MOSCOW ECONOMY

MOSCOW DEPARTMENT FOR ECONOMIC POLICY AND DEVELOPMENT

Guangzhou Institute for Urban Innovation

BRICS Urban Climate Agenda Report

August 2024

Foreword

> **Global efforts to reduce greenhouse gas emissions and prevent climate risks from growing to levels that threaten the well-being of current and future generations will not be successful without an active involvement of BRICS countries in this process.**

This BRICS Urban Climate Agenda Report is a new research study within the series of reports of the Complex of Economic Policy of the City of Moscow, whose purpose is to assess the efforts taken by leading cities to combat climate change.

Today, the transition to a low-carbon development trajectory is on the agenda of an increasing number of cities around the world. This is not surprising, since cities consume the largest volume of resources and, as a result, account for the overwhelming majority of global greenhouse gas emissions. At the same time, their population and infrastructure are exposed to serious and growing risks associated with climate change.

Given their dynamic economic development and high population growth rates, cities in BRICS countries face fundamental climate challenges. Damaging the urban environment and endangering people's health, extreme weather events and natural disasters divert significant resources required to adapt to and overcome their negative consequences, which complicates the solution of urgent problems in the socio-economic sphere.

Global efforts to reduce greenhouse gas emissions and prevent climate risks from growing to levels that threaten the well-being of current and future generations will not be successful without an active involvement of BRICS countries in this process.

The crucial role that cities play in the BRICS sustainable development agenda makes it important to have a dialogue and cooperation within the organization on climate change issues at the subnational level. This report aims to promote international cooperation in this area through the exchange of experience and knowledge.

We express our sincere gratitude to city governments and research organizations for providing some of the data used in the report, and invite other cities from BRICS countries to join the exchange of information that is a valuable source of data for the development of climate policy and the assessment of its results.

Maria Bagreeva
Deputy Mayor of Moscow
in the Government of
Moscow, Head of the Moscow
Department for Economic
Policy and Development

This report comes at a very timely moment. The Urban Climate Agenda has become an urgent agenda. Cities and metropolitan regions, the principal contributors to greenhouse gas emissions are also increasingly being affected by climate change. Flash floods and extreme weather conditions are affecting the lives and livelihoods of entire communities and increasing vulnerabilities and risks.

“

The report highlights innovations and best practices. It provides concrete examples of how cities and regions can learn from each other’s policies, strategies, business models and partnerships. This not only contributes to knowledge sharing, it also bolsters city-to-city cooperation, one of the most effective ways for cities and public authorities to gain practical knowledge and share tested tools and methods.

The five sets of indicators used in this report are simple to use and to understand. Far from being simplistic, they provide an invaluable means to guide policy and decision-making. The indicators constitute the foundations of an index which can help policy makers prioritize interventions based on the most pressing needs and the highest potential impact.

The data required for the indicators are, in the majority of cases, relatively easy to collect and to analyze. The proposed methodology allows for continuous monitoring, thus greatly facilitating the possibility to track progress and to assess the impact of policies and actions. By providing a clear, measurable and easy to understand set of indicators, the report fosters transparency, making it easier for citizens and stakeholders to hold all tiers of government and industry accountable for their climate actions or inactions.

The report highlights innovations and best practices. By doing so, it provides concrete examples of how cities and regions can learn from each other’s policies, strategies, business models and partnerships. This not only contributes to knowledge sharing, it also bolsters city-to-city cooperation, one of the most effective ways for cities and public authorities to gain practical knowledge and share tested tools and methods.

Last but not least, I would like to highlight one of the key benefits of this unique report and methodology. Urban climate challenges are interconnected, involving energy, transportation, waste management, urban greening and more. This report provides the seminal foundations of an index that encourages a systems approach to climate action, ensuring that all relevant sectors and stakeholders are considered in climate planning and the attainment of the global agendas.

Nicholas You
Executive Director of
Guangzhou Institute
for Urban Innovation

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About This Report

Evolution and Role of BRICS

It was more than 20 years ago when the largest emerging economies – **Brazil, Russia, India and China** – came to be accepted as **a new powerful source of influence on the world economy.** The idea that these countries as global players with rapid economic growth could take a dominant position in the world economy by the middle of the century was popularized in an article published in 2001 by Jim O'Neill, an economist at Goldman Sachs [1]. He was also the one who coined the acronym, BRIC.

Over the next decade, BRICS gradually took institutional shape. The starting point of its existence as an organization is considered to be the meeting of the Ministers of Foreign Affairs of Russia, China and Brazil and the Indian Minister of Defense, which took place in 2006 on the sidelines of the 61st session of the UN General Assembly in New York. **In 2008, Ministers of Foreign Affairs of the four countries held a full-scale meeting in Yekaterinburg and adopted a joint communiqué [2].** Among other things, the document expressed the desire of the BRIC countries to develop cooperation in order **to counter the challenges** facing humanity, including **global climate change.**

The first BRIC summit meeting also took place in Yekaterinburg a year later. The joint statement by the heads of Brazil, Russia, India and China [3] after the summit once again emphasized the commitment of the members to expand multifaceted cooperation in socially significant areas. On climate change, the main emphasis of the statement was on the importance of strengthening international cooperation to increase energy efficiency and uphold the principle of common but differentiated responsibility, which implies that the responsibility of countries to reduce the carbon footprint should depend on their levels of socio-economic development.

Since 2009, BRICS summits, during which the leaders of the member countries of the organization formulate the agenda for its develop-

> The first BRIC summit meeting took place in 2009 in Yekaterinburg, where the heads of Brazil, Russia, India and China emphasized the commitment to expand multifaceted cooperation in terms of sustainable development

2001
The BRIC acronym was used for the first time

2008
BRIC countries came up with a joint communique after the meeting in Yekaterinburg

2009
BRIC held its first summit in Yekaterinburg

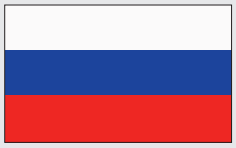
2011
South Africa joined BRIC

2015
The BRICS New Development Bank was established

2017
The BRICS+ concept was formed to foster cooperation with other developing countries on a permanent basis

2024
Four new members join BRICS: Egypt, Iran, the UAE and Ethiopia

BRICS



ment, have been held annually. **In 2011, the summit formally admitted the Republic of South Africa to BRIC,** after which the group acquired the name it retains to this day [4]. Subsequently, **BRICS established permanent organizations and bodies to ensure interaction between the participating countries in between summits:**

New Development Bank

New Development Bank

BRICS Business Council

BRICS Business Council

BRICS THINK TANKS COUNCIL

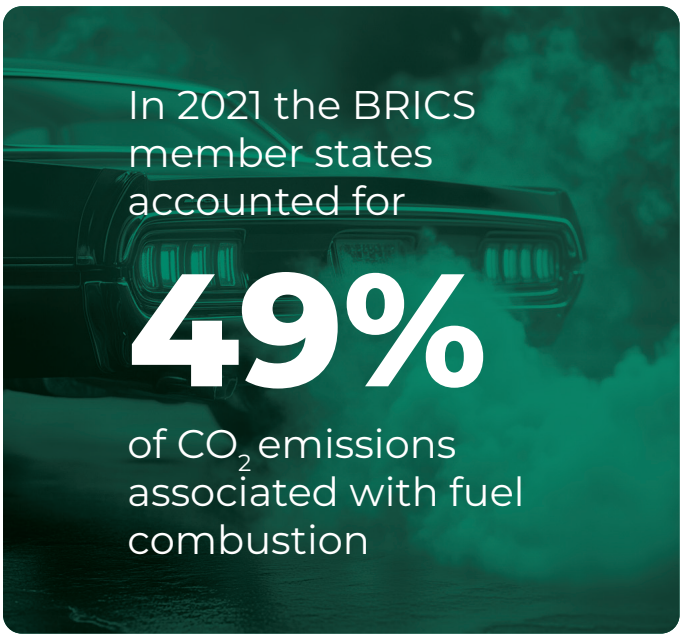
BRICS Think Tanks Council

as well as working groups in various areas, including the BRICS Contact Group on Climate Change and Sustainable Development, which began its work in 2024 at the initiative of Russia [5].

On January 1, 2024, 4 more countries officially joined BRICS: Egypt, Iran, the UAE and Ethiopia. Today, the organization has **9 member countries,** which are home to **45% of the world's population [6] and create 36% of the world's GDP** (PPP) [7].

Given the significant weight of BRICS in the global economy, the efforts to transition to a low-carbon development trajectory undertaken by the countries of the organization will largely determine the global dynamics of anthropogenic greenhouse gas emissions.

This is evidenced, in particular, by data from the International Energy Agency (IEA), according to which **in 2021, the 9 BRICS member states accounted for 41% of the world's final energy consumption and 49% of CO_2 emissions associated with fuel combustion [8].**



BRICS Cities as Important Players in the Climate Agenda

In terms of their urbanization levels, the BRICS countries differ significantly – almost 90% of the people in some member countries live in urban areas (Brazil, UAE), while in some others there is a noticeable predominance of the rural population (India, Ethiopia) [9]. At the same time, large cities are leading and quickly growing centers of economic activity, in which significant labor, financial and production resources are concentrated. **In most BRICS countries, the largest city is a very important contributor to the national GDP,** with a share exceeding 10% in many cases.

The concentration of business activity in large cities makes them significant global emitters of greenhouse gases, even despite a relatively small area they occupy.

According to available estimates of the carbon footprint at the city level, **the top 100 urban CO_2 emitters account for about 18% of global emissions, and 41 such cities are located in BRICS countries, including 28 ones in China [10].** Therefore, realizing the city decarbonization potential is therefore extremely important for achieving global climate goals.

41%

of the world's final energy consumption was accounted for by 9 BRICS member states in 2021

Map of the Report

Population data are for the latest available year [11-25]. For most cities, this is 2022 or 2023 (except for cities in India, where the latest available periods are 2019-2021).

For the purposes of comparability, 2021 data on per capita gross urban product (city's GDP) [26-43] are presented at purchasing power parity [44]. For Moscow, the value of gross regional product (GRP) was used instead of GDP to take into account the financial sector.

For the UAE, data are provided for individual emirates. The per capita city's GDPs of Tehran and Addis Ababa are calculated based on their share of the country's gross domestic product (GDP) [45].

— population
— per capita city's GDP

Cairo
10.10 million people
9.1% of the country's population
US$ 49,000 per capita
28.2% – share of the country's GDP

Brasília
2.82 million people
1.3% of the country's population
US$ 43,000 per capita
3.2% – share of the country's GDP

Addis Ababa
3.94 million people
3.2% of the country's population
US$ 9,000 per capita
11.0% – share of the country's GDP

Rio de Janeiro
6.21 million people
2.9% of the country's population
US$ 24,000 per capita
4.0% – share of the country's GDP

São Paulo
11.45 million people
5.3% of the country's population
US$ 30,000 per capita
9.2% – share of the country's GDP

Cape Town
4.77 million people
8.0% of the country's population
US$ 17,000 per capita
9.7% – share of the country's GDP

Saint Petersburg
5.60 million people
3.8% of the country's population
US$ 74,000 per capita
6.9% – share of the country's GDP

Kazan
1.31 million people
0.9% of the country's population
US$ 38,000 per capita
0.8% – share of the country's GDP

Moscow
13.10 million people
8.9% of the country's population
US$ 88,000 per capita
20.0% – share of the country's GDP

Tehran
9.07 million people
10.2% of the country's population
US$ 24,000 per capita
16.3% – share of the country's GDP

Delhi
20.57 million people
1.5% of the country's population
US$ 21,000 per capita
3.7% – share of the country's GDP

Mumbai
12.88 million people
0.9% of the country's population
US$ 22,000 per capita
2.5% – share of the country's GDP

Beijing
21.84 million people
1.5% of the country's population
US$ 47,000 per capita
3.6% – share of the country's GDP

Shanghai
24.75 million people
1.8% of the country's population
US$ 44,000 per capita
3.8% – share of the country's GDP

Abu Dhabi
3.79 million people
38.7% of the country's population
US$ 101,000 per capita
57.0% – share of the country's GDP

Guangzhou
18.83 million people
1.3% of the country's population
US$ 38,000 per capita
2.5% – share of the country's GDP

Bengaluru
13.00 million people
0.9% of the country's population
US$ 26,000 per capita
3.0% – share of the country's GDP

Johannesburg
4.80 million people
8.0% of the country's population
US$ 27,000 per capita
15.5% – share of the country's GDP

Dubai
3.55 million people
37.6% of the country's population
US$ 51,000 per capita
27.5% – share of the country's GDP

Pretoria
4.04 million people
6.7% of the country's population
US$ 21,000 per capita
9.9% – share of the country's GDP

> 10%

is the share of the largest city in the national GDP of most BRICS members

Purpose and Parameters of the Study

The purpose of this report is to evaluate the efforts to combat climate change undertaken by cities in BRICS countries. It is intended to serve as a source of information for city governments, experts and all stakeholders who promote sustainable development and the reduction of negative environmental impacts.

