MOSCOW ECONOMY

MOSCOW DEPARTMENT OF ECONOMIC POLICY AND DEVELOPMENT

THE URBAN CLIMATE AGENDA REPORT

CONTENTS

Foreword

The Moscow City Government Department of Economic Policy and Development presents the first edition of the Urban Climate Agenda Report, prepared with the participation of M.V. Lomonosov Moscow State University. This research is based on an original methodology to evaluate and compare the efforts undertaken by city governments to combat climate change.

In line with our values of transparency and openness, we disclose our data sources and research methodology. The research is based on urban data obtained from reliable, publicly available international sources and official municipal statistics.

We are open for cooperation with city governments and other owners of data and will be glad to improve and update the information we use. We also intend to expand our research geographically by adding new cities in future editions.

This research may be useful to the academic community and municipal authorities. It offers an analysis of the best practices to include in climate strategies and can aid in efficiency evaluations of currently existing measures.

Reviews

Cities have a huge impact on climate change, and their role will only increase in the future. This makes the transition to sustainable development, the achievement of carbon neutrality and the formation of an urban green economy principal.

With this in mind, we were pleased to participate in the preparation of the Moscow City Government Department's of Economic Policy and Development study «The Urban Climate Agenda Report» to analyze the methodology and the results of the study.

By integrating the climate factor, this study is a constructive attempt to assess the climate agenda based on its key elements in the urban context. This distinguishes it from many international and national studies.

The authors' merit lies in the development of the key criteria and principles underlying the research. The identification of five factors proposed in the research that most significantly affect the balance of greenhouse gases seems to be quite reasonable. Moreover, one can note adequate statistical support, the use of reliable data for the research construction, which, in turn, makes it transparent, verifiable, and replicable in the future, considering presumable changes in the main parameters.

Committee of Experts of M.V. Lomonosov Moscow State University

Andrey Fedyanin,

Doctor of Science in Mathematics and Physics, professor, Head of Department of Nanophotonics of the Faculty of Physics of M.V. Lomonosov Moscow State University, prorector of M.V. Lomonosov Moscow State University

Sergey Bobylev,

Doctor of Science in Economics, professor, Head of Environmental Economics Division of the Faculty of Economics of M.V. Lomonosov Moscow State University. Chief Editor of the UNDP Human Development Reports of the Russian Federation in 2000-2013. Member of the independent scientists group created for preparation of UN Global Sustainable Development Report

Sergey Gulev

Doctor of Science in Mathematics and Physics, professor, corresponding member of the Russian Academy of Sciences

The climate agenda, which has become one of the main sustainable development items over the past few decades, has a direct bearing on the quality of life of people, including those living in large urban centers. The desire to protect the habitat for the present and future generations has brought about changes in economic activity, and has stimulated the introduction of new technologies that reduce human impact on nature and climate. However, there is still no common agreement on such matters as what should be the exact goals of economic development and what specific measures should be taken to protect the environment and the climate.

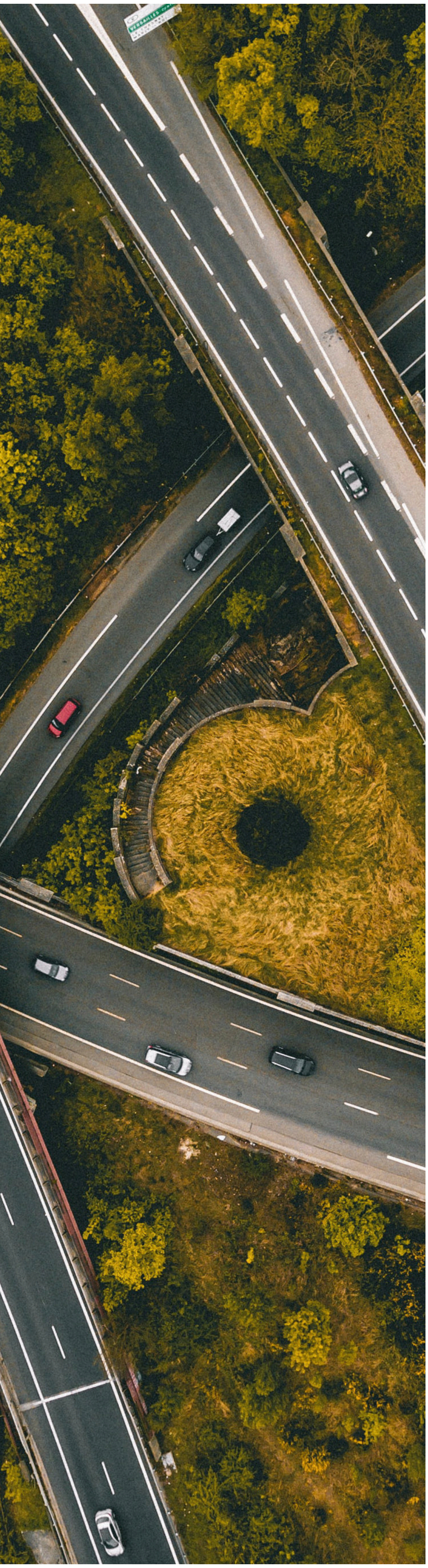
Megacities like Moscow have a special role to play in this respect. On the one hand, they tend to be more economically advanced than other regions and have more opportunities. They are in a position to lead their countries in implementing the most effective solutions. These solutions can then be replicated in other regions, ensuring that the entire economy undergoes modernization.

On the other hand, large urban centers consume a lot, which has an indirect impact on the economic development across the economy, but also leads to higher greenhouse gas emissions.

The study summing up the experience of the world's largest cities in the field of climate protection may have important practical implications, as an element contributing to the development of effective city management policies. In this regard, it is surprising to see that there are only so few ranking studies that are entirely devoted to the analysis of municipal climate policies: normally, municipal rankings have a bigger scope, where climate policies do not get the attention they deserve. This study helps fill this gap. It has both theoretical and practical value, as it provides an analytical toolkit for municipal climate-management policies and makes it possible for cities to benchmark their performance against the leaders in this area.

