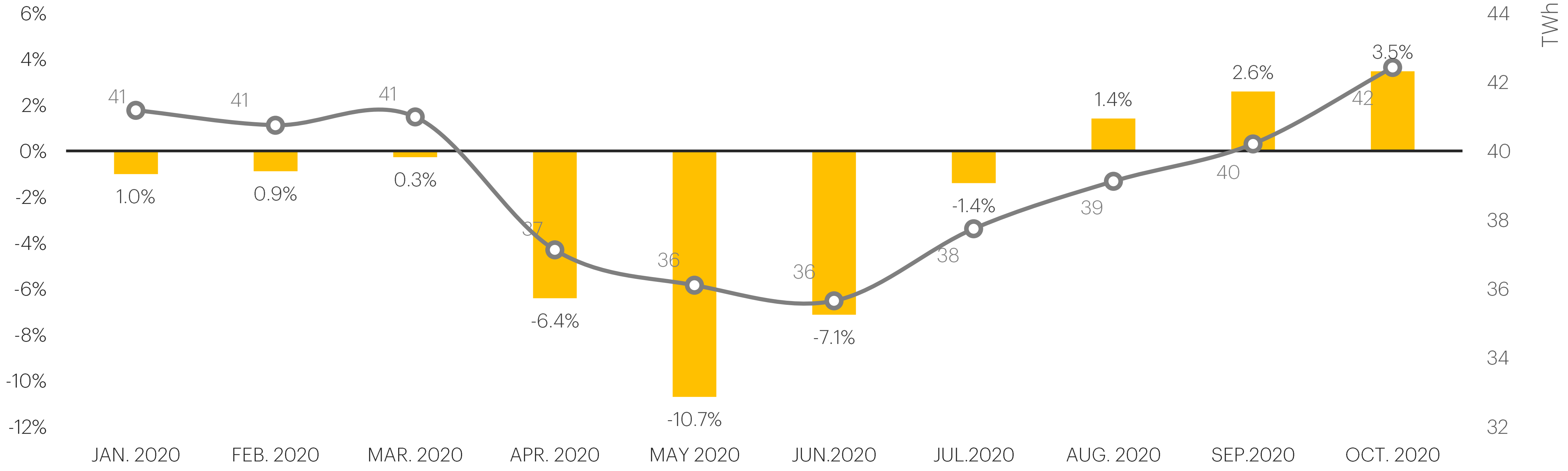


[11] This is a composite measure based on nine response indicators including school closures, workplace closures, and travel bans, rescaled to a value from 0 to 100 (100 = strictest). If policies vary at the subnational level, the index is shown as the response level of the strictest sub-region. This index simply records the number and strictness of government policies, and should not be interpreted as 'scoring' the appropriateness or effectiveness of a country's response. For more information, visit: https://bit.ly/3o3OZww

Change in electricity demand compared to 2019 - Brazil

Figure 59 – Change in electricity demand by month, 2020 vs. 2019

Source: Compiled by EPE, using EPE (2020d)

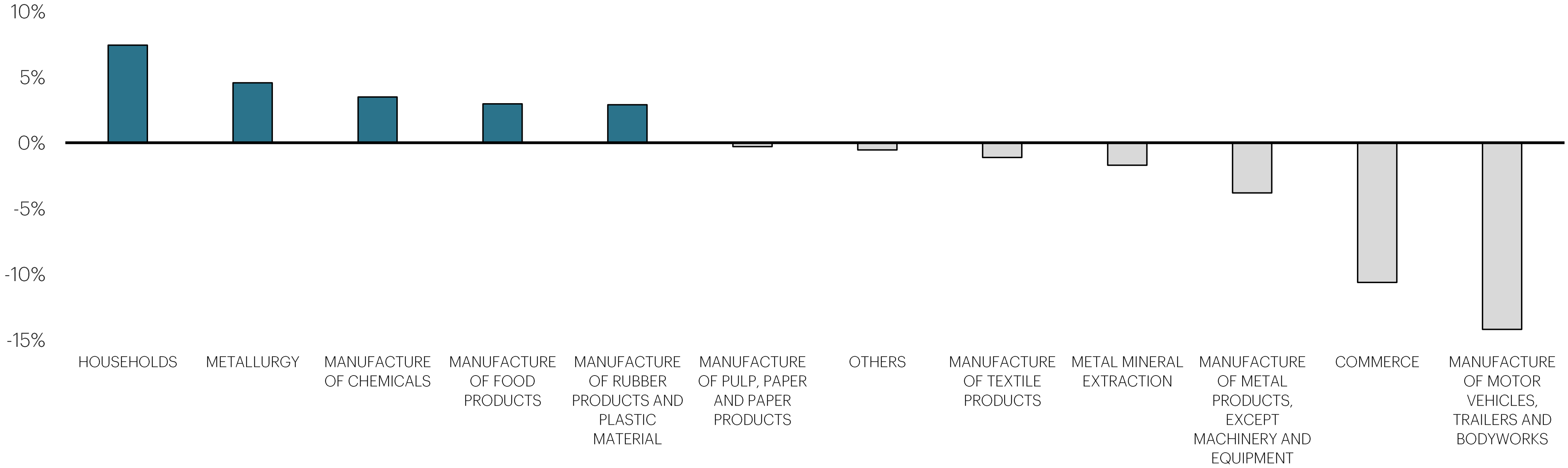


Electricity demand contracted to 10.7% below 2019 levels in May 2020. By October, demand had rebounded to 3.5% above 2019 levels