The results of the study can be used to develop city strategies and action plans, and as a source of information for the exchange of experience and cooperation between cities in BRICS countries and other regions of the world.

The report analyses **five key areas** (categories) related to **greenhouse gas emissions** in cities:

Energy Sources
Carbon intensity of the electricity consumed by the city

Energy Consumption
Electricity intensity of city's GDP

Transport
Use of clean means of transport

Green Spaces
Area of green spaces in the city

Waste
Waste generation and waste management system

Each category is assessed on the basis of **quantitative indications** (statistical data from official sources) and **qualitative indicators** (targets set by cities in a corresponding category).

Evaluation Process

Based on the values of the indicators in each category, **cities are assigned from 10 to 100 points.** To determine the final score of a city, a weighting system is used that reflects relative contribution of each area (category) to the overall balance of greenhouse gas emissions in cities around the world:

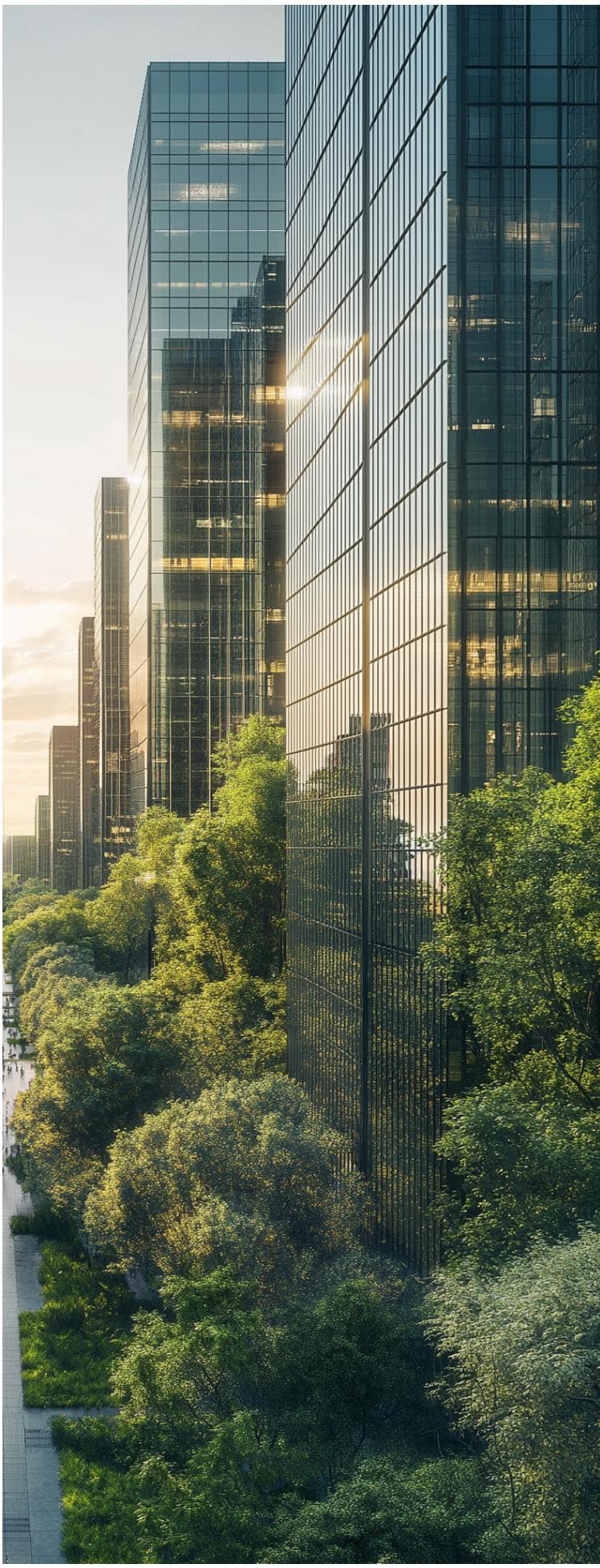
Where a, b, c, d, and e are the weights assigned to a corresponding category

Data Used in the Study

City-level data were predominantly used in the study as obtained **from official sources** (municipal, national sources and international organizations), or specially requested from city governments or research institutions. In some cases, when the required statistical information was not available, additional calculations were made to adjust the national-level data to determine a corresponding value for a city (for more details, see Appendix 1. Methodology).

High-quality statistical information is the foundation for analysis and reasoned decision-making at all levels of government. In this regard, it is crucial to emphasize the importance of collecting and processing relevant data at city level, which **requires detailed monitoring of all areas of urban life.** If such monitoring is not available, then it is necessary to develop methods for bringing existing national-level data to values reflecting the situation in a particular city.

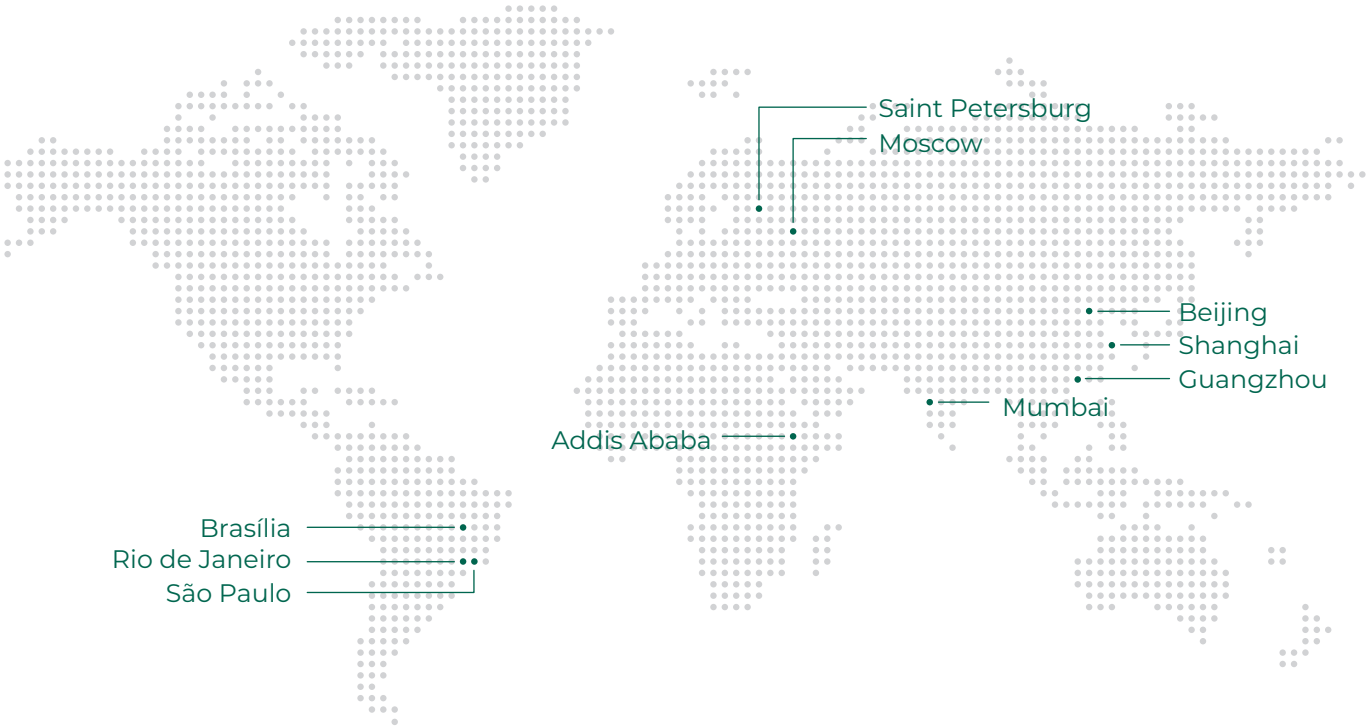
Data transparency and openness are also very important, and cities should have systems in place to publish their data and make it available to the global community by submitting statistical information to relevant international organizations.



Results

Results

Leaders



Balanced leaders

Guangzhou, Moscow, Mumbai, Beijing, Saint Petersburg, and Shanghai are the leading cities, having the most balanced approach to sustainable development in key areas of city operations in terms of their impact on climate. All of them **performed better** than the average for the 20 cities in the report on most of the quantitative indicators.

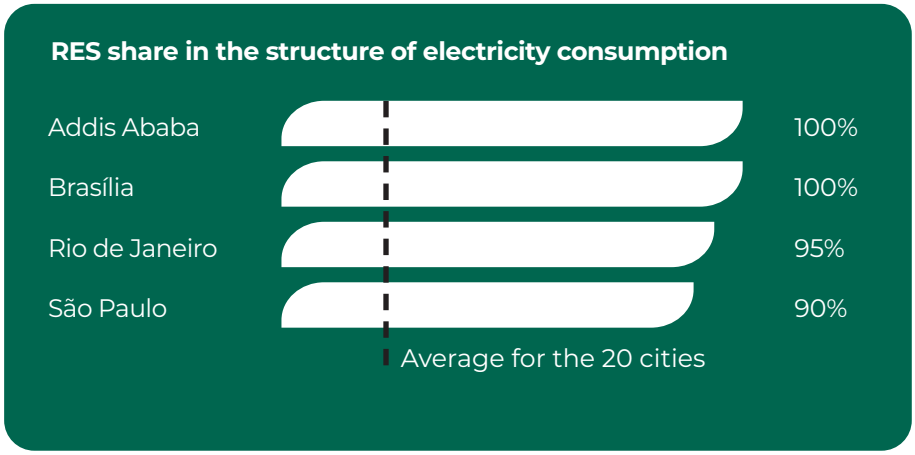
— Average points for Guangzhou, Moscow, Mumbai, Beijing, Saint Petersburg and Shanghai

— Average points for the 20 cities

Guangzhou, Moscow, Mumbai, Beijing, Saint Petersburg and Shanghai have the most balanced approach to sustainable development in key areas of city operations in terms of their impact on climate change

Renewable energy leaders

Addis Ababa, Brasília, Rio de Janeiro, and São Paulo received high final scores due to a significant lead over other cities in one or two categories. All four cities have **the highest share of renewable energy sources (RES)** in the structure of electricity consumption among all the cities, but the **penetration of clean transport** in their transport systems **is comparatively low.** Thus, these cities have considerable **untapped decarbonization potential** in some sectors of their economy.



Global leaders

Moscow, Beijing, and São Paulo also made it into the top 10 of the last year's edition of the study, which assessed 20 major cities from various regions of the world. As **leaders of the climate agenda both at the BRICS and global level,** these cities can share valuable experience of combating climate change for city governments around the world.

Climate planning in BRICS cities

More than half of the cities in the study have adopted city-level climate strategies, including a comprehensive action plan to reduce greenhouse gas emissions in the key emitting sectors and corresponding medium- and long-term targets that are an important factor showing the commitment of BRICS cities to the climate agenda.

Level of economic development does not determine the cities' final results

The results of the research show that there is **no direct connection between the final scores of the cities and the level of their economic development:** the correlation coefficient between the final scores and the per capita city's GDP at PPP is practically zero.

The results indicate **the dual nature of the impact the economic growth** has on the progress of BRICS cities in combating climate change. On the one hand, as a result of socio-economic development, city administrations have **more opportunities to implement measures aimed at decarbonization.** However, at the same time,

economic growth is directly related to rising consumption of the resources necessary to ensure it, which can cause an increase in the carbon footprint of cities.

The identified feature indicates **the importance of implementing a comprehensive climate policy at the city level** in order to compensate for the negative impact of the growth in consumption of energy resources and goods on the climate by switching to a low-carbon development trajectory.

Energy Sources: development of renewable energy sources is one of the priorities

Own power generating capacity of most cities in the study is insufficient to cover their electricity needs, with some cities almost entirely dependent on external energy supplies. In this regard, **the structure of power generation at the national or regional level defines how much clean energy is consumed by individual cities.** For example, in the Brazilian cities and Addis Ababa, a high proportion of electricity is from renewable energy, where generation comes from large hydroelectric power plants located in other regions that supply electricity to the unified grid.