Alexander Shirov,

Doctor of Science in Economics, Director of the Institute of Economic Forecasting of the Russian Academy of Sciences, corresponding member of the Russian Academy of Sciences



Executive Summary

As **one of the best known global issues, climate change** is largely caused by greenhouse gas emissions produced by human activities [1].

A total of **196 countries signed the Paris Agreement** in 2015 to coordinate their efforts to address climate change [2], setting a common goal for the acceding parties to hold the increase in the global average temperature to below 2°C and pursue efforts to limit it to 1.5°C above preindustrial levels.

The involvement of city governments and residents in the climate agenda is extremely important to make sure these efforts are effective, because **cities**, as centers of economic activity, **make the greatest impact on climate change [3].**

In our research, we have compiled **a ranking of 20 major cities** around the world located in different geographical regions with the aim of making a comprehensive **assessment of their potential to combat climate change**.

One of the key drivers of climate change is greenhouse gas emissions

The cities are evaluated on their performance in five areas of city operations (categories), which are most responsible for greenhouse gas emissions:

- Energy Sources,
- Energy Consumption,
- Transport,
- Green Spaces,
- Waste.

Each of the categories is measured using **two types of indicators:**

quantitative

statistics from publicly available sources

qualitative

measurable targets set by city governments to achieve progress in the above categories

London topped the ranking, scoring highly in almost all categories:

- → 3 place in promoting clean transport,
- → 4 place in development of clean sources of energy,
- → 6 place in waste management,
- → 7 place in energy consumption.

The other two European capital cities, **Paris** and **Berlin, took second and third place**, respectively. Both were among the leaders in Transport (fourth and second place, respectively). Paris also scored high in Energy Sources, and Berlin performed well in Energy Consumption.

Moscow and **Tokyo** were also **among the top five**: Moscow got a high score for its success in promoting clean transport and the expansion of green spaces, and Tokyo excelled at its clean transport and waste management.

About this Report

Cities as major contributors to climate change

We can already observe the manifestations of long-term changes in the planet's climate system caused by the anthropogenic impact on the environment [4]. The increase in the average global temperature has accelerated markedly over the past 100 years due to the accumulation of greenhouse gases in the atmosphere, which has resulted in shrinking volumes of Arctic sea ice and the buildup of heat in the upper layers of the world ocean. There has been an increase in the frequency of extreme droughts, floods, and storms in some regions of the world. If the current trends persist, the intensity of these processes will grow, which may eventually lead to the loss of the livable environment.

Large cities have a special role to play in fighting climate change: according to the report issued by the Intergovernmental Panel on Climate Change (IPCC) in 2022, cities account for 67–72% of total emissions of carbon dioxide (CO_2) and methane (CH_4), which are two of the most widespread greenhouse gases. Moreover, the contribution made by cities to global emissions has been growing continuously [3].

Cities account for 67–72% of total global emissions of carbon dioxide (CO_2) and methane (CH_4)

The 2015 Paris Agreement [2] has set the limit for the rise in the global average temperature in this century to 1.5°C, the threshold beyond which the worst-case scenario may unfold. To contain global warming, the signatory nations have assumed obligations to cut the emissions of greenhouse gases, the key element of anthropogenic impact on climate.

Municipal authorities are stepping up their efforts to reverse the trend and mitigate climate change — more than 800 cities around the world have set the target of becoming carbon neutral [3]. Furthermore, cities have created their own international associations in order to make joint commitments to reduce greenhouse gas emissions and remove their causes, in particular, the C40 group and the Global Covenant of Mayors for Climate and Energy (GCoM).

Causes of Climate Change

The key activities causing anthropogenic greenhouse gas emissions are [5]:

Production of energy and goods

Energy supplied to buildings

Transport

Deforestation

Unsustainable consumption

Agriculture

Our research focuses on all of these elements with the exception of agriculture, because they are integral components of a city's economy.

The Impact of Cities on Climate Change

The research evaluates the key areas of the activities of cities causing greenhouse gas emissions and the efforts of city governments to reduce them.

Each area (or category) is analyzed using quantitative and qualitative indicators: statistical data and specific targets defined by the city governments. For calculation purposes, each category is assigned an individual weight characterizing the relative contribution of a particular category to the overall emissions of greenhouse gases by the city.

The indicators have been selected in line with recommendations of key international organizations dealing with climate change, including the UN [6], OECD [7], and C40 [8].

Please note that this research focuses solely on a city's GHG mitigation measures, and total GHG emissions are not evaluated.

The following formula is used to calculate each city's final score:

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

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

You can find more information on the indicators and research methodology in Appendix 1.