Change in electricity demand by sector compared to 2019 - Brazil

Figure 60 – Change in electricity demand by sector, Q3 2020 vs. Q3 2019

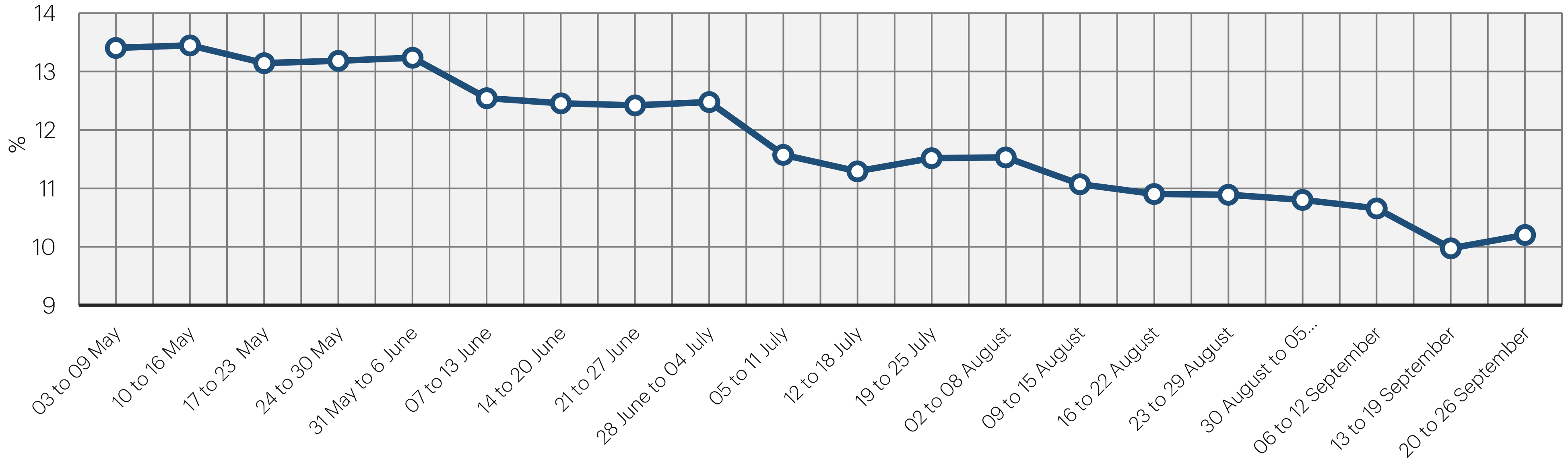
Source: Compiled by EPE, using EPE (2020d)



Electricity demand in several sectors, including households, was above 2019 levels. At the same time, several sectors, most notably commerce and vehicle manufacturing remained well below 2019 levels.

Shifts in time spent at home and visits to workplaces impacted energy consumption

Figure 61 – Percentage of actively employed population working remotely – Brazil (%)
Source: Compiled by EPE using IBGE (2020b)[12]



Additional time spent at home indicates a change in appliance and energy use profiles in residential buildings.

[12] For more information, visit: https://www.ibge.gov.br/estatisticas/investigacoes-experimentais/estatisticas-experimentais/27946-divulgacao-semanal-pnadcovid1

Shifts in time spent at home and visits to workplaces impacted energy consumption

Figure 62 – Change in average time spent at home, 2020 vs. 2019

Source: Google (2020a)[13]

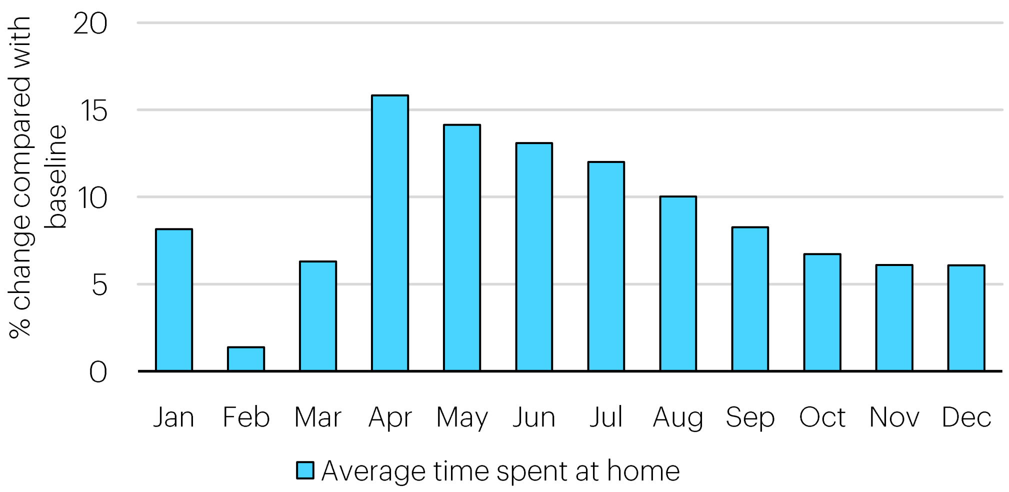
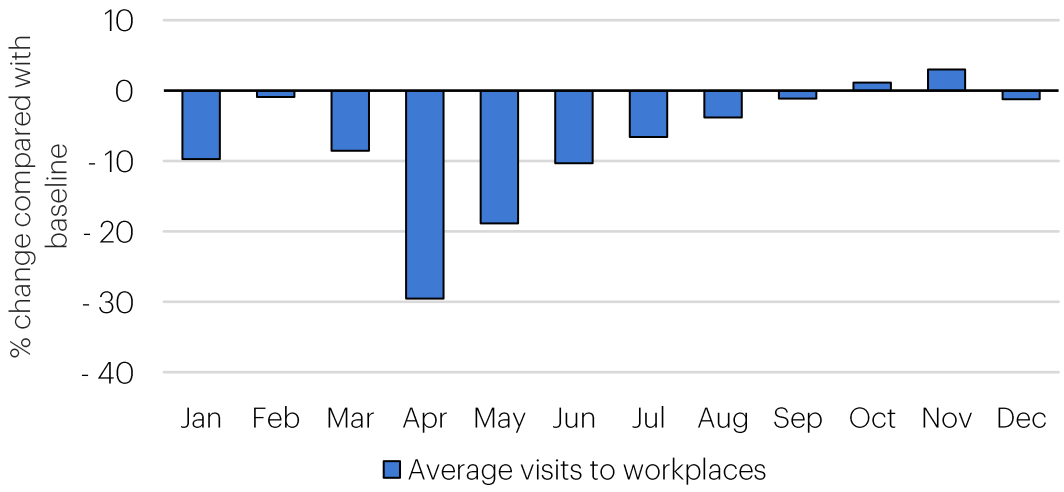


Figure 63 – Change in average visits to workplaces, 2020 vs. 2019

Source: Google (2020a)[13]



In Brazil, as visits to workplaces have resumed, average time spent at home has decreased, though it remained well above 2019 levels until December. Available data suggest sharper drops in average visits to workplaces in April and May 2020. However by October average visits to workplaces had recovered.

[13] **Google Covid-19 Community Mobility Reports** show mobility trends by region for different site categories. For each category in a region, the reports show changes in two different ways:

- Main number: compares the mobility on the date of the report with the reference day. Calculated for the report date (unless there are gaps) and reported as a positive or negative percentage.
- Trend graph: percentage changes in the six weeks prior to the report date. It is displayed as a graph.