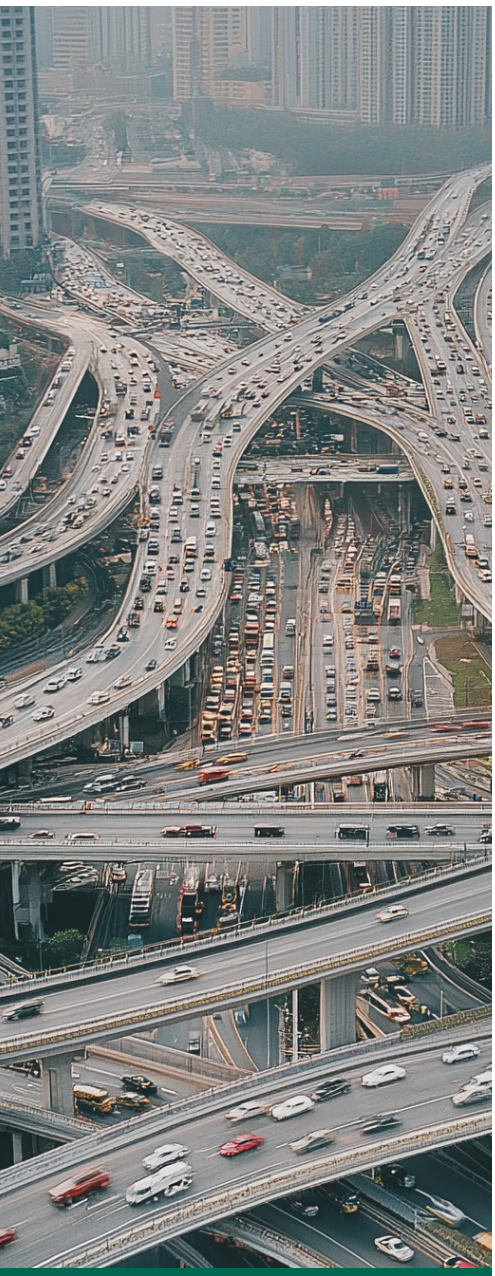
Importantly, climate plans and energy strategies of most cities have goals to increase the share of renewable energy in their energy consumption structure. In 11 cities, one of the priority areas is stimulating the development of distributed energy generation based on solar power. This approach involves installing solar panels in close proximity to places where electricity is consumed, in particular on the roofs of houses.

Also, in their strategy documents, a number of cities have declared their intention to boost cooperation with neighboring regions to create large generating capacities based on renewable energy sources.

Number of cities that have established clean energy targets, by target category

11 out of 20

cities stimulate the development of distributed energy generation based on solar power



14 out of 20
cities aim to reduce the use of private cars

13 out of 20
cities aim to increase the share of electric buses and buses using clean fuels

Number of cities that have established energy efficiency targets, by target category

Energy Consumption: focus on improving the energy efficiency of buildings

Unlike power generation, where city governments may have limited influence, **improving the energy efficiency of the urban economy is under their control.**

The analysis of city plans and strategies shows that **many cities focus on increasing the energy efficiency of buildings:** 12 cities have goals to ensure that newly constructed buildings have high energy efficiency. The main tool to achieve this in most cases is the introduction of **«green» standards in construction and mandatory requirements for the use of energy-saving technologies.** Goals for increasing energy efficiency in existing buildings, also set in most cities, include measures to stimulate the use of energy-saving equipment and implement comprehensive programs for the energy-efficient modernization of residential, commercial and municipal buildings.

Transport: expanding the city's clean vehicle fleet and encouraging people to stop using private cars with internal combustion engines

Today, the transport systems of the BRICS cities in the study differ significantly from each other in terms of both what kinds of transport residents use and what makes up the public transport fleet.

Number of cities that have established targets to decarbonize the transport system, by target category

Leading cities have a higher proportion of residents who prefer using alternative modes of transport to personal cars for regular travel. The differences in the level of electrification of public transport are even more pronounced: along with cities where electric buses make up the majority of the bus fleet (Guangzhou, Shanghai, Beijing), there are operating on cities where the first electric vehicles are only planned to start operating on regular routes (Dubai, Pretoria).

At the same time, in varying degrees **all climate plans and city strategies have goals to decarbonize the transport system.** Most commonly, municipal strategies aim to increase the share of electric buses and buses using clean fuels (13 cities), and reduce the use of private cars with internal combustion engines in favor of green vehicles and alternative modes of transportation by creating an appropriate infrastructure and introducing financial incentives (14 cities).

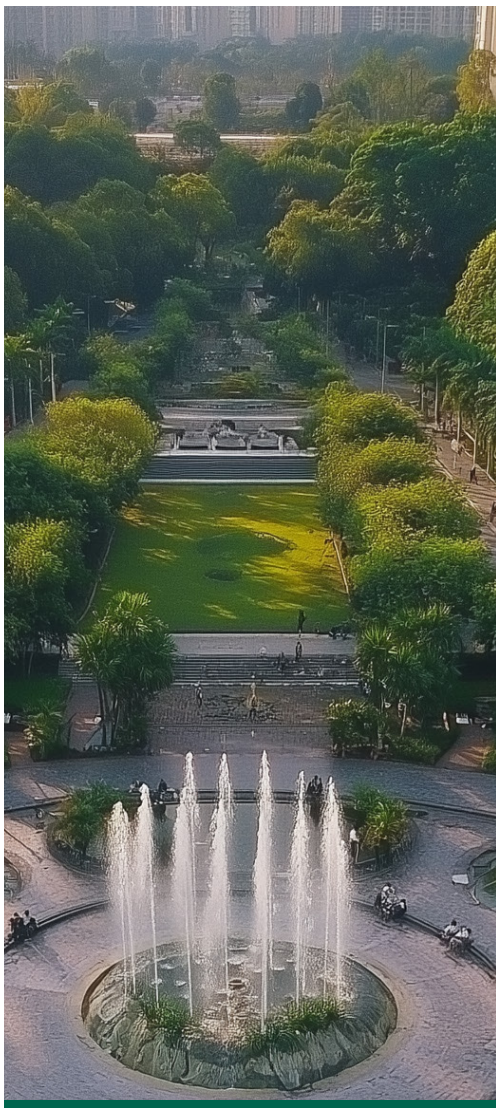
Green Spaces: a common adaptation and mitigation tool in BRICS cities

There are significant differences in terms of how much green spaces the cities have. This is caused by both climatic and territorial factors, in particular, some cities historically have large forested areas within their administrative boundaries. In this regard, **the ability of city governments to increase the area of green spaces is limited by the conditions that have developed over time in their area.**

However, climate plans of all the cities in the study contain provisions aimed at preserving existing green spaces and creating new ones. Among the goals set by the BRICS cities are increasing the ratio of green spaces to the city's territory (12 cities), planting trees and increasing the area of green spaces (10 cities), and creating and restoring protected natural areas (4 cities).

Number of cities that have established targets for urban green spaces, by target category

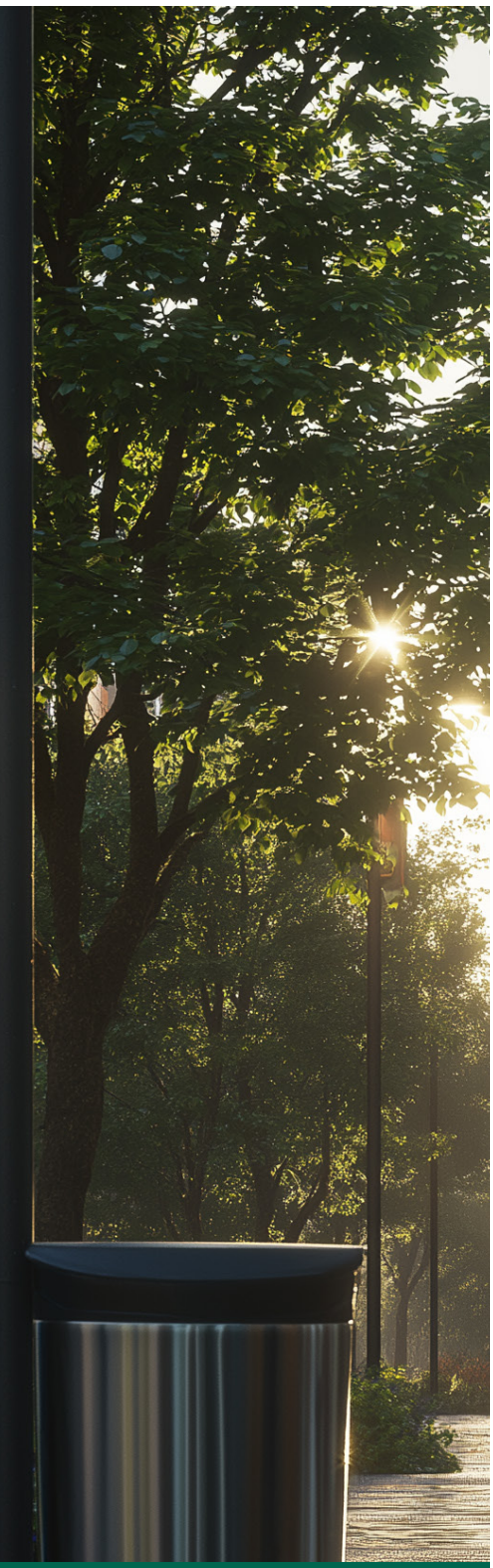
Not surprisingly, urban green spaces are considered as a mitigation tool mainly in cities that already have large forested areas within their administrative borders. In cities where such ecosystems are absent, greening is aimed primarily at increasing the resilience of the urban environment to climate change.



12 out of 20
cities increase the ratio of green spaces to the city's territory

10 out of 20
cities plant trees and increase the area of green spaces

4 out of 20
cities create and restore protected natural areas



18 out of 20

cities aim to improve the waste management systems

Waste: on the way from landfilling to recycling

In the BRICS cities, the per capita mass of municipal solid waste (MSW) is lower than that in the cities in the last year's study (424 kg per year versus 462 kg per year). In the area of waste management, the situation is opposite: the share of MSW disposed of in landfills is significantly higher in the BRICS cities than that in the cities from last year's study (61% versus 45%).

At the same time, **the differences in approaches to MSW management among the BRICS cities are quite significant** — while some cities have completely or almost abandoned waste disposal in landfills (Guangzhou, Beijing, Shanghai), in most other cities the overwhelming proportion of MSW is still sent to landfills.

The waste management policies of BRICS cities are largely focused on improving the MSW management system and transitioning from landfilling to recycling. Measurable targets in this area are set in the climate plans and sectoral strategies of 18 cities. The key mechanisms for achieving them are stimulating separate waste collection and increasing recycling capacity.

Number of cities that have established waste management targets, by target category

Improving the waste management system	18
Waste reduction	5

Results by Category

Energy Sources

Increased electricity production has a direct correlation with economic growth and industrial expansion, as confirmed by studies conducted in many countries, including BRICS members [46]. However, **power generation from fossil fuels is the largest contributor to climate change,** accounting for about 44% of global energy-related CO_2 emissions [8]. By comparison, the share of carbon emissions from fuel combustion by all modes of transport is about 23% [8].

Over the past decades, **the BRICS countries have demonstrated accelerated growth in electricity production.** Between 1990 and 2021, annual power generation volumes in the countries of the organization increased by more than 5 times, while global generation over the same period increased by only 2.4 times [8].

Given that electricity production is vital for economic growth, **the key solution for the BRICS countries on their way to low-carbon development is the decarbonization of the electricity sector,** in particular, by abandoning coal generation and increasing the share of renewable energy.

Large cities as the main consumers of energy play an important role in this process. Even in cases where electricity supply management issues fall beyond the control of city governments, they can **promote renewable energy through financial incentives, regulatory measures and mechanisms for purchasing electricity for their own needs.**

Indicators

- Carbon intensity of city's electricity consumption

  The greater the share of electricity generated by the combustion of fossil fuels (in particular, coal as the most carbon-intensive one) in a city's consumption mix, the higher the value of the indicator.