Selecting Cities

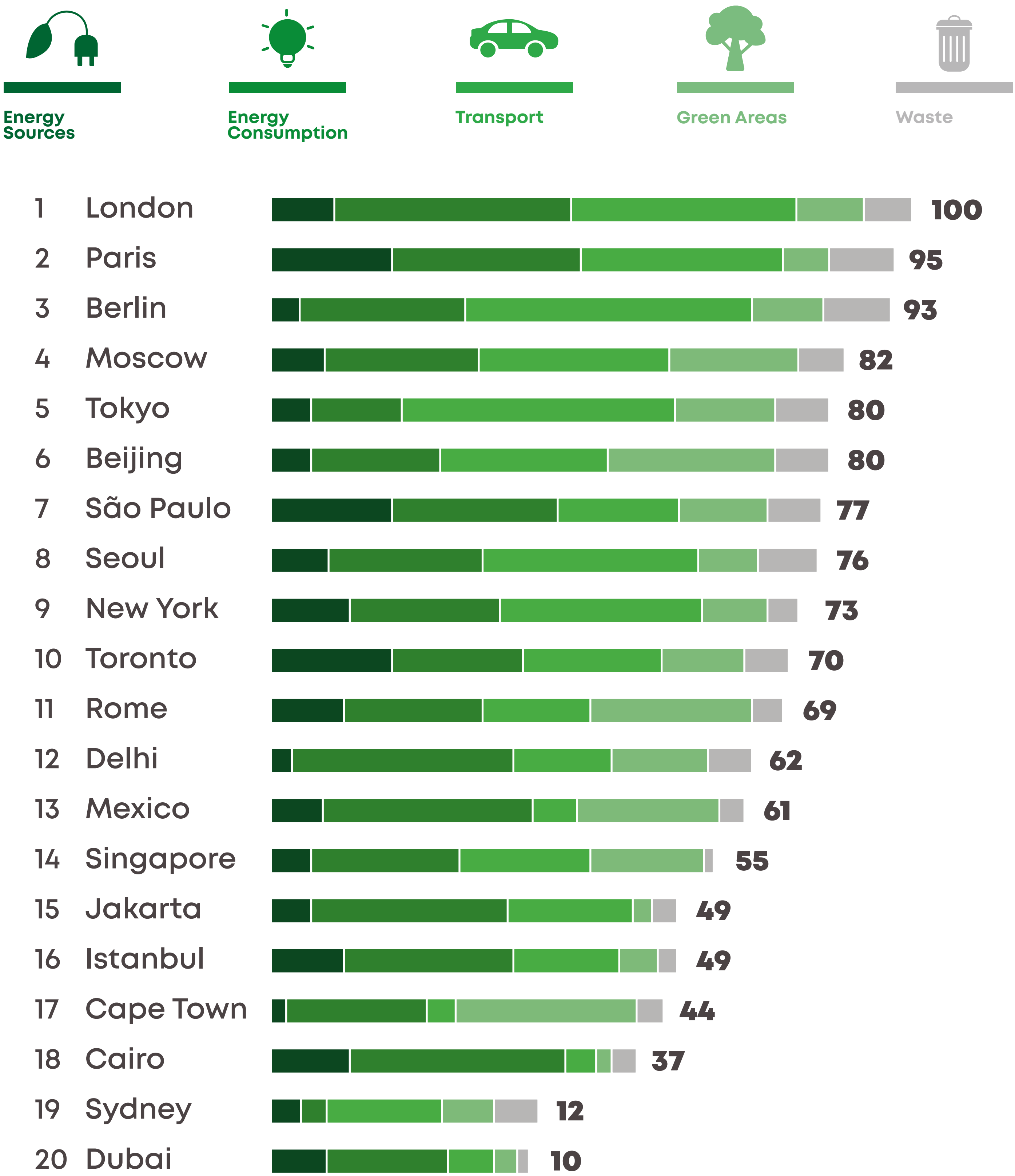
The research focuses on 20 major cities around the world that are leaders in terms of both population and gross regional product.

The importance of having equal representation of cities in developed and developing countries,[1] as well as the coverage of various regions (Africa, Asia, Australia and Oceania, Europe, Latin America, North America, and the Middle East) have been taken into consideration in the selection process.

[1] *According to the UN M49 classifiation*

Final Results

Consolidated Ranking



Leader Cities

London has become **the top-rated city**. The capital of the United Kingdom secured first place thanks to strong results in each of the categories, hitting the top five in both Energy Sources and Transport.

The United Kingdom (and London) is successfully moving away from coal: over the past 10 years, its consumption has decreased by 90% [9]. In addition, it is promoting renewable energy sources (RESs): according to the data presented to the CDP, the UK produces 23% of all the energy it consumes from renewable sources, while London plans to reach 15% of RESs by 2030.

Ecofriendly transport is widely used in London: there is an extensive underground network and well-developed infrastructure for bicycles, and electric buses are quite common [10]. In addition, a significant proportion of its residents do not use their private cars for daily transportation; among other things, this has been facilitated by restricted entry zones for vehicles that have a negative impact on the environment [11, 12]

Paris came in second; its high position has been secured by great performance in Energy Sources *(thanks to the use of nuclear and RESs)* and Transport.

#1 London

In other areas, though, the city comes in closer to the middle of the ranking. Paris is only ninth in the category of Waste: the city generates a large amount of municipal solid waste (MSW) per capita. However, most of the waste is incinerated or recycled, rather than sent to landfills.

Berlin, another European capital, **ranked third**.

It performed well in the categories of Energy Consumption, Transportation, and Waste. **The city is the most energy efficient among all ranked cities in the developed countries**, which may be due to both the high environmental awareness of its residents and economic disincentives in the form of high energy prices [13, 14].