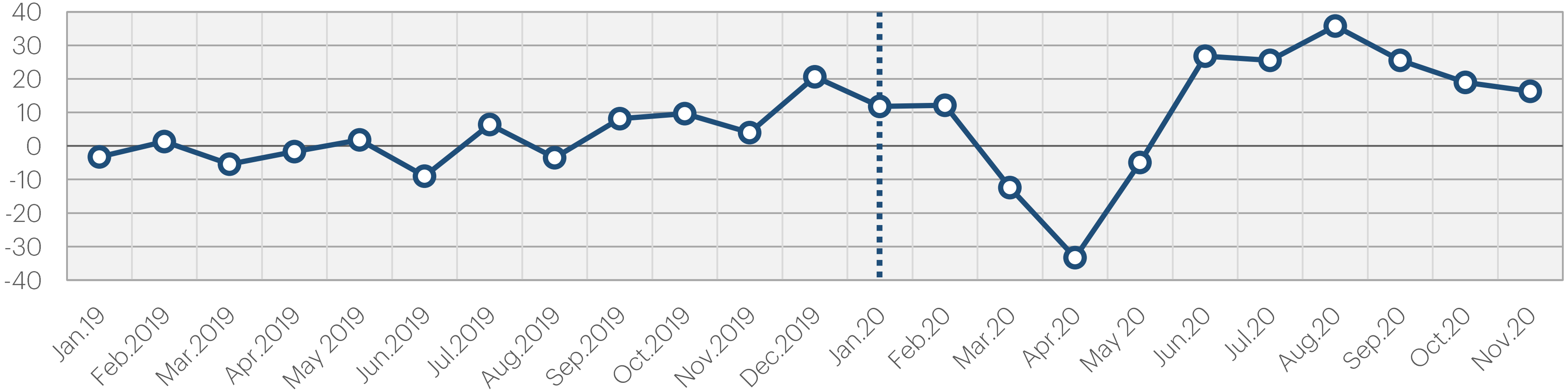
Personal identification information such as location, contacts and movement of individuals are never made available. These reports are created with aggregated and anonymous data sets of users that have activated the Location History setting, which is disabled by default. For more information, visit: , https://www.google.com/covid19/mobility/

Increase in sales of household appliances

Data show that there was a considerable decrease in household appliances sales in the first three months of the pandemic (March to May). From June on, with lower expectations of the end of the pandemic, there was a shift, reflecting a trend of increased online sales of household appliances as well as an increase in their total sales. Online activity has increased as well. Data from ABINEE[14] (2020) further support this, finding that companies are seeing an increase in online purchases. Online sales in Brazil of appliances and air and ventilation products grew 95.4% in the second quarter of this year compared to the same period last year.

Figure 64 – Monthly change in sales of household appliances, compared to the same month of the previous year (%).

Source: Compiled by EPE using IBGE (2020c)



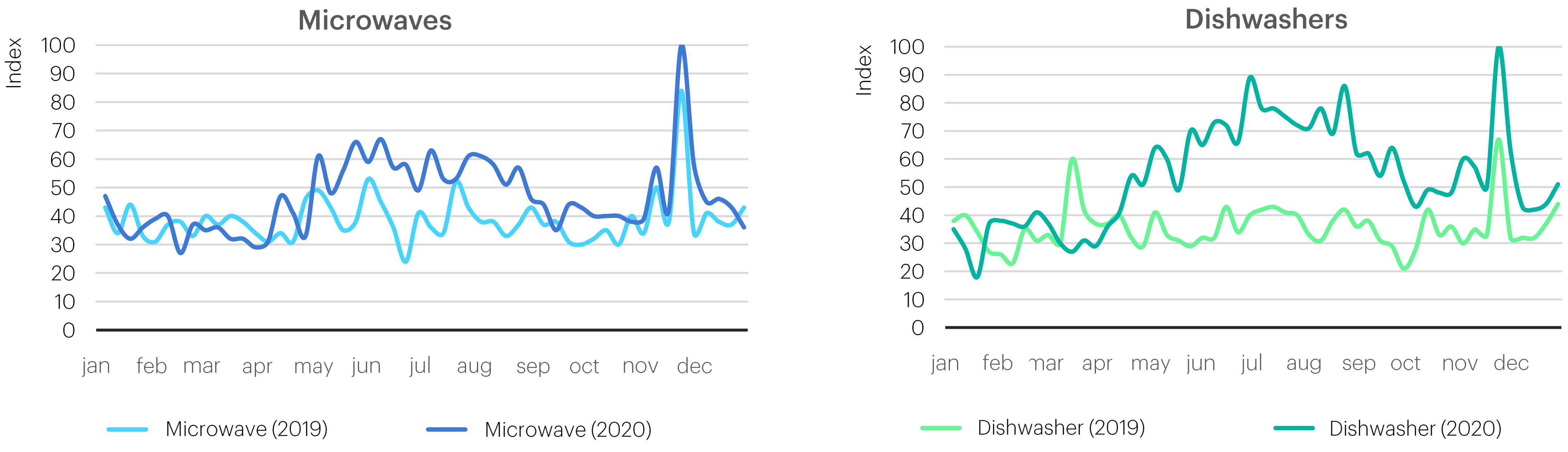
To the extent that more efficient appliances are replacing older, less efficient models, the increase in sales may improve energy efficiency of households. It is important to ensure that labels are clearly visible and able to inform customer decisions. This may require a review of requirements for standards and labelling to ensure effectiveness of labels for online purchases.

[14] Associação Brasileira da Indústria Elétrica e Eletrônica, for more information visit: http://www.abinee.org.br/noticias/com243.htm

Increase in sales of household appliances

Figure 65 – Weekly online shopping search indices for microwaves and dishwashers, 2019 vs. 2020[15]

Source: Google (2020b)



Available data regarding online appliance shopping find that the two classes of appliances with the most noteworthy difference between 2019 and 2020 were microwaves and dishwashers. While these are not the main sources of appliance demand in Brazil, we believe that they provide a valuable data point in combination with other sources.

[15] Google Trends is a Google tool that shows the most popular search terms in the recent past. It displays graphics as often as a particular term is searched in various regions of the world, and in various languages.