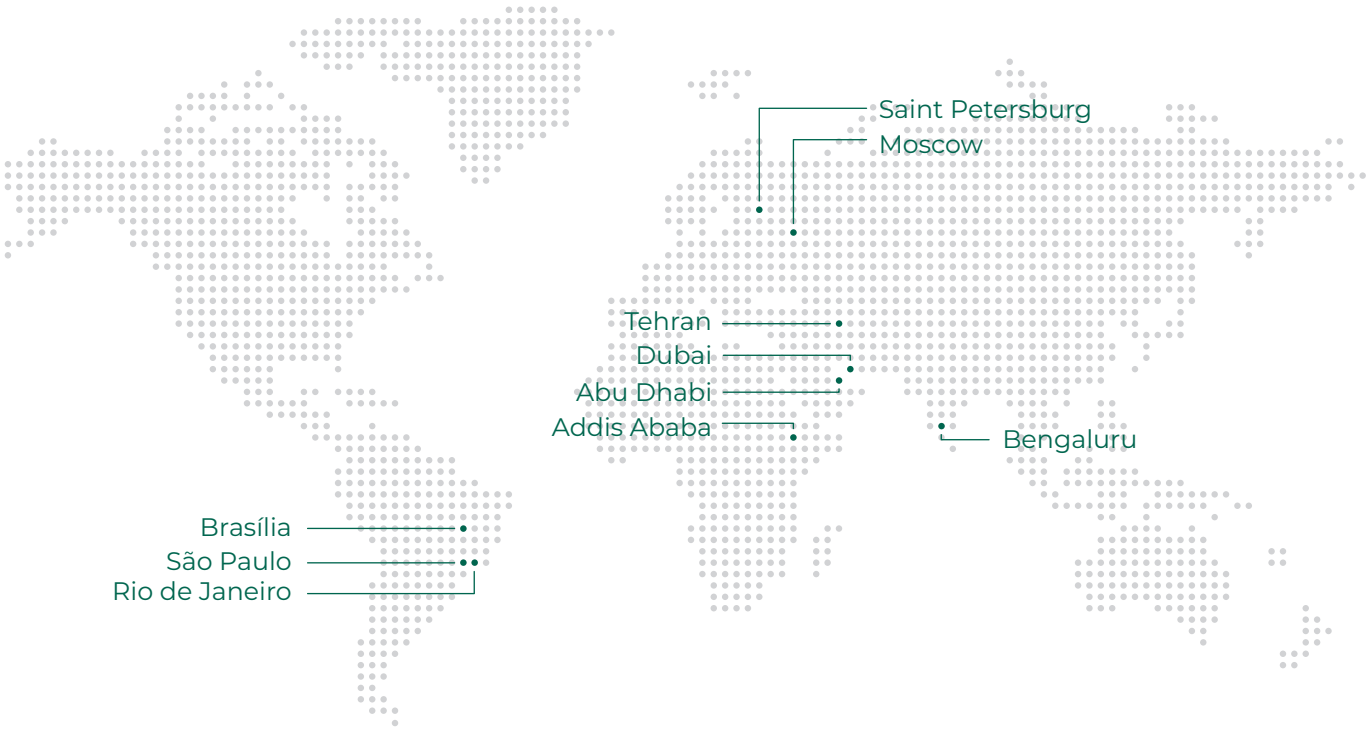
- Targets to increase generation and consumption of renewable energy

Leaders

1. In three cities from the leading group – **Brasília, São Paulo and Addis Ababa** – more than 90% of the consumed energy is produced from renewable energy sources. Most of the electricity consumed in these cities is generated by hydroelectric power plants located outside their borders. Since the electricity consumption in these cities largely depends on supplies from other regions, **the energy goals in their climate plans focus on the development of decentralized generation by equipping city buildings with solar panels and collectors (São Paulo, Addis Ababa) and installing photovoltaic systems in undeveloped areas (Brasília).**

2. **Abu Dhabi, Dubai, Moscow, Saint Petersburg and Tehran,** which are also in the group of leaders, **have natural gas as the dominant source of consumed electricity and have no coal generation.** The highest share of alternative sources of energy (renewable energy and nuclear energy) among the cities in this group is in Saint Petersburg and Dubai due to their proximity to large nuclear (Saint Petersburg) and solar (Dubai) power plants. In the other three cities, the share of such sources in the generation of their electricity supply is insignificant. **Goals to increase the proportion of alternative sources** in the energy balance **up to 2050** are set by **Abu Dhabi, Dubai and Tehran. In Moscow and Saint Petersburg,** the potential for the development of renewable energy sources is limited because of natural climatic conditions, and therefore they **don't have long-term goals to increase the capacity of renewable energy.**

3. The relatively low carbon intensity of the power sector in **Rio de Janeiro** and **Bengaluru,** where coal generation is present, has been made possible by a high share of renewable energy sources.



Energy Consumption

In terms of energy consumption growth rates and share in the global structure of final energy consumption over the past 30 years, electricity has significantly outpaced other traditional energy sources, including coal, petroleum products and natural gas. When compared with 1990, **global electricity consumption in 2021 increased by 2.5 times,** and **its share grew from 13% to more than 20%,** exceeding the share of natural gas and being second only to oil products, which are primarily used as fuel for transport [8].

Given the growing importance of electricity for the global economy, its **efficient use** not only helps reduce the anthropogenic impact on climate, but also **creates additional incentives for economic growth.**

Improving energy efficiency at the national and global level is impossible without the contribution of large cities, where a significant proportion of energy is consumed. Thus, **the 20 cities represented in the study account for more than 2% of the total electricity consumption in BRICS countries,** and in some cities (Abu Dhabi, Addis Ababa, Dubai, and Cairo) the volume of electricity consumption is more than 10% of the total electricity consumption in their respective country [8].

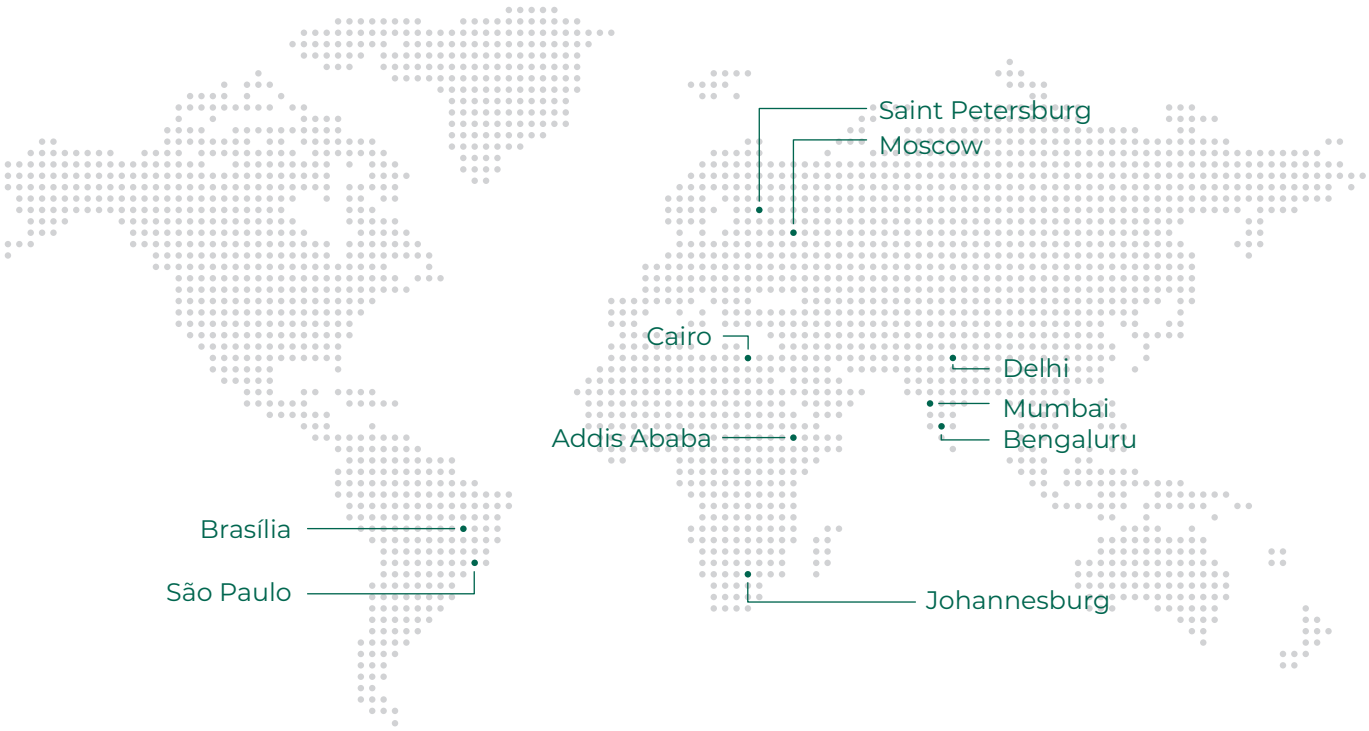
Indicators

- Electricity consumption per unit of city's GDP

  In order to ensure comparability, the volume of urban electricity consumption per unit of city's GDP is adjusted for temperature.

- Targets to reduce energy consumption and increase energy effiency of the city's economy or its individual sectors

Leaders



1. There is **a lot of variances among the cities in terms of electricity consumption per unit of city's GDP.** Even before temperature adjustment, the volume of electricity consumption by cities per thousand dollars of city's GDP varies in the range from less than 50 kW*h to more than 200 kW*h. The average electric intensity of city's GDP for the 10 leading cities in this category is 2.5 times lower than the average for the cities from the second ten.

2. Most of the cities in the study have **lower values of electricity consumption per unit of city's GDP than the national level.** This pattern is observed both in the cities from the leading group and in the 9 cities that rank lower, including Shanghai and Guangzhou, where the bulk of electricity consumption falls on industrial enterprises, while households and the commercial sector together account for only about a half of total electricity consumption. This means that **the differences in electricity intensity indicators are not fully determined by the structure of the economy, but largely depend on the level of energy efficiency of the urban economy.**

Transport

Since transport emissions are concentrated in cities, measures to reduce the negative impact of this sector on climate are a priority for the urban climate agenda.

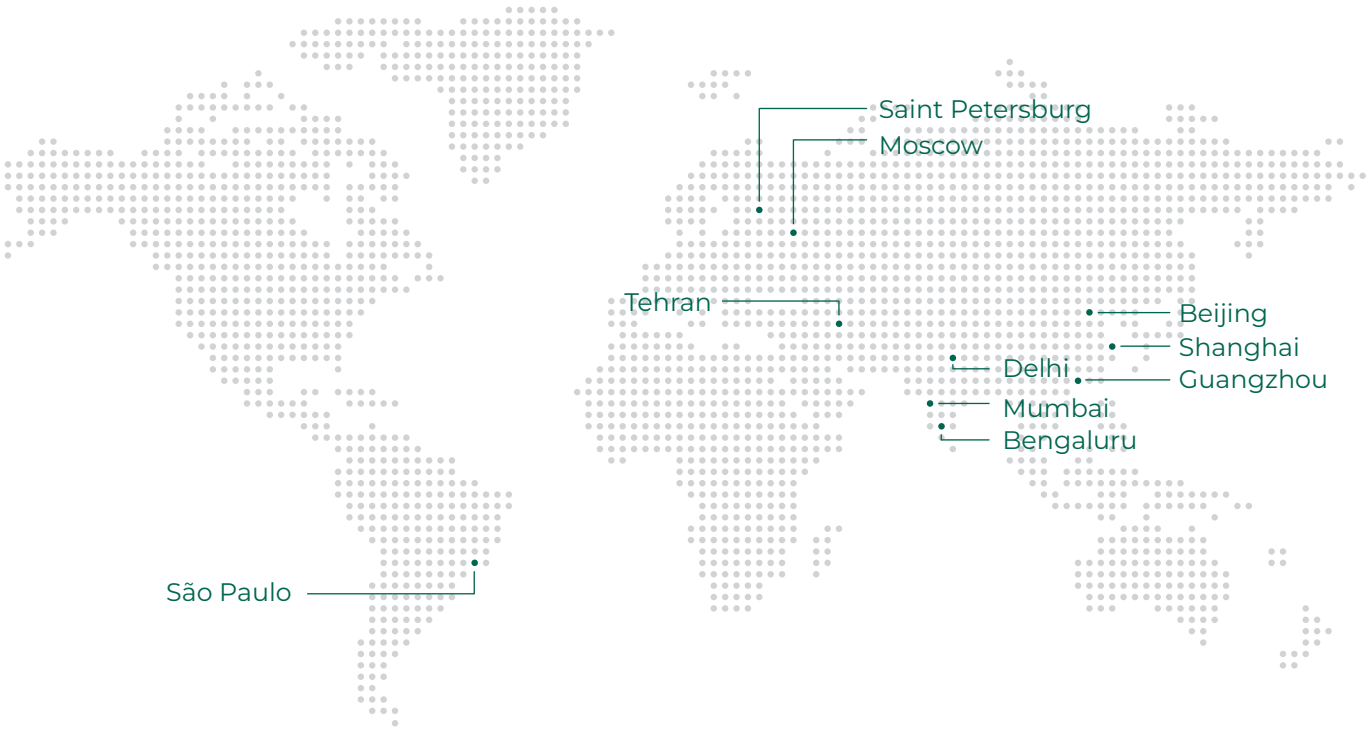
For large BRICS cities, the issues of decarbonizing the transport system are of particular relevance, since in recent decades these cities have seen **a rapid increase in the number of private motor vehicles,** first of all associated with rising prosperity [47]. In 2021, out of the top 10 cities with the highest value of the TomTom Traffic Index, which measures the level of road congestion, 5 were located in BRICS countries [48].