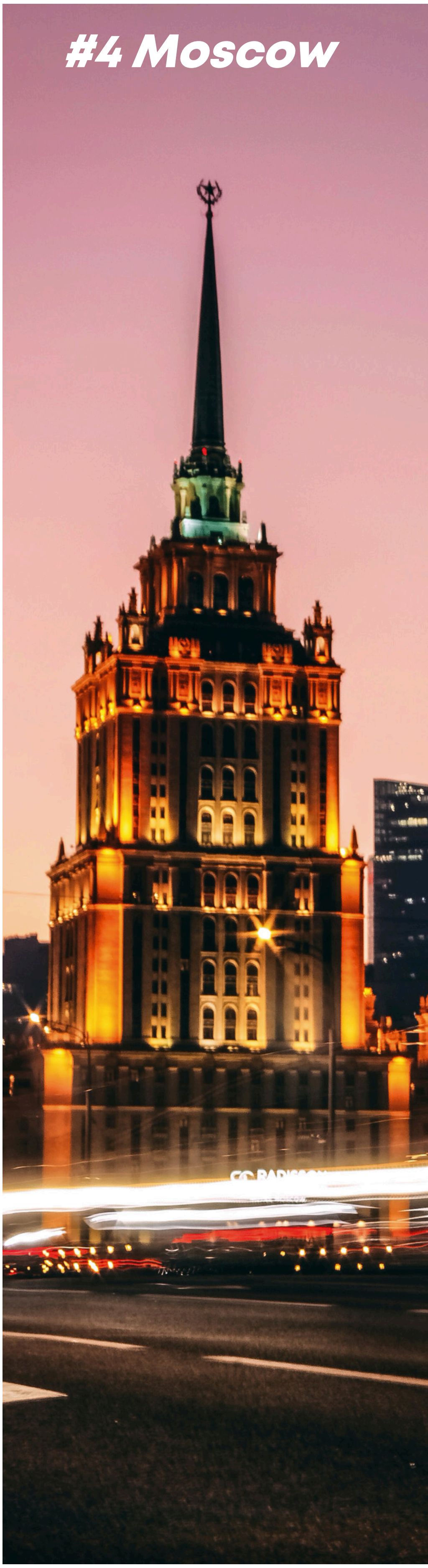
Berlin's position in the overall ranking was affected by a low score in the category of Energy Sources, with a significant share of the city's energy supply still coming from coal generation.

Clean means of transport are widely utilized in Berlin: about a quarter of residents use bicycles to commute on a regular basis

Moscow ended up in the fourth position thanks to high scores in Transport and Green Spaces. The city has an extensive system of clean urban transport (metro and electric buses), and the authorities continue doing a lot to improve it, with new metro lines being built [15], and the bus fleet being regularly replenished with environmentally friendly vehicles [16]. **Green spaces, including parks, squares and forests, account for about 50% of the city's area.**

The capital of Russia showed relatively low results in Waste: it generates a significant amount of MSW, with only five ranked cities having higher mass of MSW per inhabitant than in Moscow.

Clean transport in Moscow is well-developed, and about 50% of city area is covered with green spaces



Tokyo rounded out the top five, coming in first in Transport and second in Waste. Tokyo's public transport system (especially its subway) is renowned worldwide for its efficiency [17]. Tokyo's success in waste management is due to the city government's systemic measures to promote the 3R principle: reduce, reuse, and recycle [18].

However, the Japanese metropolis is located closer to the bottom of the ranking in areas related to Energy Sources and Consumption: its energy consumption is relatively high and is supplied predominantly by burning fossil sources (natural gas and coal).

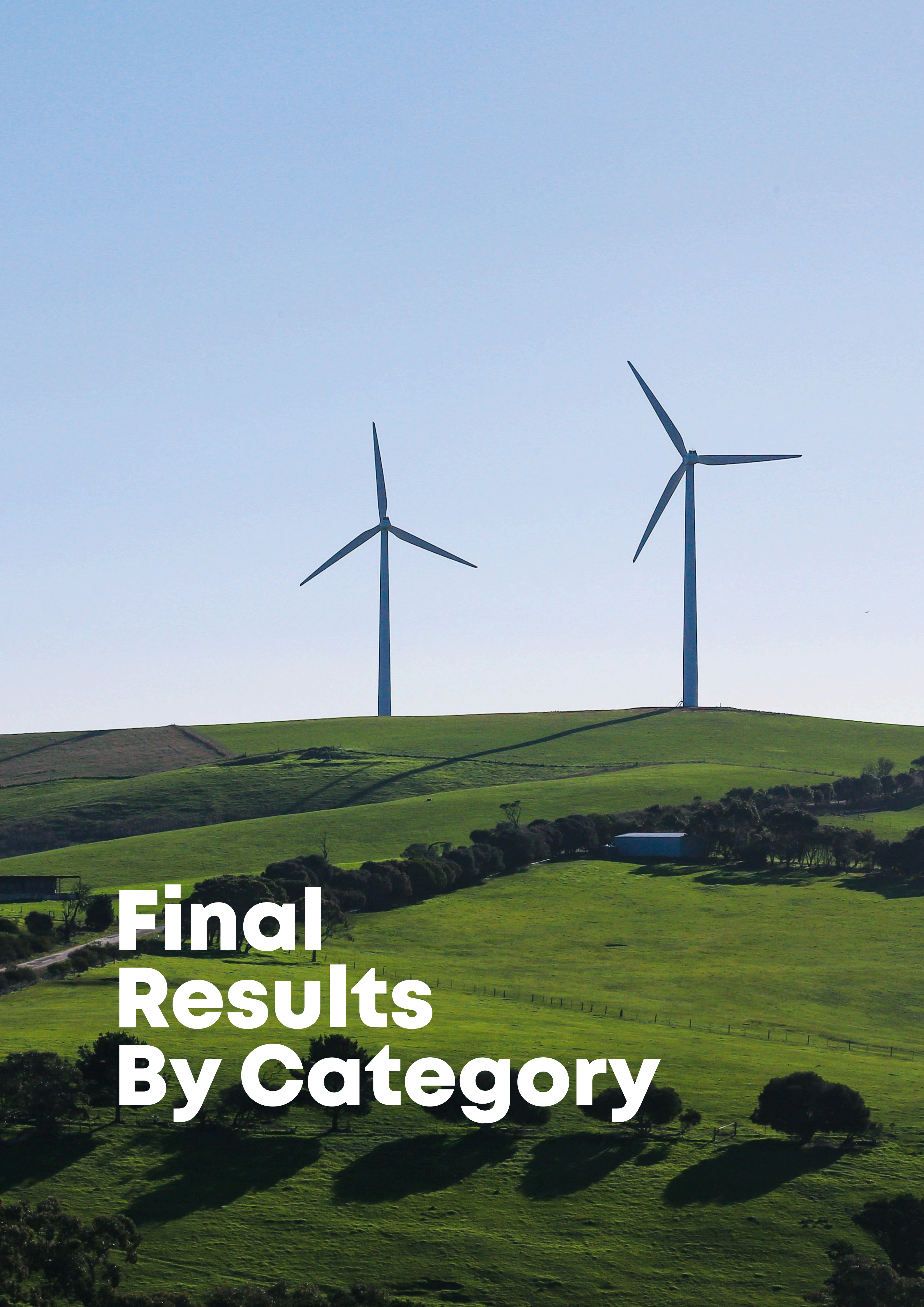
Beijing ranks sixth, with high scores in Transport (a developed subway system and a large number of clean buses), Waste (there is practically no disposal of urban waste in landfills) and Green Spaces and low scores in Energy Sources and Energy Consumption.