Additional considerations: households

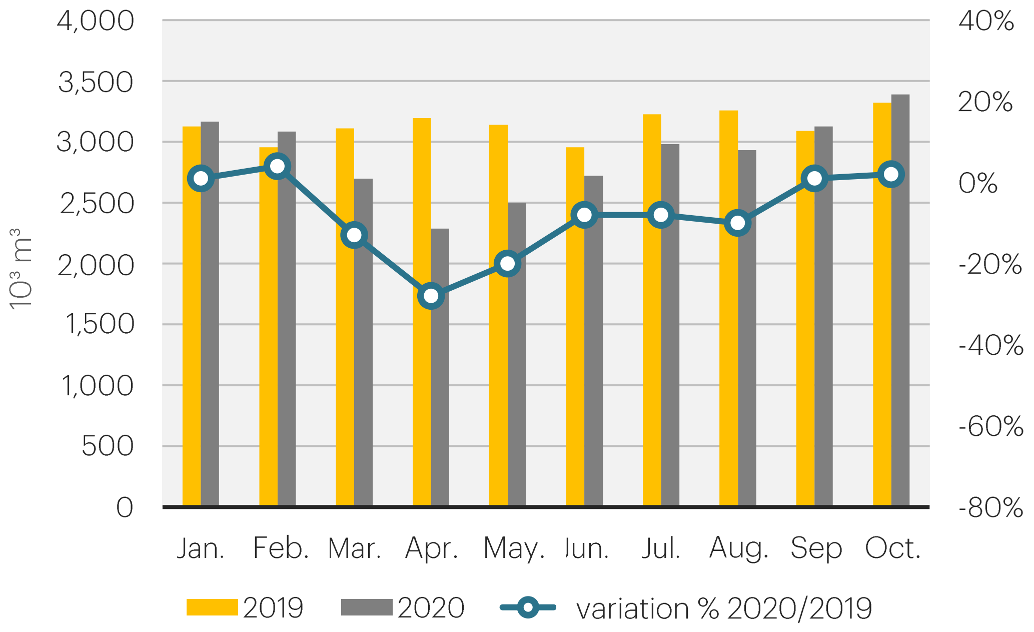
The Covid-19 crisis has brought to light inequities in terms of the quality and healthfulness of housing. It is important to note that at the same time that average time in homes increases and some purchases of appliances have increased, there are many households that have found themselves in financial difficulty. In these cases, rules established by ANEEL to protect households from shutdown of electricity and other energy source have been particularly important.

Energy efficiency can help lower household bills, while improving the quality of energy services such as light, refrigeration and space cooling. Because of the high jobs-potential identified in the IEA's Sustainable Recovery Plan [16] (IEA, 2020b), it is important to consider ways to ramp up energy efficiency programmes to address the dual challenge of joblessness and poverty. In this sense, Brazil is in a strong position to build on existing programmes, given progress made under programmes such as the PEE and Procel Edifica.

[16] The IEA's Sustainable Recovery Plan is a document developed in collaboration with the IMF to identify actions that can be taken over the next three years. It focuses on cost-effective measures that could be implemented from 2021 to 2023 across six key sectors: electricity, transport, industry, buildings, fuels and emerging low-carbon technologies. The plan takes into account national and international objectives for long-term growth, future-proofed jobs and sustainable development goals. The effect on employment would be significant, saving or creating roughly 9 million jobs a year over the next three years globally. For more information, visit: https://www.iea.org/reports/sustainable-recovery/covid-19-and-energy-setting-the-scene#abstract

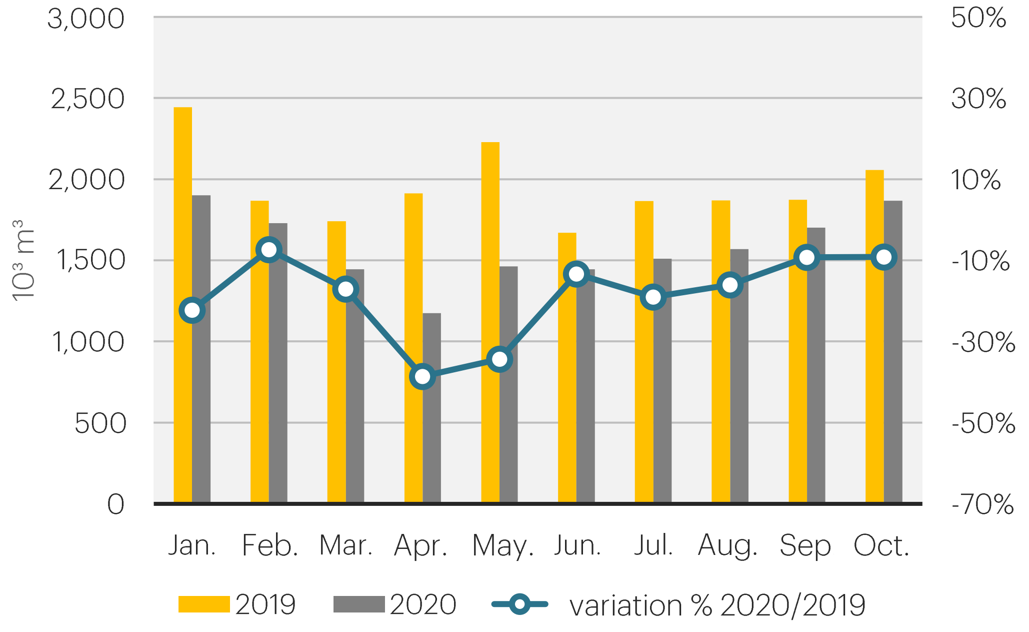
Changes in demand, gasoline and ethanol, 2020 vs. 2019

Figure 66 – Gasoline demand (10³ m³)
Source: Compiled by EPE



Between January and October, there was a significant drop in demand for gasoline and ethanol in transport, reaching lows of between 28 and 39% of 2019 demand levels respectively in April.

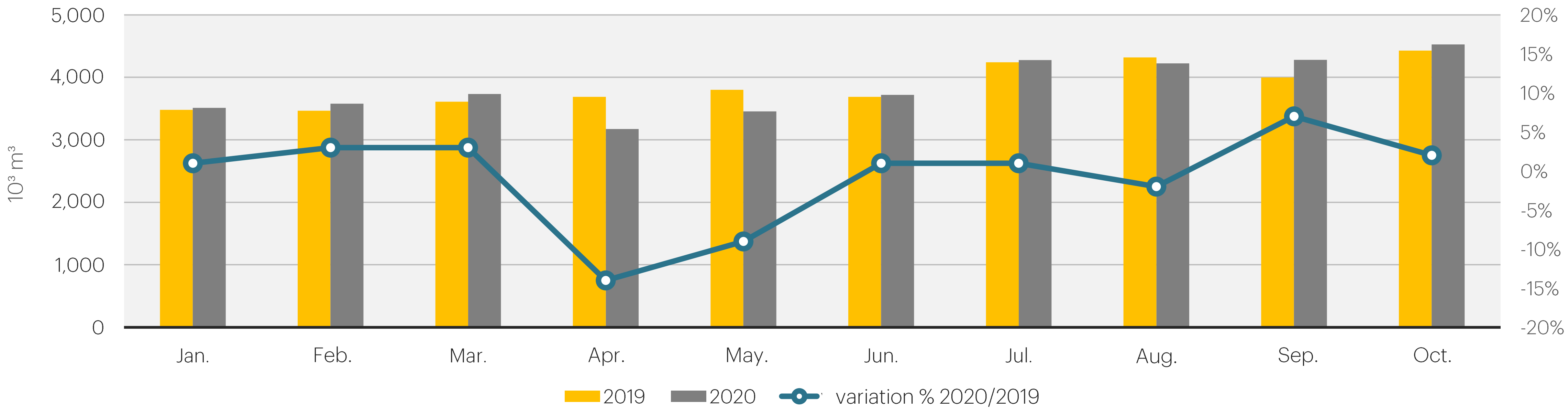
Figure 67 – Hydrous etanol demand (10³ m³)
Source: Compiled by EPE