The Intergovernmental Panel on Climate Change (IPCC) estimates that **the transport sector accounts for about a quarter of global carbon emissions** related to energy consumption, and has seen the highest growth rate among all fuel combustion sectors over the past decade [49].

Indicators

- Share of city residents who regularly travel to places of work or study using clean modes of transportation, which include public electric transport, private electric vehicles, and personal mobility devices (PMDs), walking or work from home
- Targets to increase the share of clean transport in the city's vehicle fleet and reduce the number of trips by private cars

Leaders



1. In the top 10 cities in this category, **more than a third of city residents regularly use clean modes of transportation,** with their share exceeding 50% in 5 of them (Guangzhou, Moscow, Beijing, Saint Petersburg, and Shanghai). By contrast, in the cities of the second ten, the average share of residents getting to work or school by clean transport is about 16%.

2. In the leading cities, despite their size and relatively high income levels, **personal transport is not the main means of transportation,** and most city residents use public transport for regular trips or travel on foot. At the same time, **the usage of PMDs is relatively low,** which is a typical feature of most of the cities in the study. Thus, only in 2 cities — Bengaluru and Mumbai — the proportion of residents who regularly use bicycle exceeds 10%.

3. Another important f**actor contributing to the gap** between the leaders and the other cities **is the level of electrification of ground public transport.** In this area, China's cities stand out from the rest, with the share of electric vehicles in the city bus fleet ranging from 60% to more than 90%, with the average for the top 10 cities in the study being only 31%.

Green Spaces

Rapid population growth and economic development of cities lead to the expansion of their boundaries and an increase in the area of urbanized territories. **Between 1990 and 2015, the area of land occupied by urban development increased by almost 40% worldwide [50]. In BRICS** countries, the growth rate over the same period was **over 45%,** and **in Ethiopia and the UAE,** the area of urban territories increased **more than twice [50].** According to the existing estimates, if current trends continue until 2050, the increase in the area of urbanized territories will proceed at a higher rate than the growth of the urban population [51].

Urban sprawl, especially if uncontrolled, **can cause serious damage to surrounding ecosystems** by destroying the habitats of biological species and damaging biodiversity [52]. In addition to its impact on the environment, this process **can also have negative consequences for the climate [53, 54].**

Expansion of urban areas at the expense of adjacent forests → Reduction in the absorption capacity of natural ecosystems

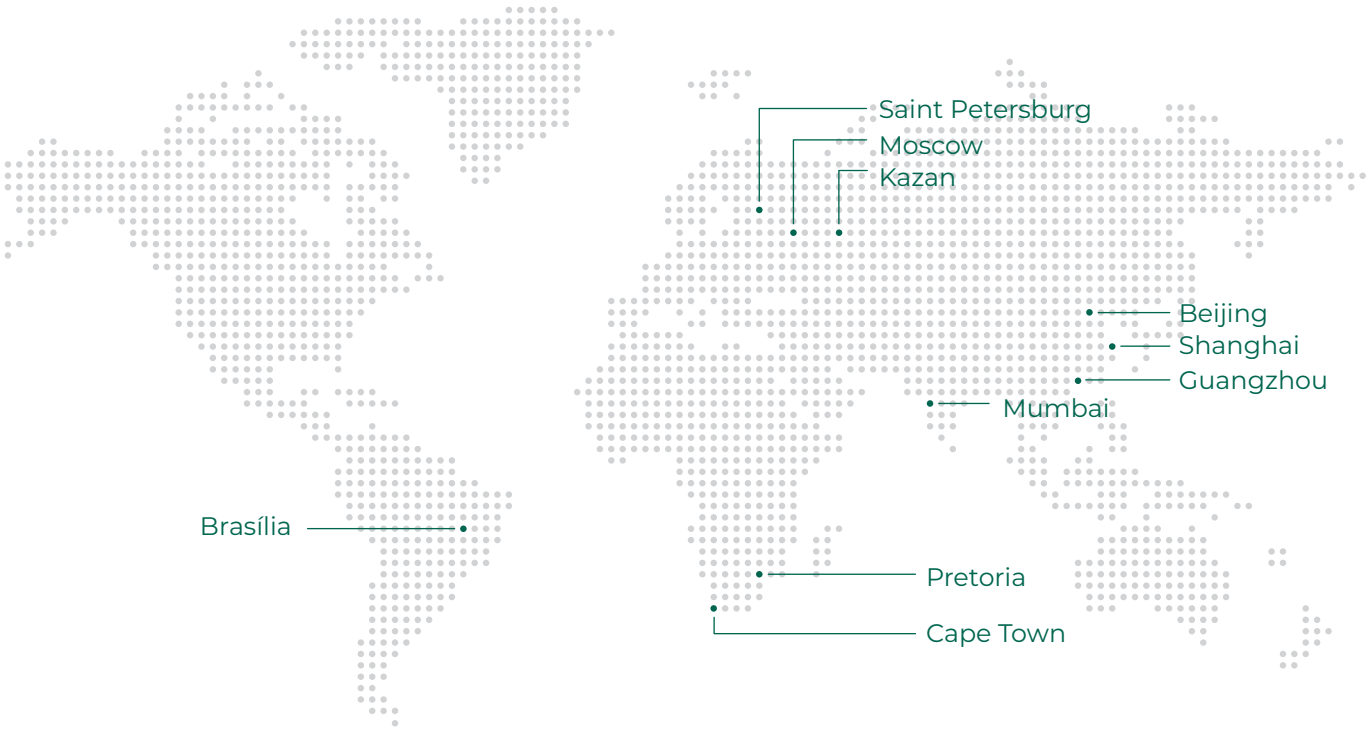
Economic activity on previously unused land, including urban construction → Greenhouse gas emissions accumulated in the soil and plants

Therefore, the goals of increasing the area of urban green spaces and preserving existing natural ecosystems should be an integral element of a comprehensive climate policy at the city level.

Indicators

- Ratio of green space area to the total area of the city
- Targets to increase / keep the share or area of green spaces in the city, for example, by planting trees or expanding zones with nature protection status

Leaders



1. **In 8 out of the 10 cities** that took the top positions in this category, **the ratio of green spaces to the total area** inside the municipal boundaries **is more than 50%, and in some cases** (Brasília, Beijing, and Guangzhou) undeveloped areas with natural landscapes occupy **more than 2/3 of the urban area.** At the same time, the average value of the ratio in the cities that are not among the leaders in the category is only about 18%, which is associated, among other things, with climatic factors - 4 of these 10 cities (Abu Dhabi, Dubai, Cairo, and Tehran) are located in arid subtropical climate.

2. A distinctive feature of most cities from the leading group is the fact that they have **large forested areas within their administrative boundaries.** Such forests form the bulk of their green spaces. Most often, these areas are located in vast territories outside the urban development zone (Brasília, Guangzhou, Kazan, and Saint Petersburg), but in some cities (Moscow and Mumbai) urban forests are wedged into built-up areas, forming the basis of their environmental framework.

3. **In their climate plans and environmental strategies,** the governments of such cities with large forests define **the protection of these natural territories as one of their priorities.** More detailed policy measures in this area usually include reforestation and giving such areas a protected status, which limits the activity on their territory that may harm the ecosystem. In some cases (Guangzhou and Beijing), municipal strategy documents specifically state that achieving reforestation goals are aimed, among other things, at increasing greenhouse gas absorption rates.

Waste

According to the World Bank estimates, **the amount of solid waste generated in the world will increase more than one and a half times by 2050 compared to the 2016 level,** with the highest rates of waste production growth expected to be in low- and middle-income countries [55]. The prime causes of increased municipal solid waste (MSW) generation are population growth and higher income levels, and the dynamics of socio-economic development require that governments adopt clear policy goals in the field of waste management to prevent serious negative consequences for the environment and the climate.

After agriculture and energy, **waste is the third largest source of anthropogenic emissions of methane,** a major greenhouse gas that contributes about 30% to global temperature rise [56]. Reducing the climate impact of this sector requires a comprehensive approach aimed at both reducing waste production by stimulating more efficient consumption and developing alternative waste management methods, the most preferable ones being recycling to obtain secondary materials and composting [57].

Cities play a leading role in the transition to sustainable waste management, as **they produce about 70% of the world's MSW [58],** and in most countries waste management issues are the responsibility of local authorities [55].

Indicators

- Annual per capita mass of municipal solid waste (MSW) generated by businesses and households

  MSW is defined as waste produced by households through the consumption of products and goods, and similar waste generated by businesses.

- Share of municipal solid waste (MSW) generated by businesses and households, which is disposed of in landfill

  Instead of landfilling, cities can use other waste management methods to reduce the sector's negative impact on the climate, such as recycling, composting, and incineration of waste to generate energy.

- Targets to reduce the mass of generated waste or to reduce the proportion or volume of waste that ends up in landfills

Leaders

1. **In 6 out of 10 leading cities in this category** (Guangzhou, Delhi, Mumbai, Beijing, Tehran, and Shanghai), **the values of both indicators** — per capita mass of MSW generated and the share of MSW disposed of in landfills — **are lower than the average for the 20 cities analyzed in the study.** In these cities, most of the waste that does not end up in landfills is incinerated to produce energy or, in the case of organic waste, is composted. Recycling of waste into secondary raw materials is less common, but the climate plans of Mumbai and the Chinese cities have targets to promote this MSW management method.

2. **Addis Ababa and Bengaluru** have some of the lowest per capita MSW generation levels, but they are not among the top-performers in terms of waste management. **Over 70% of MSW** generated in these cities **ends up in conventional landfills with no off-gas collection systems.** The targets set in their climate plans call for a dramatic reduction in the proportion of waste sent to landfills by 2050 by increasing organic waste composting and paper and plastic recycling capacity.

3. **In Brasília and Moscow, the per capita mass of waste generated is higher than the average for the 20 cities in the study.** These two cities are in the group of leaders mainly because a relatively low proportion of their waste is disposed of in landfills – it is less than 2/3 in Brasília and less than 50% in Moscow. As in the case with the other leading cities, the main alternative methods of handling waste (other than landfill disposal) they use are **energy recovery (Moscow) and composting (Brasília).**

Country Profiles

Brazil

In 2023, Brazil submitted an updated Nationally Determined Contribution (NDC) to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), in which the country committed to reduce its annual greenhouse gas emissions by 53.1% by 2030 compared to the 2005 levels, and reaffirmed its commitment to **achieving carbon neutrality by 2050 [59].**

The central element of Brazil's climate policy at the current stage is **combating deforestation in the Amazon,** the largest tropical rain forest on the planet, which occupies more than a third of the country's territory [60]. This issue is vital for Brazil due to the peculiarities of its greenhouse gas emissions structure. **In 2022, 48% of the country's total greenhouse gas emissions came from the land management and forestry sectors,** with almost three-quarters of this sector's contribution coming from deforestation in the Amazon [61].

The Amazon Region Protected Areas Program (ARPA) implemented by the Brazilian government since 2002, is the largest initiative of its kind in the world [62]. To date, **120 zones with a total area of over 62 million hectares have been granted protected status** under the program, representing **about 20% of the entire rainforest area** in the Brazilian part of the Amazon basin [63].

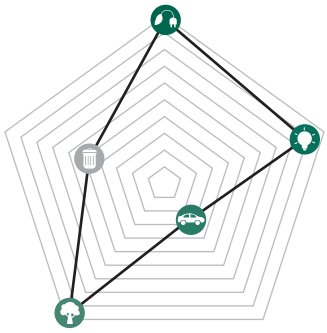
The guidelines of the national strategy to achieve carbon neutrality contain decarbonization targets in other sectors as well [64]. In particular, this document states the country's intention to increase the share of renewable energy sources in the energy balance. At the same time, **renewable sources already account for about 50% of total energy consumption and more than 90% of electricity production [65],** which makes Brazil's energy matrix one of the cleanest in the world.

The share of renewable energy sources is also high in the transport sector, where **biodiesel and ethanol account for over 22% of the fuel consumed by transport [65].** The process is facilitated by a state program to stimulate the production of biofuels through a combination of regulatory and market mechanisms [66].