Very little MSW is disposed of in a landfill in Beijing

São Paulo comes in seventh. Brazil's largest city performed well in Energy Sources, with the highest share of hydropower in electricity generation among the 20 cities, but ranked below 10th when compared against other cities in Transport and Waste.

A significant share of the electricity consumed in São Paulo is produced in hydroelectric power plants

Seoul, New York, and **Toronto** took eighth, ninth and tenth places, respectively. Each of these cities ranked in the top 5 in one of the categories: Seoul in Waste, New York in Transport, and Toronto in Energy Sources.



Final Results By Category

Paris

Most of the electricity consumed in Paris is generated outside the city, so its energy consumption structure is largely defined by the national energy system, where a significant part of generation comes from nuclear power. Still, the local government is taking measures to increase the share of renewable sources in the city's energy balance. Since 2016, all electricity purchased by the municipal authorities for street lighting and power supply of municipal buildings has been produced from renewable sources [22]. Electricity suppliers contracted by the city are obliged to provide certificates confirming that the amount of energy produced from renewable sources can cover the amount purchased by the city authorities.

In addition, the municipal area of Paris is implementing a large-scale program to be completed by 2030 to develop its own generating capacity based on renewable energy [23]. The program, at a cost of 46 million euros, is expected to double the amount of energy produced from RESs within the region and increase the share of energy from renewable sources to 40% of total consumption.

Energy Sources

The **power generation sector** is one of the **largest contributors to greenhouse gas emissions** [19]. Switching to cleaner energy sources is a key challenge for the world's megacities.

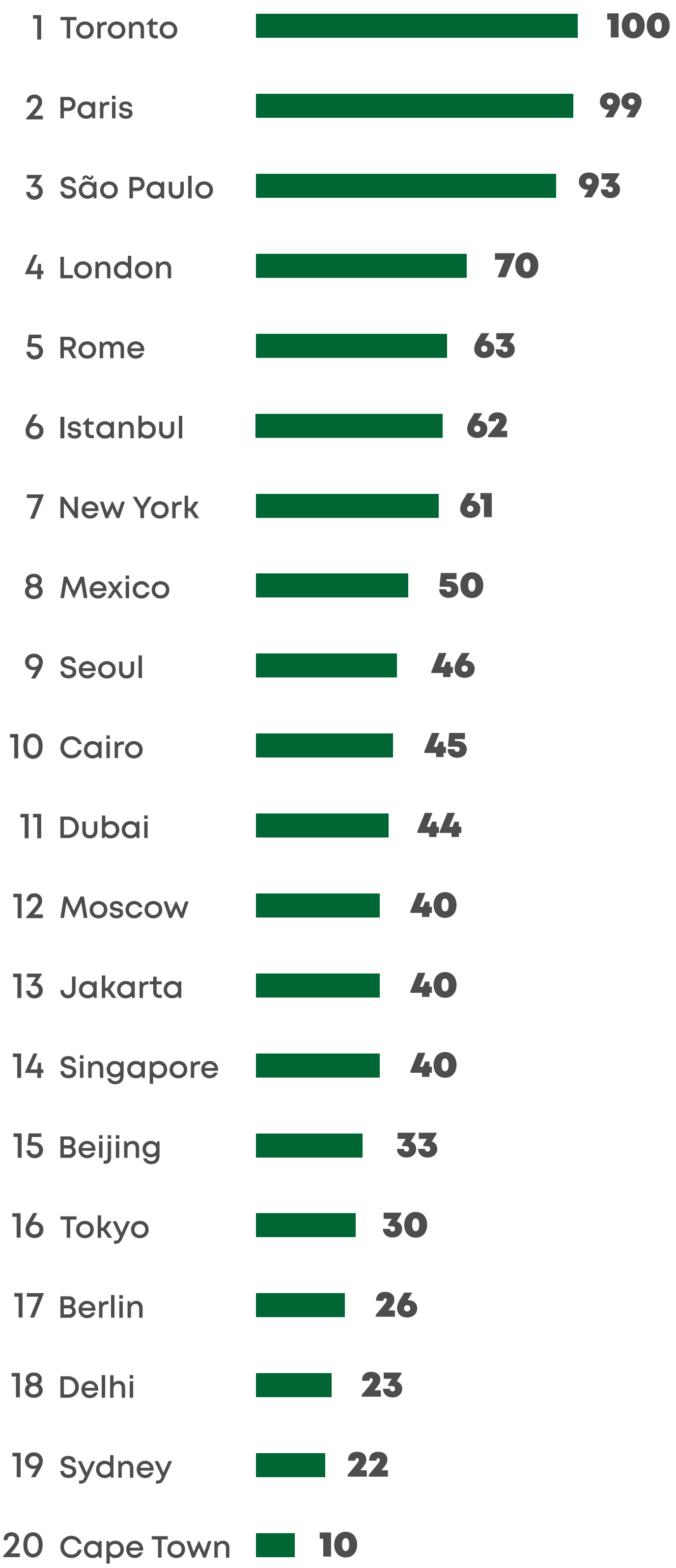
The research compares the energy consumption mix of cities in terms of carbon intensity: the cleaner the energy sources, the higher the score[1]

Due to data availability constraints, in some cases national-level energy consumption mix is used to evaluate individual cities. For instance, Paris and London, both ranking high in the category, are evaluated on the national level data. These cities import most of the electricity they consume from other regions, so their sources of energy are largely defined by the structure of the country's overall energy system.