Since May, there has been some increase in demand for these fuels. Gasoline demand recovered to 2019 levels in September and October; however, demand for ethanol remained low.

Impact on diesel oil 2020 *vs.* 2019

Figure 68 – Diesel demand – transportation sector (10^3 m^3)
Source: Compiled by EPE

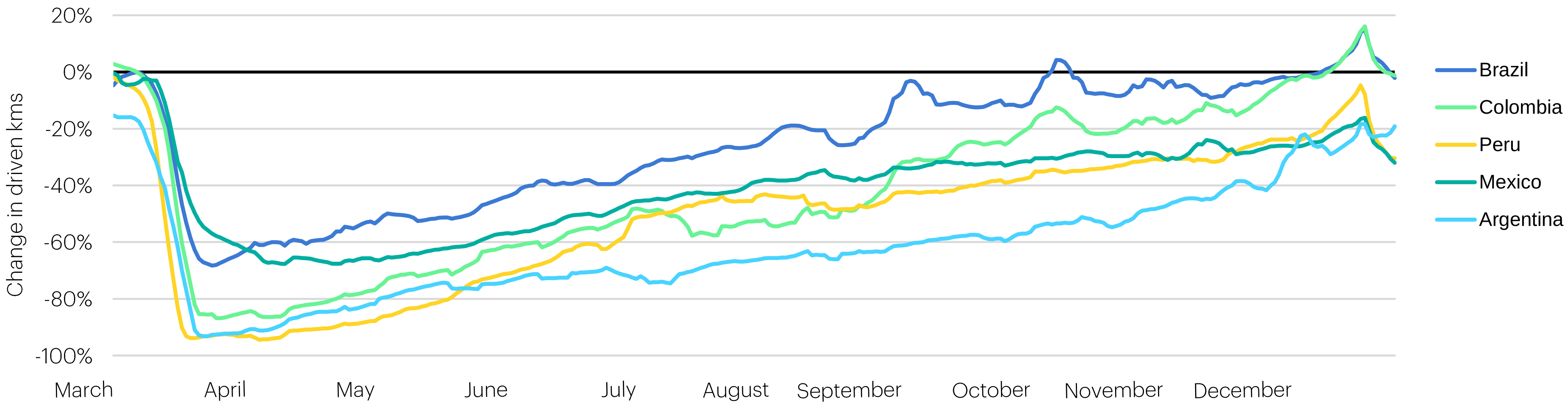


While demand for diesel fuels also decreased, it recovered more quickly as road freight levels were less affected from Covid-19-related restrictions than personal mobility. It dropped 14% below 2019 levels in April, but rebounded soon after increasing to 7% above 2019 levels in September.

Mobility levels are down, but not as much as in other countries in the region

Figure 69 – Percent change in driven kilometres by day in select countries [17]

Source: WAZE (2020)



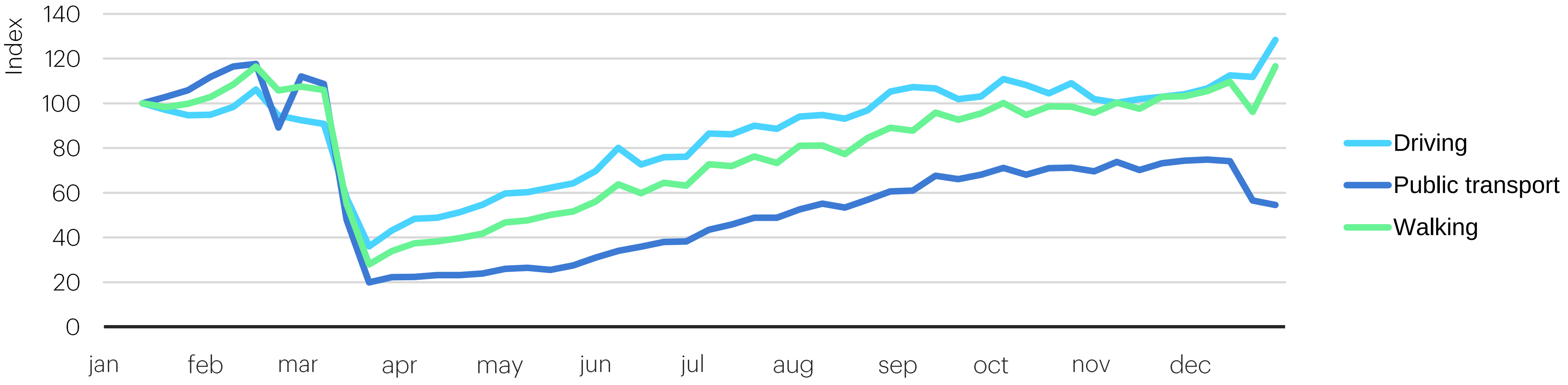
The decline in transport energy demand is due to lockdowns and teleworking policies, which have reduced distances travelled by ground transport and the number of trips taken. For road transport, the graph indicates that declines in activity have been less strong in Brazil than in other countries in Latin America.