Best Practices

Brasília

Biodiesel fuel [67]



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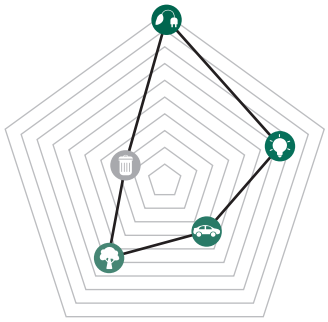
Since 2018, Brasília has been implementing a program to collect and process cooking oil into biodiesel fuel. Anyone can bring used oil (for example, leftovers from cooking at home or in a restaurant) to one of the collection points, from where it is sent to a biodiesel plant. In turn, it is used not only as a green fuel for vehicles, but also to run generators responsible for wastewater treatment in the capital.

Planting Day [68, 69]

Since 2023, Brasília has been holding an annual tree planting day in parks and other public spaces in the city. The seedlings come from the Cerrado ecoregion in eastern Brazil. In the 2023 event, about 10,000 trees were planted in the capital.



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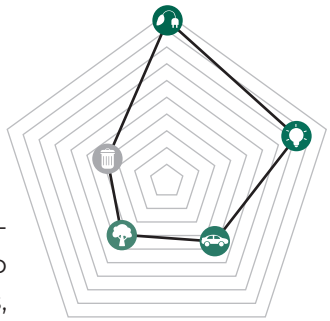
Rio de Janeiro

Purchasing clean energy for municipal buildings [70]

Since 2022, Rio de Janeiro has been steadily expanding the purchase of renewable energy directly on the free market to supply municipal buildings. Currently, the energy is purchased for the São Sebastião Administrative Center and the Operations Center, as well as 20 health facilities. In the future, the city plans to extend the practice to the entire network of its municipal buildings.

São Paulo

Solar energy used to heat water [71, 72]



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Since 2008, São Paulo has had a regulation in place requiring that all new buildings install solar-powered water heating systems. The requirement applies to both residential buildings and various types of non-residential buildings: hotels, sports clubs, hospitals, schools, etc.

Biogas plants [73, 74]

In the late 2000s, São Paulo implemented one of the first biogas energy projects in the country. After the decommissioning of the large Bandeirantes landfill, a biogas plant was built on the site, which captures and burns landfill methane to produce more than 170 thousand MWh of energy per year, the amount sufficient to serve a city of more than 400 thousand residents.

Egypt

One of the fundamental objectives of Egypt National Climate Change Strategy is **to achieve sustainable economic growth and low-carbon development** across various sectors.

There is **particular focus on the energy sector,** which accounts for about 64.5% of total greenhouse gas emissions, due to the high proportion of natural gas and petroleum products in energy production [75].

Government measures have managed to improve the situation in recent years, and **the share of renewable energy sources in the energy balance has grown.** This has been made possible by both the construction of centralized energy supply systems based on clean sources (wind power plants, solar parks, bioenergy plants, etc.), and the promotion of distributed energy production from solar panels on the roofs of buildings in cities and the use of solar water heaters [75].

There are also helpful initiatives to maximize energy efficiency at the national and local levels that stimulate energy conservation, in particular, projects to modernize urban infrastructure [75].

Other sectors of the Egyptian economy **are also making efforts to reduce CO_2 emissions.** There is a project for a green upgrade of urban public transport with the introduction of electric buses, plans to expand the metro network [76] and a project to promote the use of electric vehicles, in particular, by opening new charging stations [77].

Intensive work is also being carried out to create a comprehensive waste management system based on the principles of the 4R concept (Reduce, Reuse, Recycle, Recover), which should ensure a significant reduction in waste generation and a high level of recycling [75].

~64.5%

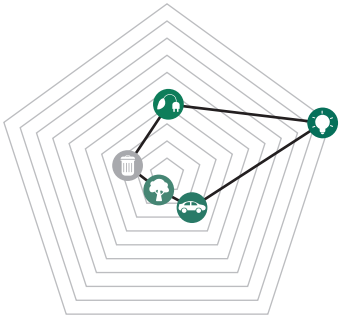
of gas emissions in the country are accounted for by the energy sector

Best Practices

Cairo

Sustainable energy consumption [78-80]

Cairo is implementing projects to use solar power in buildings (in particular, government buildings), to upgrade city lighting by installing energy-efficient street lights, and to increase the efficiency of energy consumption in municipal buildings and facilities (energy-saving methods such as using LED lamps and switching off internal and external lighting in government buildings after business hours).



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India

In 2022, India for the first time set **a strategic target of achieving carbon neutrality by 2070 [81].** The interim **target of reducing the carbon intensity of GDP by 45% by 2030 compared to the 2005 levels** implies scaling up decarbonization efforts across all sectors of the economy in accordance with the action plan outlined in India's Long-Term Low-Carbon Development Strategy [82].

In the electric power sector, an ambitious **target has been set to increase the share of non-fossil sources in total installed capacity to 50% by 2030.** India has already made significant progress towards achieving this target: **as of mid-2023, renewable energy and nuclear energy accounted for 43% of its generating capacity,** including over 16% coming from solar generation [83].

This progress in the use of renewable energy is the result of a comprehensive government policy for the development of this sector, which includes **subsidies for individuals and organizations [84] and regulatory mechanisms** that establish obligations for market participants to purchase electricity from renewable energy sources and build generating capacity [85].

Energy efficiency measures apply to the construction and industrial sectors. **In 2007,** the Indian government developed **an energy efficiency standard for new commercial buildings,** which has now been adopted by most states, and, **in 2018, an energy efficiency standard for residential buildings** was also introduced [86]. In the industrial sector, there is a program setting targets for large energy consumers to reduce the energy consumption per unit of production [87].

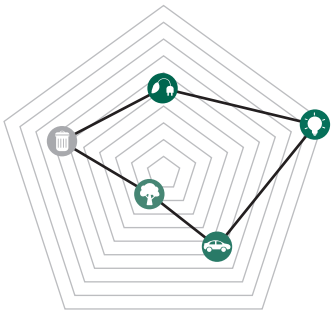
Transport sector decarbonization is also one of the key priorities of the Low-Carbon Development Strategy. In this sector, the strategy envisages measures **to increase the share of biofuels and natural gas in the fuel mix, develop rail transport and stimulate the production and use of electric vehicles [82].**

India's forest management policy includes a host of programs **to increase forest cover, green urban areas, and restore natural ecosystems.** The target is to increase forest absorption capacity by 2.5 billion tons of CO_2 equivalent [81].

Best Practices

Bengaluru

Solar roofs [88-90]



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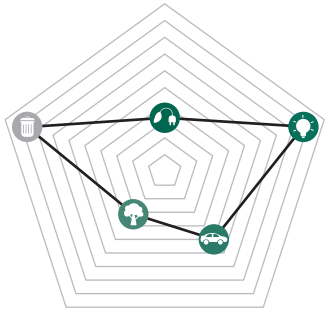
Bengaluru is promoting solar panel projects, installing them on the roofs of administrative buildings and in public spaces (city parks). Moreover, according to the current requirements, new residential buildings in Bengaluru will not be commissioned for operation unless they are equipped with solar water heaters and solar panels on the roofs.



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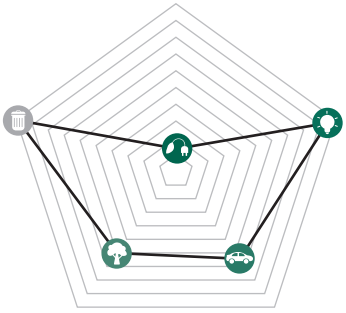
Delhi

Energy efficiency projects [91-93]

The city is implementing a number of initiatives to improve energy efficiency and conservation:
– installing LED lamps in street lighting fixtures
– stimulating households to use LED lamps: one of the initiatives implied purchasing these lamps by residents at a reduced price
– conducting an energy audit of Delhi government buildings to identify areas of excessive energy consumption and find ways to minimize it

Mumbai

Waste recycling [94, 95]



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Most of the city's mixed municipal waste is delivered to the Mumbai municipality's large waste management complex, which includes:
– a bioreactor with an installed capacity of 3,000 to 6,500 tons per day, which, among other things, produces clean electricity
– a mechanized materials recovery facility (MRF)
– a composting facility with an integrated automated SCADA system that monitors the operating parameters

Also, the Mumbai municipality has a near-future project to build a waste-to-energy plant with a capacity of 600 tons per day.

Iran

One of Iran's key sustainable development priorities is **the promotion of clean urban transport [96].** There is an active process to electrify the transport system, with both modernization of the fleet of public vehicles and expansion of the infrastructure necessary for it.

There is also a drive **to transform the waste management system.** The authorities are reducing landfills, with their number going down by 80% over a 7-year period, and the ultimate goal being to completely eliminate them [97].

To process municipal waste into energy, it is planned to build more waste incineration plants in cities. Also, a number of rules limiting the use of single-use plastic items has recently been introduced in the country [97].

Iran has a wealth of renewable energy resources, the potential of which has not yet been fully tapped, and its energy balance is still dominated by natural gas [98].

However, in the future, the country is expected to accelerate the development of renewable energy sources, including wind and solar energy.

The number of landfills went down

by 80%

over a 7-year period

Best Practices

Tehran

Improving the city's waste management system [97, 99]

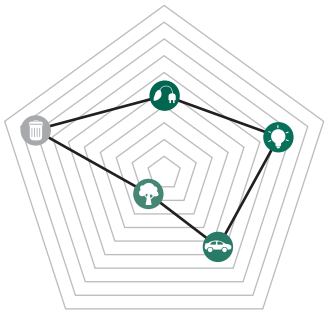
Tehran has a whole range of projects and initiatives, including:

- Installing containers for separate waste collection in residential complexes, offices, government buildings, public and shopping centers;
- Installing reverse vending machines, where people can return empty beverage containers;
- Building specialized materials recovery facilities (MRFs) in dedicated city areas

Promoting clean transport [100, 101]

In 2022 and 2023, about half of the municipal budget was allocated to the development of public transport, which involves the opening of three new metro lines, renewal and replacement of the bus fleet, and other initiatives.

Tehran is also in the process of electrifying its taxi fleet. Owners of taxis with the vehicle age more than 10 years will now be eligible for city support to exchange their vehicles for new electric vehicles, thanks to an agreement achieved with a car manufacturing company in 2024.



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China

Key to China's low-carbon agenda are its two stated goals of **peaking carbon emissions by 2030 and achieving carbon neutrality by 2060 [102].**

China has demonstrated significant progress in many sectors responsible for greenhouse gas emissions. **It has been the world leader in the production and sale of new energy vehicles for many years in a row [103].**

The country is also active in the development of bicycle infrastructure, stimulates the use of electric vehicles, and invests heavily in the modernization of public transport systems (in some Chinese cities, the share of electric buses in the ground transport fleet exceeds 80%).

There are important initiatives to promote low-carbon awareness and behaviors among citizens. According to statistics, **the Chinese public's awareness of climate change and ways to reduce carbon emissions is very high, at over 80% [104].**

Preservation and expansion of green spaces is an equally high priority area in China's climate policy. One of its main programs is the **construction of "forest cities",** which involves the introduction of sustainable solutions into the urban landscape and massive greening of territories. Among other things, this program has contributed to an impressive achievement: the average share of green spaces in the total area of urban built-up areas across the country has reached 42.7% [105].

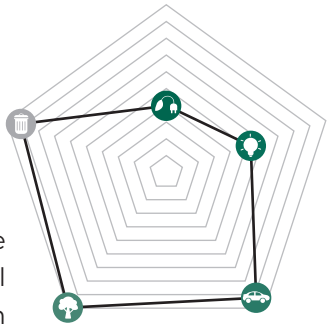
The country also continues to improve its waste management system, based, among other things, on further promotion of separate waste collection, and accelerated construction of integrated urban facilities for the processing of household waste [106].

At the same time, China is among the countries with the fastest growth rates of renewable energy capacity, with its large-scale projects to install **wind turbines, hydroelectric systems and solar panels [107].**

Best Practices

Guangzhou

0% of household waste goes to landfills [108, 109]



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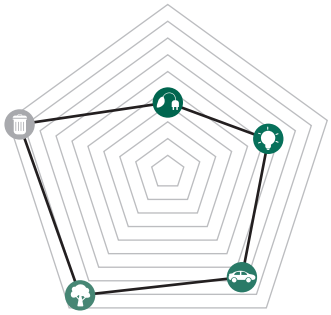
Guangzhou's zero household waste goal has been achieved through a comprehensive approach. It involves the reduction of total amount of waste promoted by a special citywide waste classification system, and a new waste management model with an emphasis on incineration as the primary method and biochemistry and recycling as complementary approaches.