Thus, only 5% of the electricity consumed in the region of Paris is produced on its territory [20], with the balance supplied from other regions of France. The energy system of London is organized in a similar way: the city is supplied with electricity generated by power plants located outside [21].

[1] *For the purposes of the research, clean energy sources include RESs (solar, wind, hydro, etc.), and nuclear energy, the production of which does not result in greenhouse gas emissions*

City Ranking: Energy Sources



São Paulo

About 60% of power generated in the state of São Paulo is produced from RESs [24].

A large proportion of energy is generated by hydro and biomass power plants (mainly using sugarcane waste called bagasse). Today, São Paulo has 128 hydro power plants and 233 thermal power plants that use biomass as fuel. Together, they account for almost 90% of the state's generating capacity [24].

City authorities have placed emphasis on developing solar energy. Since 2007, São Paulo has had a law requiring all new buildings with four or more bathrooms to be equipped with solar water heaters providing at least 40% of the energy required to heat the water [25].

Berlin

Berlin, the city with the highest ranking in this category among all cities in developed countries, was one of the first cities to introduce an energy efficiency retrofit program based on energy service contracts. Later, other cities followed suit; in particular, a similar REFIT program has been successfully operating in London since 2010, and it is expected to be completed in 2025 [27].

In 1996, the Government of Berlin, jointly with the Berlin Energy Agency (BEA), launched a mechanism to attract private funding for energy-efficiency retrofits of public buildings [28] based on energy service contracts between building owners and energy companies. Such contracts require companies to bear the cost of the upgrades, which is then reimbursed by the owner from a portion of their savings on utility bills over the term of the contract (usually 8–12 years).

The BEA acts as the main coordinator at all stages. Among other things, it selects buildings that require modernization, prepares tender procedures, evaluates bids from energy service companies, monitors the process and results, and helps the energy service companies get bank loans.

Over 1,400 public buildings have been renovated under this program. Energy costs have fallen on average by 26%, and the reduction in GHG emissions is estimated at 70,000 t annually [28].

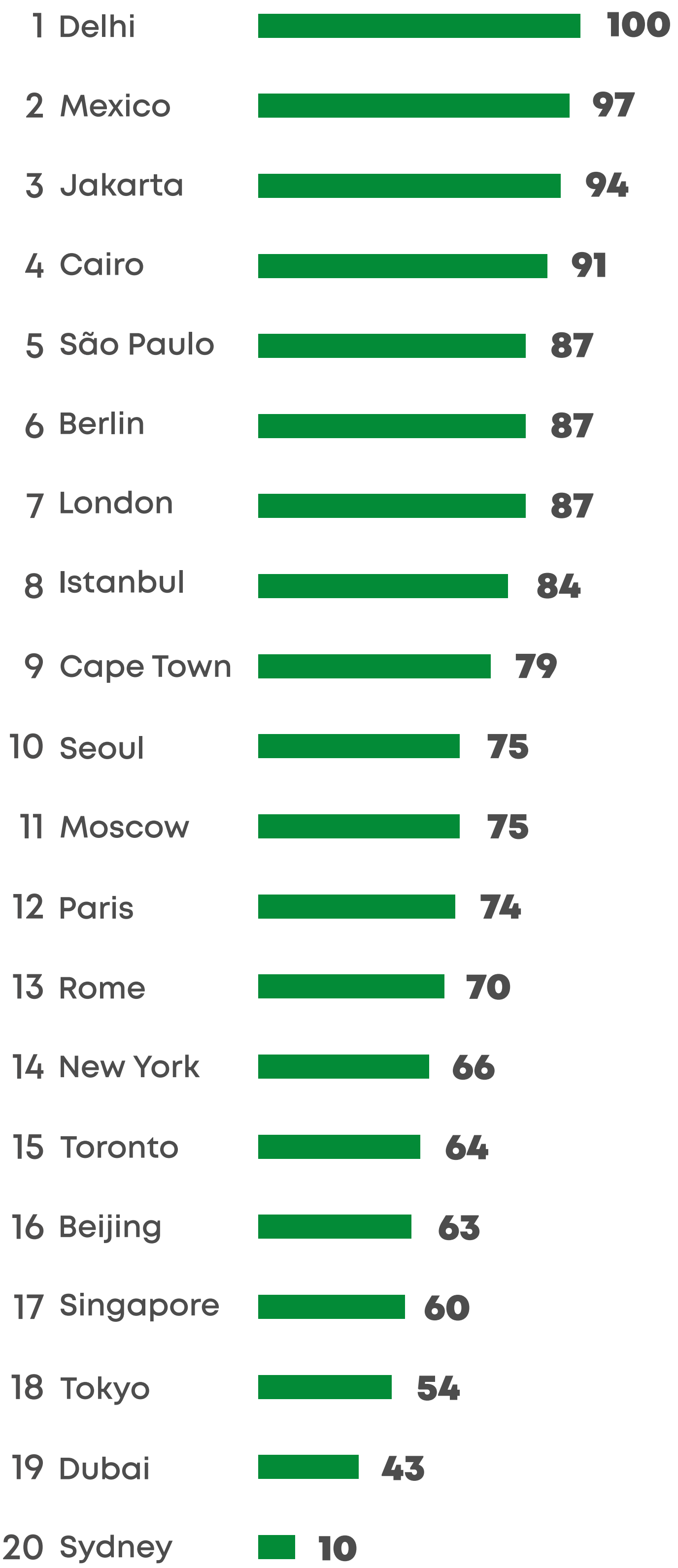
Energy Consumption

The ability of cities to switch to clean energy sources may be limited by factors beyond their control. The potential for solar, wind, and hydropower generation is largely determined by the geographical location of a city and its climate. If cities cannot meet the energy demand from clean sources, they can **reduce the impact on the climate by reducing energy consumption** [26].