[17] The driven kilometers percent change data being shared comes from the Waze app and is aggregated and anonymized. These insights were generated using differential privacy to protect user privacy. No personally identifiable information, such as an individual's location, contacts, or movement, is available through this data. These reports show the increase or decrease in driven kilometers/miles as a percent change compared to a baseline. The changes for each day are compared to a baseline value for that day of the week. (i) The baseline is the average value, for the corresponding day of the week, during the 2-week period February 11, 2020 to February 25, 2020. (ii) The reports show trends over two weeks with the most recent data representing approximately 2-3 days ago. As with all samples, this may or may not represent the exact behavior of a wider population. For more information, visit: https://www.waze.com/en-GB/covid19

Transport activity partially shifted to less efficient modes

Figure 70 – Index of changes in work week transport trip requests by mode in Brazil, Jan-Dec 2020

Source: Apple (2020)[18]



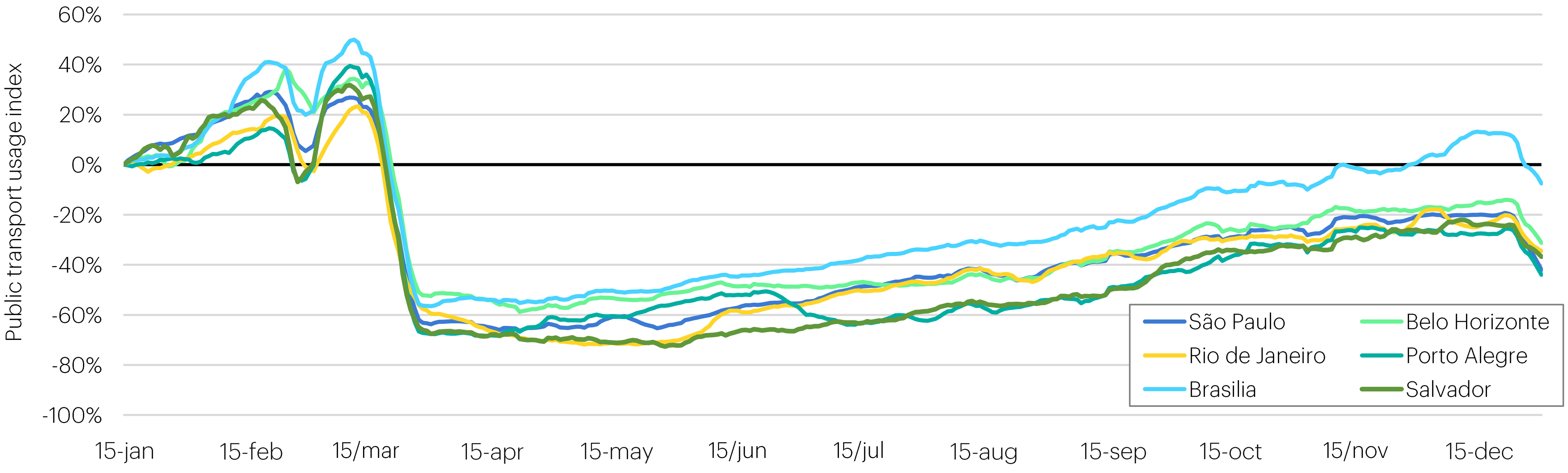
Some transport modes were affected more significantly than others. Health concerns have led to shifts from public transport to other options – with mobility levels for private cars and walking recovering more quickly than public transport and beginning to rise above the previous year's levels.

[18] The graphs on this site show a relative volume of requests for directions by country/region, sub-region or city compared to a reference volume on January 13, 2020. A day from midnight to midnight Pacific time was established. Cities are defined as large metropolitan regions and their geographic boundaries remain constant in the data set. In many countries/regions, sub-regions and cities, the relative volume has increased since January 13, consistent with normal seasonal use of Apple Maps. The effects of the days of the week are important to normalize as you use this data. Data sent from users' devices to the Maps service is associated with random rotary identifiers, so Apple does not have a profile of specific movements and searches. Apple Maps does not have demographic information about our users. Therefore, we cannot make any statement about usage representativeness in relation to the general population. For more information, visit: https://covid19.apple.com/mobility

Public transit index, Δ% change to week 15 January

Figure 71 – Percentage variation in public transport in selected countries

Source: Moovit (2020)[19]



From a regional point of view, there were differences in Brazil in the decline and level of recovery in public transit ridership by city.

[19] Moovit analyzed the repercussions of Coronavirus (COVID-19) on public transportation ridership, relative to the typical usage before the outbreak began. Updated daily, Moovit's insights show the percentage of changed demand for public transit around the world. For more information, visit: https://bit.ly/2Y12m64

Lower levels of economic activity and mobility reduced GHG emissions and improved air quality

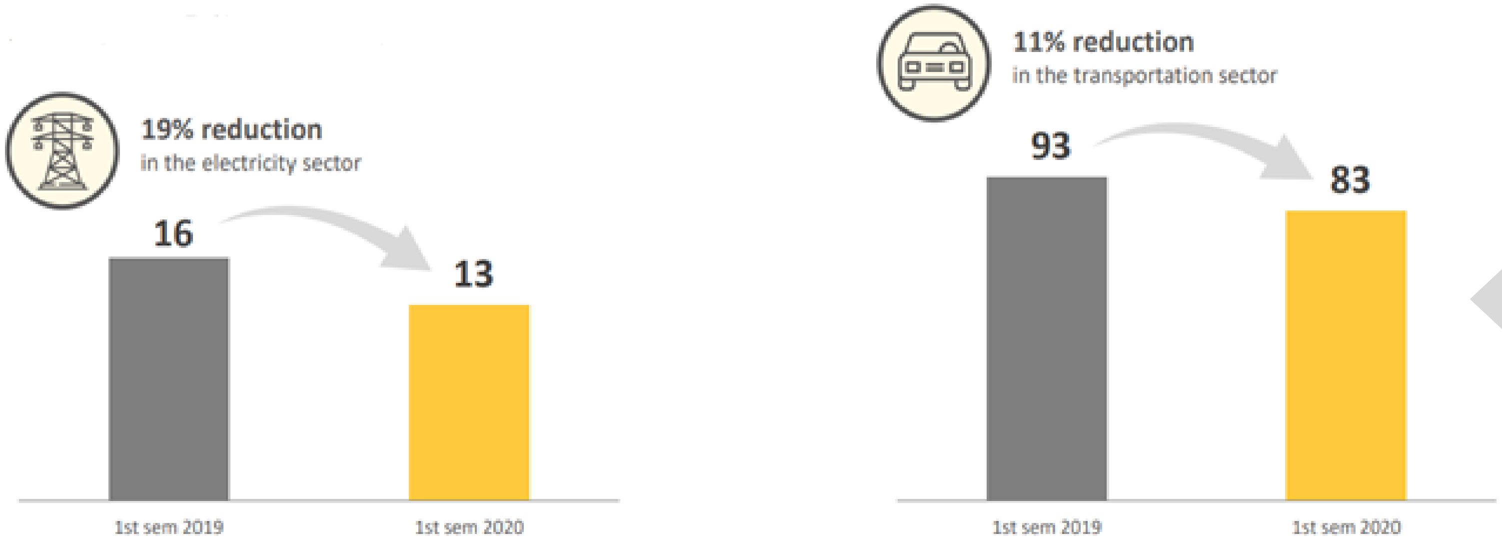
In big cities such as São Paulo and Rio de Janeiro, reductions in NOx, CO and PM10[20] emissions were observed. However, this decline was temporary and linked to social restrictions (IATA, 2020).