For more than 20 years of active work, Guangzhou has built 7 circular economy industrial parks for processing household waste with a total of 24 treatment facilities and the design capacity of 39 thousand tons per day.



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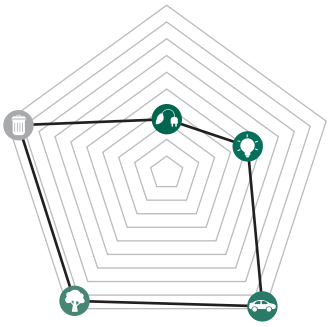
Beijing

National Forest City [105, 110]

The city has been implementing greening activities since 2012. Thanks to large-scale afforestation projects, Beijing's green and water areas have increased by 160 thousand hectares over a ten-year period, and the total number of parks has reached 1,065. For achieving the established national standards in the conservation and development of green spaces and the protection of biodiversity, Beijing was officially awarded the title of "National Forest City" in 2024.

Shanghai

Developing electric vehicle infrastructure [111]



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Currently, there are about 770,000 charging stations in Shanghai, of which 180,000 are public. Shanghai is not stopping there, and plans to build more than 30,000 more public charging stations between 2024 and 2026.

Apps to encourage the use of public transport [112]

To encourage residents to use public transport more often, Shanghai uses city transport apps: when registering for a ride on the subway or bus, a certain amount of so-called "green credits" is added to a special passenger account, which they can then use for various purposes. For example, users of the Shanghai Public Transportation Card app can exchange their accumulated credits for digital yuan.

United Arab Emirates (UAE)

The UAE's transition to a green economy is marked by large-scale renewable energy projects [113].

One of the most significant initiatives to achieve the country's target of producing 100% of its energy from clean sources by 2050 is **the Mohammed bin Rashid Al Maktoum Solar Park,** considered to be one of the largest solar energy projects in the world [114]. **By 2030,** after the completion of all phases of construction, **the park is expected to have a capacity of 5,000 MW and reduce CO_2 emissions by 6.5 million tons per year [115].**

Promoting distributed solar power production in cities is another way to expand the use of renewable energy sources.

Energy efficiency is also on the UAE's agenda: some of the measures to significantly reduce energy consumption include **green construction programs, wastewater reuse, standards for lighting systems,** etc. [113]

The UAE's urban transport sector is set to undergo intensive electrification in the coming decades, with plans to stimulate the use of electric vehicles and increase the number of charging stations by many times [116], upgrade the bus fleet and switch to hybrid vehicles and electric buses [117].

A lot is being done **to preserve and expand green spaces,** and such projects are particularly important amid the continuous threat of desertification [118].

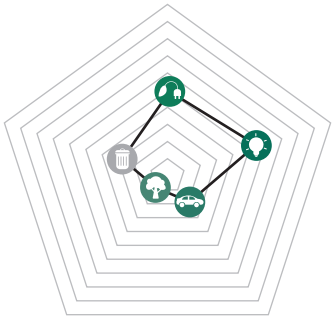
100%

of energy in the UAE is going to be produced from clean sources by 2050

Best Practices

Abu Dhabi

Sustainable urban lighting [119, 120]



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The Abu Dhabi municipality is using sustainable solutions in urban design. In one of such projects completed in December 2023, it installed solar-powered decorative lighting along the Corniche pedestrian walkway.

Following a comprehensive assessment of the project's results, the city intends to extend the use of solar batteries to other public spaces, sites and attractions in Abu Dhabi.

Dubai

Green solutions in urban development [121, 122]

Top-10 in:

In 2021, Dubai opened its first green parking zone, with solar panels installed on its roof to generate the energy needed for the building's operation. The installed solar energy system has a capacity of 500 kW and comprises 1,530 panels covering an area of about 2,500 m^2.

The Blossoms City Park is also designed with sustainability in mind: solar panels have been installed as leaf-shaped "umbrellas" on the open central area and children's playgrounds. These panels create shaded areas and provide 85% of the park's electricity needs.

Russia

Reducing greenhouse gas emissions has become an increasingly important objective for Russia in recent years. The country currently ranks fourth in the world in terms of annual emissions [123], and is actively working to reduce its carbon footprint.

In 2021, the country adopted the Strategy of Socio-economic Development of the Russian Federation with a Low Level of Greenhouse Gas Emissions until 2050 [124], which defined a target scenario for achieving zero emissions, and in 2023, it set the goal of achieving carbon neutrality by 2060 [125].

The carbon intensity of electricity in Russia is already lower than the world average, largely due to a considerable proportion of generation at nuclear and hydroelectric power plants, which are usually located outside large cities [126]. In the cities of the European part of Russia analyzed in this report, generation is carried out at thermal power plants that use natural gas as the main fuel, which is the cleanest of fossil fuels [127].

An important objective to achieve carbon neutrality is to decarbonize the transport sector. Russia has a leading position in the world in terms of the use of rail transport in the structure of freight transportation, which helps reduce greenhouse gas emissions and improve environmental performance in logistics [124]. For large cities, passenger transport plays an important role: in this area, Russian cities can boast a well-developed public transport system, including low-emission types of transport - metro, electric buses, trolleybuses and trams.

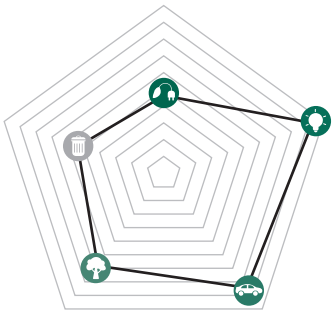
The goal of achieving

carbon neutrality by 2060

was set in 2023

Best Practices

Moscow



Top-10 in:

Electric river trams [128, 129]

In 2023, Moscow launched a regular electric river tram service, opening two all-seasonal routes which employ 50 seater vessels.

The project has improved the accessibility of public transport for residents of 18 districts of Moscow, taken the load off the ground transport network, and reduced harmful emissions.

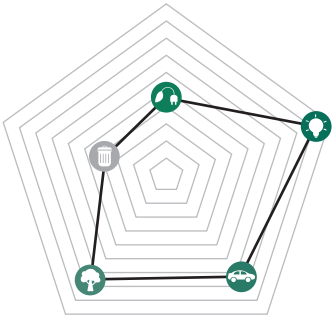
Green bonds [130]

In 2021, the green bonds worth RUB 70 billion were issued on the Moscow Exchange, and the 2023 issue was RUB 2 billion. The raised funds were used to:

— purchase more than 450 electric buses; and

— build new and rebuild some existing facilities of the Big Circle Line of the metro.

This project alone helps reduce emissions of pollutants by almost 1 thousand tons per year, and greenhouse gas emissions, by 42 thousand tons per year.



Top-10 in:

Saint Petersburg

Stimulating the use of electric vehicles [131-133]

As is the case with Moscow, Saint Petersburg is quickly expanding the infrastructure for electric vehicles: in 2023, the number of charging stations in the city exceeded 200.

The city also stimulates the process with regulations: since 2016, owners of electric vehicles have the right to place their vehicles for free in the parking lot (including on paid parking lots - subject to obtaining an appropriate parking permit).

Saint Petersburg also offers a tax benefit to owners of electric vehicles: they are exempt from the payment of transport tax during the first five years of owning an electric vehicle.

Kazan

Top-10 in:

Sustainable urban space [134]

Kazan has built a 16.3-hectare park with areas for active recreation on the site of a littered and insufficiently maintained embankment of the Noksa River.

Among other things, the project involved:

— landscaping, with 88.5 thousand square meters of lawn sown and 1,480 trees and 1,300 shrubs planted.

— removing and disposing of more than 4 thousand tons of waste.

Ethiopia

Renewable energy plays a key role in Ethiopia's energy mix. **The country's power system is almost completely decarbonized,** with hydroelectric power generating more than 90% of the country's electricity [135].

The use of other alternative sources like **wind and solar** is also expanding that helps to address the country's need to increase the level of electrification [136].

In addition, Ethiopia's sustainable development policy places emphasis on measures to promote energy efficient technologies that help reduce energy consumption and carbon footprint [136].

In the waste management sector, **Ethiopia seeks to create a comprehensive sustainable management system that will ensure lower waste generation and higher recycling rates.**

This includes both specialized regulations, such as restrictions on the use of single-use items, and various programs to increase processing capacity [136]. In the future, Ethiopia also intends to build more waste-to-energy plants in major cities across the country.

Ethiopia has plans to modernize its transport system in the coming years: it implies **the significant increase in the length of its railway network** (by more than 4.5 times) [137], **development of urban cycling infrastructure, and promotion of the use of ground electric transport [136].**

>90%

of the country's electricity is produced with hydroelectric power

Best Practices

Addis Ababa

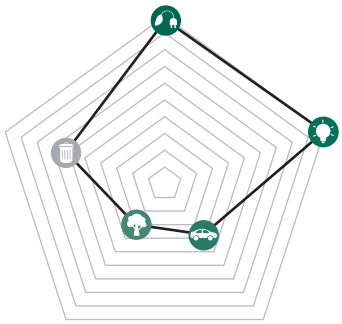
Low-carbon buildings [138, 139]

Due to rising population and relatively low housing affordability, the city has become increasingly plagued by slums. To address the problem, the Addis Ababa City Administration has taken the initiative to promote low-carbon building projects to provide energy-efficient, sustainable housing to various groups, including low-income people.

Waste-to-energy plant [140, 141]
Addis Ababa became the first city in Africa to build a waste-to-energy plant in 2018.

The plant uses modern flue gas treatment technology, which significantly reduces emissions of heavy metals and dioxins from incineration.

The plant has a significant cross-sectoral impact, as the green energy generated from the city's waste (with its capacity of 1,400 tons of waste per day, the plant burns a large proportion of waste produced in the city) is used to meet a considerable portion of household electricity needs



Top-10 in:

Republic of South Africa (RSA)

South Africa aims to achieve net zero emissions by 2050 [142], and the government is consistently developing policies, implementing initiatives and supporting projects in the various sectors responsible for the majority of the country's greenhouse gas emissions.

There is much focus in South Africa to improve the energy efficiency and reduce the carbon footprint of new buildings, with special **national standards for energy efficiency and energy consumption in buildings introduced [143].**

One of the key priorities of South Africa's climate policy is **to preserve carbon-absorbing green spaces.** There are **programs to create and restore eco-friendly recreational parks, and build tree nurseries and plant trees [144].** Municipal authorities also involve residents in their projects to plant greenery and protect biodiversity and have environmental awareness programs for the people.

In the coming years, **the energy sector of South Africa will undergo a significant transformation,** which will also have an impact on the transport sector [145].

The strategic plans call for **a transition from the** predominant use of **coal to renewable energy** (with investments in the development of solar, wind and other alternative forms of energy [146]), where South Africa has great potential [145]. This process is also expected to support the electrification of urban transport systems [146].

South Africa aims to achieve

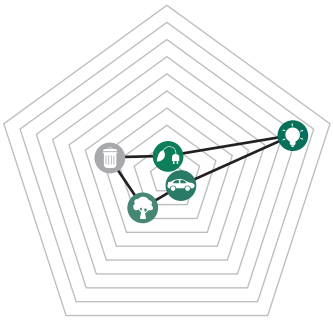
net zero emissions

by 2050

Best Practices

Johannesburg

Various energy efficiency and energy saving initiatives [147-149]



Top-10 in:

— Replacement of lighting in municipal buildings with energy-efficient systems
— Arrangement of courses for building maintenance personnel to train green skills
— Audit of compliance with the rules for mandatory provision and display of energy efficiency certificates in municipal buildings

Top-10 in:

Cape Town

BioNet biodiversity plan [150, 151]

The BioNet is a spatial representation of the network of sites needed to meet the national conservation targets of the terrestrial vegetation and wetland ecosystems in Cape Town. This requires the establishment of a special legal protection regime for these areas in accordance with national legislation. Currently, over 55,000 hectares (over 65% of BioNet) are already protected (including through conservation agreements with private landowners).

Pretoria

Expanding tree planting areas [152]

Top-10 in:

As part of the initiative to green urban spaces, the Tshwane Municipality is donating trees to public schools, communities and non-profit organizations for planting. The city had a target of donating 8,000 tree seedlings for the 2022/23 financial year.

Interested parties may apply for plants once per financial year and must provide transport and labor for the collection of plants.