To assess the efficiency of their energy consumption, cities were evaluated on the basis of heat and electricity consumption, adjusted for the average annual temperature

Due to data availability limitations, the research focuses on electricity and heat consumption, which comprises only part of the total energy consumption of a city.

City Ranking: Energy Consumption



Transport

Transport systems account for about a third of greenhouse gas emissions in cities [29], and their impact on climate change largely depends on the means of transportation its residents prefer.

Clean means of transportation are not equipped with internal combustion engines. Instead of fossil fuels they are powered by electricity or hydrogen fuel cells. Such vehicles do not emit greenhouse gases during operation.

In this research, the following are considered clean means of transport: metro and railway, trams, zero-emission buses, private electric cars, bicycles and walking.

In this category, cities are measured by the availability of clean means of transport. The cleaner the city transport is, the higher the score is received

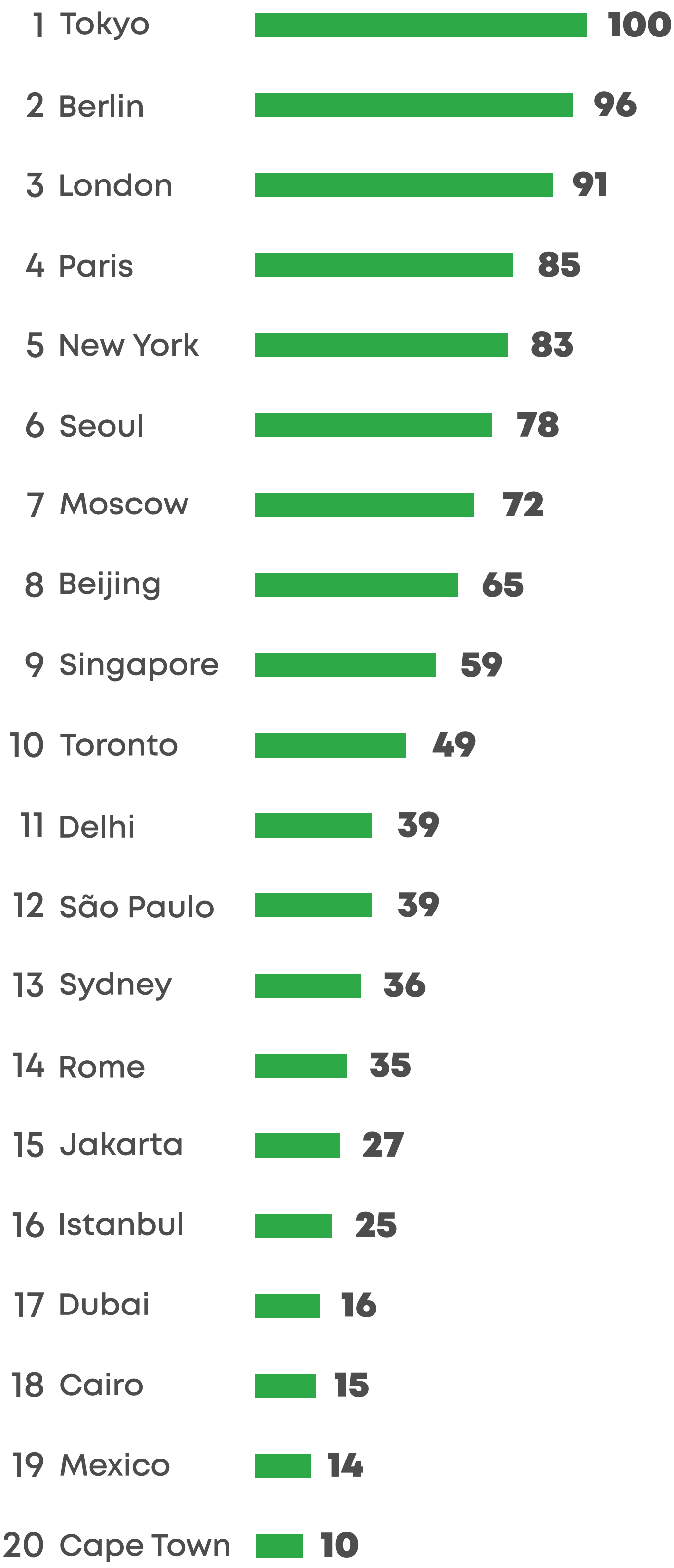
Beijing

Beijing authorities offer market-based incentives encouraging residents to move away from private cars in favor of more environmentally friendly transportation. The system is based on digital technologies, a MaaS platform (Mobility-as-a-Service), which integrates various types of municipal transport. It was developed by the Beijing government in collaboration with major online mapping services.

Since 2020, the platform has hosted a program that rewards users for moving around the city by public transport, bicycle, or walking [30]. The distance commuted by a registered user in such a manner is converted into carbon credits. These are conventional units that show the amount of carbon emissions reduced through the choice of alternative means of transportation to a car. Credits can then be used to donate to charity, pay for public transport, purchase discount coupons or subscribe to online services.

In June 2023, the number of platform users participating in the reward program exceeded 3.5 million people. According to the estimates of the city authorities, the program has helped reduce carbon dioxide emissions by almost 400 000 t in the 3 years it has been used [31].

Cities Ranking: Transport



Tokyo

The government of Tokyo has a whole range of measures to decarbonize the municipal transport system [32].

One priority is promoting hydrogen fuel cell vehicles.