While there is uncertainty over the duration of the pandemic, energy demand and emissions are set to rebound without a rapid structural transformation of the energy sector as outlined in the IEA's Sustainable Development Scenario)[21].

Urban transport planning strategies such as shifting to walking, cycling and public transport, alongside policies to improve fuel efficiency and decrease emissions of vehicles, will be important to structurally improve air quality and reduce GHG emissions.

Figure 72 –CO_2 emissions in the first semesters of 2019 e 2020 ($MtCO_2$)

Source: EPE (2020d)



During the first semester of 2020, Brazil saw a decrease in GHG emissions from electricity and transport by 19% and 11%, respectively. However, these drops happened for unplanned reasons and at huge economic and social costs

[20] Particulate matter with a diameter of 10 micrometers.
[21] For a description of the IEA Sustainable Development Scenario, visit HERE.

Conclusions: transport

Overall, mobility levels have been depressed in 2020, with public transport the most strongly affected mode of transport in cities across Brazil. However, access and demand to public transportation remain important (iCS, 2020)[22].

The reduction in public transport poses a short-term problem for the population, as well as a longer-term concern that people with higher incomes will shift from public transport to private cars. This could lead to higher emissions of air pollutants and of CO_2 and lower overall energy efficiency in the transport sector.

A number of cities in Latin America, including in Brazil, are looking at ways to encourage alternative modes of transport such as walking and cycling, both to address near-term health concerns and longer-term concerns associated with traffic congestion and pollution.

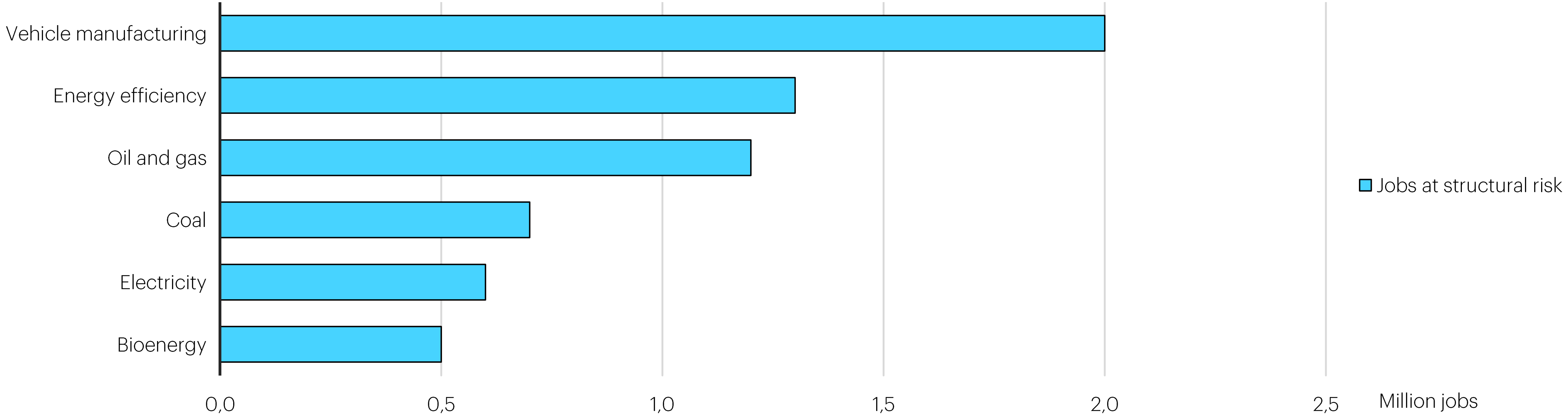
[22] https://www.climaesociedade.org/publicacoes?pgid=jjyqp4zj-3a489c81-eb44-4751-8e17-fc5180134c9a

Globally, jobs most at risk post-Covid-19

Definitions of energy efficiency jobs differ among countries and regions. For example, China only counts employment in energy service companies. Europe counts jobs in the buildings sector. The U.S. counts jobs involved in both the production and installation of energy-saving products and the provision of services that reduce end-use energy consumption. For example, the manufacture of ENERGY STAR labelled products as well as building design and contracting services that provide insulation and improve natural lighting are included in national energy efficiency jobs statistics.

Figure 73 – Jobs at structural risk

Source: IEA (2020b)



Stimulus investment in Brazil

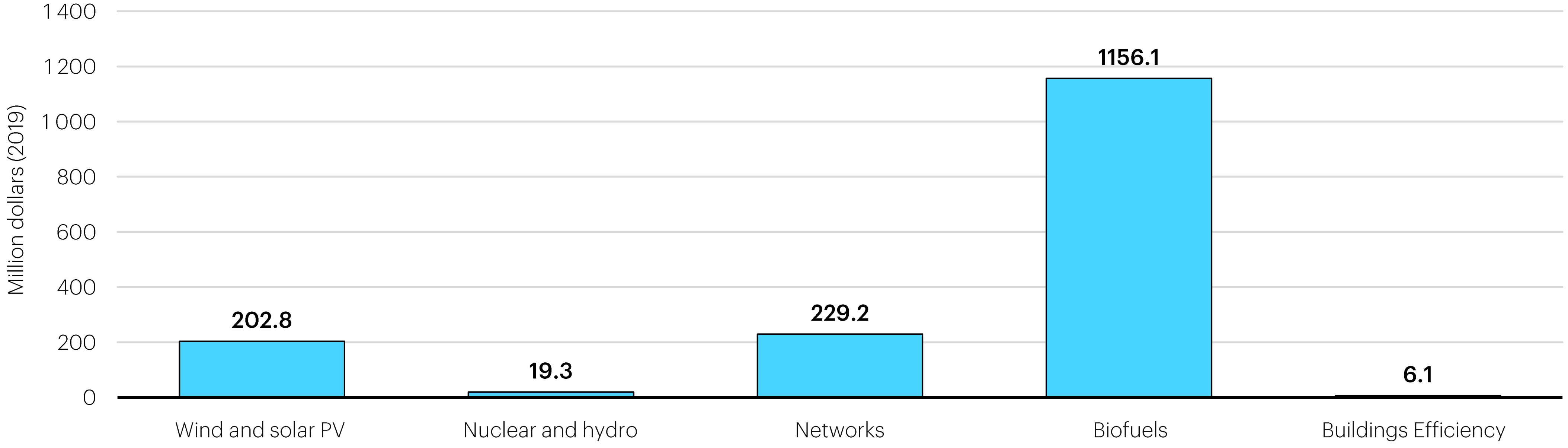
In Brazil, stimulus investment has included investment in clean energy. Biofuels make up the biggest investment, followed by networks and wind and solar PV.