Appendix 1. Methodology

General Approach

1. Compare cities and award points in each category

The score of a city in each category can take a value from 10 to 100 points and is calculated using quantitative (basic) and qualitative (adjustment) indicators.

Quantitative indicators are based on statistical data in the categories, while **qualitative** indicators are based on measurable targets (expressed numerically) set by city governments as defined in or made public through their climate policies or other official documents.

Cities are compared using the following algorithm:

- Based on the value of the quantitative indicator(s), the city is assigned an **initial score** ranging from 10 to 100, where 100 is the best score and 10 is the worst score (if 2 quantitative indicators are used, the city is assigned an initial score in the range from 5 to 50 for each indicator, where 50 points is the best score, and 5 points is the worst).

- For cities whose initial score is less than ¾ of the maximum (i.e. the city did not perform particularly well in a given category), an adjustment factor is applied: if the city government does not have any specific plans to improve such performance (qualitative indicator), the initial score is reduced by 10%, thereby giving the ranking a dimension of potential future improvements rather than just stating the status quo.

2. Calculate the final score

The final score is calculated as a weighted average of the scores assigned to the cities in each category. For calculation purposes, each of the categories is assigned an individual weight representing the category's relative contribution to urban greenhouse gas emissions (for more details, see the Assignment of Weights section).

The resulting final score is normalized to a value between 10 and 100.

Energy Sources

Basic indicator: carbon intensity of city's electricity consumption calculated on the basis of its mix of generation sources (coal, oil and petroleum products, natural gas, nuclear, other non-renewable energy sources, renewable energy)

Period: 2019-2023, depending on data availability

Sources of data: CDP Cities Energy Mix [153-155], official statistics [156-168], International Energy Agency [169], Global Energy Monitor [170]

Note: For 12 out of the 20 cities in the report, the data city governments provided to the CDP database are used. For the 8 cities for which information is not available in the CDP, official city-level statistics is used. 6 of the 8 cities only published data on the structure of electricity production (not consumption) in the city. In this case, the following algorithm is used to calculate the missing value:

(1) calculating the volume of electricity imported by the city (the difference between total electricity consumption and total production);

(2) if, according to the Global Energy Monitor, there is at least 1 operating nuclear power plant or at least 1 operating hydro power plant within a radius of 300 km from the city, the structure of sources of electricity imported by the city is taken to correspond to the structure of electricity generation in the country as a whole (for Russian cities, to the structure of electricity generation within the unified energy system (UES), to which the city belongs);

(3) if, according to the Global Energy Monitor, there are no operating nuclear power plants or hydro power plants within a radius of 300 km from the city, the structure of sources of electricity imported by the city is taken to correspond to the adjusted structure of electricity generation in the country as a whole. For adjustment purposes, the share of the corresponding source of energy (nuclear energy in the absence of nuclear power plants, and hydroelectric energy in the absence of hydro power plants) in the structure of electricity generation in the country as a whole is taken to be equal to 0.

(4) the share of each source in the structure of electricity consumed in the city is calculated as the weighted average of the shares of the corresponding source in the generation structure within the city and in the generation structure in the country as a whole. The share of electrici-

ty produced in the city in the total volume of city electricity consumption and the share of electricity imported by the city in the total volume of city electricity consumption are used as weights.

Adjustment factor: targets to increase generation and consumption of renewable energy [171-187]

Methodology to calculate the initial score:

1. Each source of energy consumed in a city is assigned a weight to capture information on the level of greenhouse gas emissions from that source. The weights for coal, oil, and gas are calculated as the ratio of emissions from the combustion of a corresponding type of fuel to the volume of its consumption. The generation of nuclear energy and energy from renewable sources does not have greenhouse gas emissions, so a zero factor is applied to these energy sources.

2. The amounts of energy consumed from each energy source in the city are multiplied by the weights described in step 1 and summed up for each city.

3. Each city is assigned from 10 points to 100 points in proportion to the value obtained in step 2 (where 10 points are assigned to the city with the highest value of the indicator, and 100 points to the one with the lowest value).

Energy Consumption

Basic indicator: electricity consumption per unit of city's GDP, kWh per $1,000 USD, adjusted for average annual temperature

Note: Due to data availability limitations, the report focuses on electricity consumption only, which comprises just a part of total energy consumption of a city. There are other ways energy resources like coal, oil, gas etc. can be used to produce energy.

For example, the energy released from burning fossil fuels can be used not only to generate electricity, but also to operate industrial equipment (for example, smelters), while petroleum products are most commonly used to fuel internal combustion engines in motor vehicles, rather than to generate electricity.

In order to ensure comparability, thermal energy is not included in the calculation, because only Russia

and China operate central heating systems; other countries use local boiler houses for heating, whose energy consumption is not captured by urban statistics.

Period: 2019-2022, depending on data availability

Note: The latest available data on cities' electricity consumption were used: for 10 cities, the latest available year was 2022, for 6 cities, 2021; for 1 city, 2020; and for 2 cities, 2019.

In two cities (Kazan and Addis Ababa), there is no data available on electricity consumption at the city level.

Kazan only publishes data on electricity consumption by households: the calculation of missing data on total electricity consumption is carried out based on the ratio of electricity consumption by households to total electricity consumption in the region (the Republic of Tatarstan) in 2022.

The International Energy Agency released data on per capita electricity consumption in Ethiopia for 2021: the missing data on total electricity consumption in Addis Ababa is calculated based on the ratio of per capita city's gross domestic product (GDP) to the country's per capita GDP.

Sources of data: CDP Cities Energy Mix [154, 155], official statistics [156,158,188-200], International Energy Agency [135]

Adjustment factor: targets to reduce energy consumption and increase energy efficiency of the city's economy or its individual sectors [172, 174, 176, 177, 179, 180, 184, 185-187, 201-206]

Methodology to calculate the initial score:

1. The electricity consumption per unit of city's GDP is calculated as follows: the electricity consumption data by the city in the latest available year is divided by the city's GDP in the same year.

Note: To ensure the comparability of the city's GDP electricity intensity values, the city's GDP values in national currency are converted to $USD using the exchange rates of the relevant currencies calculated at purchasing power parity (according to the World Bank) [44].

If the latest available data on electricity consumption are for a period prior to 2022, in order to avoid distortion of the city's GDP electricity intensity values, the city's GDP value for the relevant year is adjusted to 2022 prices using the accumulated national consumer price index (CPI) [207-212].

If no data on city's GDP is available, its volume is calculated based on the share of the city's GDP in the country's GDP [45].

2. In order to ensure comparability of values used for each city, the electrical intensity of city's GDP is adjusted for temperature using the following algorithm:

   2.1. An equation is formed that links the electrical intensity of GDP to the average annual temperature based on a sample of high- and middle-income countries [213] (according to the International Energy Agency [169]). The resulting equation is a quadratic function whose graph is a parabola that opens upward.

   2.2. In the resulting equation, the minimum point (the vertex of the parabola) is determined. The temperature value at this point represents the neutral level of the average annual temperature, at which the temperature factor does not affect the electrical intensity of GDP.

   2.3. For the same sample of countries, a new multifactor equation for the electrical intensity of GDP is formed, in which one of the factors is the square of the deviation of the average annual temperature from the neutral level as determined in step 2.2. The coefficient for the specified factor reflects the influence of the temperature factor on the electrical intensity of GDP.

   2.4. For each city, the contribution of the temperature factor to the electrical intensity of city GDP is determined by multiplying the square of the deviation of the average annual temperature in the city [214] from the neutral level by the coefficient determined in step 2.3.

   2.5. The adjusted value of the city's GDP electrical intensity is calculated by subtracting

the contribution of the temperature factor determined in step 2.4 from the original value of the city's GDP electrical intensity.

3. Each city is assigned from 10 points to 100 points in proportion to the adjusted value of the electric intensity of city's GDP obtained in step 2 (where 10 points are assigned to the city with the highest value of the indicator, and 100 points to the one with the lowest value).

Transport

Basic indicator: share of city residents who regularly travel to places of work or study using clean modes of transportation, which include public electric transport, private electric vehicles, and personal mobility devices (PMDs), walking or work from home, %

Period: as of April 2024

Sources of data: Numbeo [215], official statistics [216-224], news articles [225-238]

Adjustment factor: targets to increase the share of clean transport in the city's vehicle fleet and reduce the number of trips by private cars [172-174, 176, 177, 179, 180, 184-187, 239-243]

Methodology to calculate the initial score:

1. The share of the residents using clean transport and personal mobility devices for daily travel is calculated for each city. To determine the share of the residents using clean ground public transport, the share of people using ground public transport is multiplied by the share of electric buses and trolleybuses in the city's ground public transport fleet.

2. Each city is assigned from 10 points to 100 points in proportion to the value obtained in step 1 (where 10 points are assigned to the city with the lowest value of the indicator, and 100 points to the one with the highest value).

Green Spaces

Basic indicator: ratio of green space area to the total area of the city, %

Period: as of March 2023

Sources of data: Google Maps [244], official statistics [245-247]

Adjustment factor: targets to increase / keep the share or area of green spaces in the city [171-174, 176, 177, 179, 180, 184, 185, 187, 201, 202, 241, 248-250]

Methodology to calculate the initial score:

1. The area of green spaces in the city is determined based on online map data.

2. The ratio of green space area to the total area of the city is calculated by dividing the value obtained in step 1 by the value of the city area in its administrative borders.

3. Each city is assigned from 10 points to 100 points in proportion to the value obtained in step 2 (where 10 points are assigned to the city with the lowest value of the indicator, and 100 points to the one with the highest value).

Waste

Basic indicator 1 – waste generation: mass of municipal solid waste (MSW) generated by businesses and households, kg per capita

Period: 2019-2023, depending on data availability

Sources of data: official statistics [251-267]

Basic indicator 2 – waste management: share of municipal solid waste (MSW) generated by businesses and households, which is disposed of in landfill, %

Period: 2019-2023, depending on data availability

Sources of data: official statistics [251-256,258-264,266-269]

Adjustment factor: targets to reduce the mass of generated waste or to reduce the proportion or volume of waste that ends up in landfills [172-174, 176, 177, 179, 180, 184-187, 201, 202, 262, 263, 270]

Methodology to calculate the initial score:

1. Per capita mass of MSW is calculated: the latest available data on the mass of generated MSW are divided by the city's population for the corresponding year.

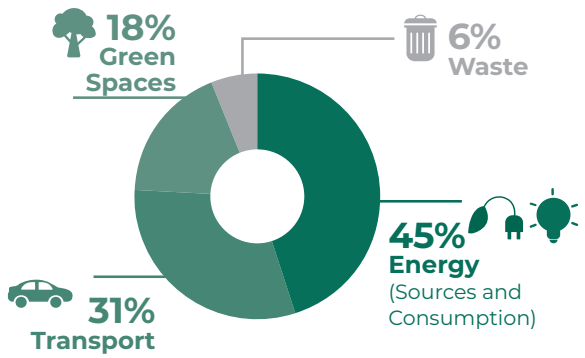
2. The share of waste disposed of in landfills is calculated: the data on the mass of MSW disposed of in landfills for the last available year are divided by the data on the mass of generated MSW for the same year.

3. Each city is assigned from 5 points to 50 points in proportion to the value of each of the basic indicators (where 5 points are assigned to the city with the highest value of the indicator, and 50 points to the one with the lowest value).

4. The values obtained in step 3 for each of the basic indicators are summed up for each city and then normalized to a value between 10 and 100.

Assignment of weights

The following weights are used to calculate the final score:



Note: The weights of Energy Consumption and Energy Sources are distributed as 2/3 and 1/3 of the total weight of the Energy sector, respectively, since cities have much more influence over the volume of energy consumption than they have over energy generation sources.

All categories, except for Green Spaces, represent sectors responsible for greenhouse gas emissions. For the purposes of the assessment, their weights are calculated based on the structure of emissions as submitted by cities to CDP in 2022 [271] (using the most common methodology, the GCoM CRF reporting framework, with contributions from more than 200 cities):

- **Energy:** emissions from fuel combustion in stationary sources (direct), and related to the consumption of energy received from distribution networks (indirect).

- **Transport:** emissions from combustion of fuel in vehicle engines (direct).

- **Waste:** emissions associated with the management of urban waste inside the city (direct) and beyond its boundaries (out of boundary).

The calculation does not take into account greenhouse gas emissions from sectors that fall outside the scope of this research: emissions from the wastewater treatment systems, aviation, etc.

Unlike other categories, Green Spaces have the opposite effect of emissions capture and storage. Achieving a net zero at a national level is still expected to leave residual emissions at 18% of the current values [272].

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