Investment in buildings efficiency has been very low, despite having a similar jobs-inducing and energy-transition potential to investments in biofuels and solar PV.

Investments in energy efficiency in buildings and other areas can be ramped up quickly by leveraging existing programmes and delivery streams, such as Procel Edifica and the PEE.

Figure 74 – Clean energy stimulus in Brazil

Source: IEA (2020c)[23]



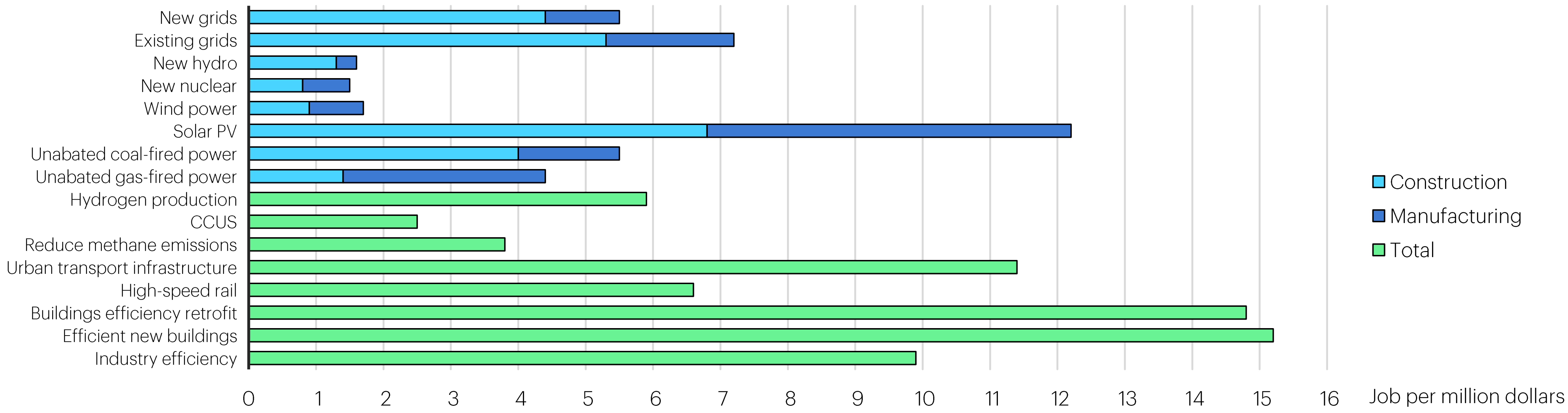
[23] Maiores detalhes em: https://www.iea.org/reports/energy-efficiency-2020

Efficiency stimulus has a high potential to create jobs worldwide

Investment in building retrofits, efficient new buildings, solar PV and urban transport infrastructure top the list of clean energy jobs with the highest job creation potential.

Figure 75 – Construction and manufacturing jobs created per USD 1 million of capital investment in the Sustainable Recovery Plan (IEA)

Source: IEA (2020b)



While Figure 75 shows a mid-estimate of the jobs potential in these sectors, the IEA's analysis shows that in emerging economies, the jobs benefits can be much higher. For example, building retrofits are estimated to create between 21 and 31 jobs per USD 1 million invested, which is similar to the number of jobs that the biofuels sector is estimated to generate in emerging economies.

Global perspective on energy efficiency and employment

- Stimulus packages provide an important opportunity to align economic and social relief and recovery with a sustainable energy strategy.
- Under the IEA's Sustainable Recovery Plan, the largest amount of new jobs would be in retrofitting buildings and other measures to improve their energy efficiency, and in the electricity sector, particularly in grids and renewables.
- In Brazil, investments in energy efficiency could be particularly powerful jobs engines, given the potential for energy efficiency identified.
- Only 0.02% of energy efficiency stimulus globally has been allocated in Latin America (IEA, 2020c)[25]. There is an opportunity to strengthen stimulus in energy efficiency in ongoing stimulus packages, taking lessons from Brazil's own experience with successful energy efficiency programmes and from international experience in designing and implementing stimulus packages.
- Strengthening data collection to track jobs in energy efficiency is an important additional step to ensure that these jobs are recognised and can be tracked within the broader economy.
- Similarly, tracking other benefits of energy efficiency, such as improvements to indoor and outdoor air quality and public health, can further help develop energy efficiency programmes to support important public health and environmental objectives.

[24] Share of Latin America in announced public energy efficiency-related stimulus funding worldwide, to the end of October 2020. IEA, Energy Efficiency 2020. https://www.iea.org/reports/energy-efficiency-2020

Additional sources of analysis on Covid-19 impacts

- For all IEA analysis on the impact of Covid-19 on the energy sector, see: https://www.iea.org/analysis/all?topic=covid-19.
- IEA, **Promoting vehicle efficiency and electrification through stimulus packages**, 2020. https://www.iea.org/articles/promoting-vehicle-efficiency-and-electrification-through-stimulus-packages
- IEA, **Paving the way to recovery with utility-funded energy efficiency**, 2020. https://www.iea.org/articles/paving-the-way-to-recovery-with-utility-funded-energy-efficiency
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- IEA, **Energy efficiency can boost economies quickly**, with long-lasting benefits, 2020. https://www.iea.org/commentaries/energy-efficiency-can-boost-economies-quickly-with-long-lasting-benefits
- Webinar series: **Energy efficiency in a time of Covid-19 for Latin America**, 2020. https://www.iea.org/events/energy-efficiency-in-the-time-of-covid-19-highlights-from-energy-efficiency-2020
- EPE, **Balanço Covid-19 – Impactos nos mercados de energia no Brasil: 1º semester de 2020** https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/balanco-covid-19-impactos-nos-mercados-de-energia-no-brasil-1-semestre-de-2020
- EPE, **Impactos da pandemia de Covid-19 no mercado brasileiro de combustíveis** https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/impactos-da-pandemia-de-covid-19-no-mercado-brasileiro-de-combustiveis

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Apple. Mobility Trends Reports. Available at: https://covid19.apple.com/mobility. Accessed in December 2020. Apple, 2020.

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