Work is underway in partnership with private companies to create appropriate infrastructure, and there is a campaign to win public support for hydrogen vehicles. A museum has been created to promote the use of hydrogen, where visitors learn about the benefits of this type of fuel and can even try to fill their car with it.

Moscow

Moscow is one of the leaders among European capitals in terms of the number of urban green spaces that have a protected status. There are 147 specially protected natural areas (SPNAs) within city limits, with a total area of more than 19,800 ha [36]. Most of these protected areas are classified as those of regional importance, which means they have been created by the city government.

The SPNA status implies that any activity that harms natural objects, flora and fauna, is prohibited within the boundaries of such a territory. Such land cannot be transferred to private or corporate ownership, and the activities that are allowed on the land are subject to a list of permitted activities, which is defined for each particular area taking into account its natural features. Moscow has established a legislative ban on reducing the size of such protected areas or abolishing them.

The number of urban protected areas has been constantly increasing. In 2020–2023 alone, 40 territories with a total area of more than 2,300 ha were given protected status [36].

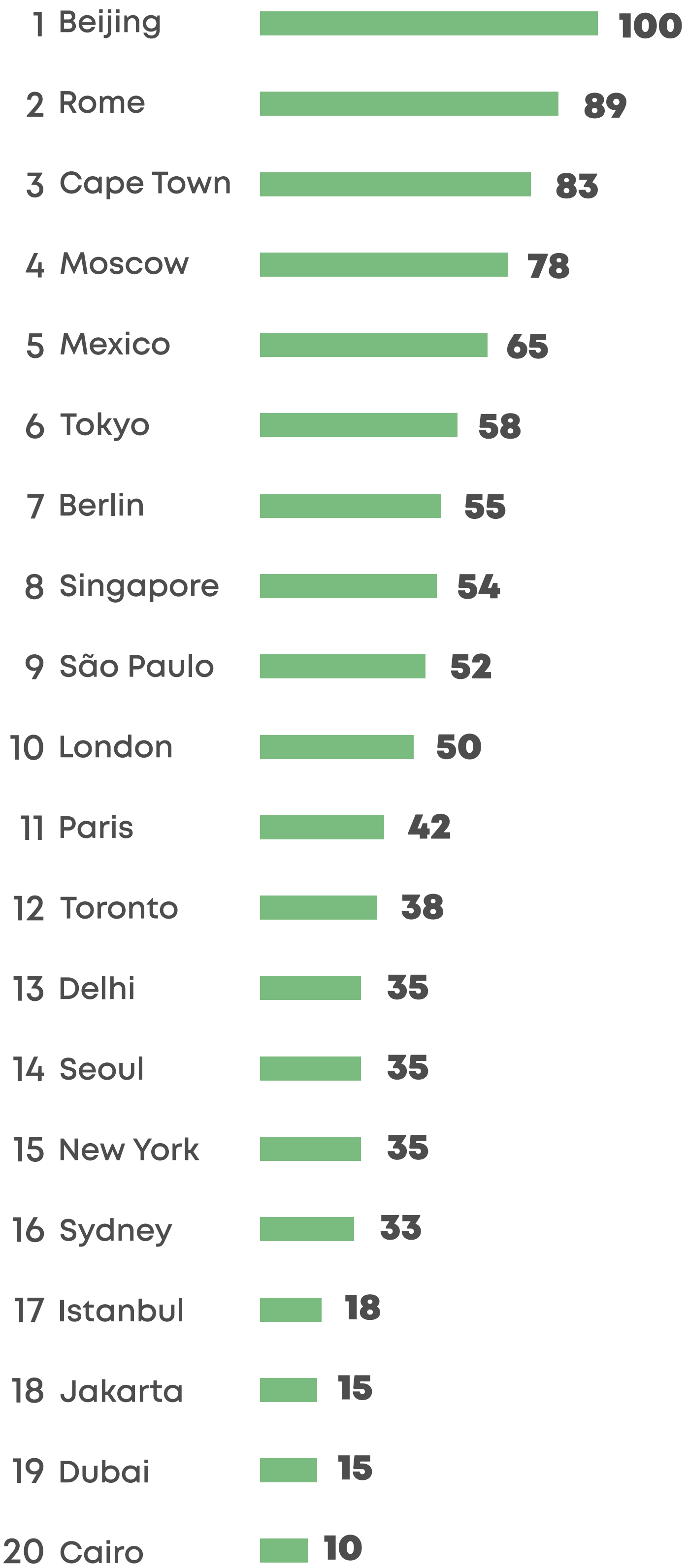
Green Spaces

Urban green spaces have significant potential as natural tools for carbon dioxide capture and storage [33]. By creating more green spaces, a city can offset greenhouse gas emissions that remain despite all the measures taken under other climate programs.

To compare cities in this category, the ratio of the area of green spaces located within its administrative boundaries to the total city area is calculated for each city based on Google Maps data. Cities with a higher proportion of green spaces score higher

The current assessments of the absorptive capacity of urban green spaces differ greatly, because it depends on many factors, including climatic conditions and the composition and density of green spaces [34]. Studies show that in some cases green spaces can absorb more than 20% of the total urban greenhouse gas emissions from fuel combustion [35]. Moreover, the effectiveness of green spaces as a mitigation tool can be enhanced through urban planning. For example, trees planted near buildings are a barrier to wind and sunlight, which helps to reduce the need for energy resources for heating and air conditioning [35].

City Ranking: Green Spaces



Beijing

China has celebrated National Tree Planting Day every year since the 1980s, with residents and political leaders planting trees with their own hands in city streets and parks.

In 2022, Beijing authorities allocated more than 70 ha of land for the planting of new trees for that day. The process was accompanied by cultural events, where residents could learn about the role of green spaces in the ecosystem of their city and ways to change their lifestyle to reduce its impact on the environment and climate.

The number of trees in Beijing has more than doubled since this holiday was introduced [37].

Waste

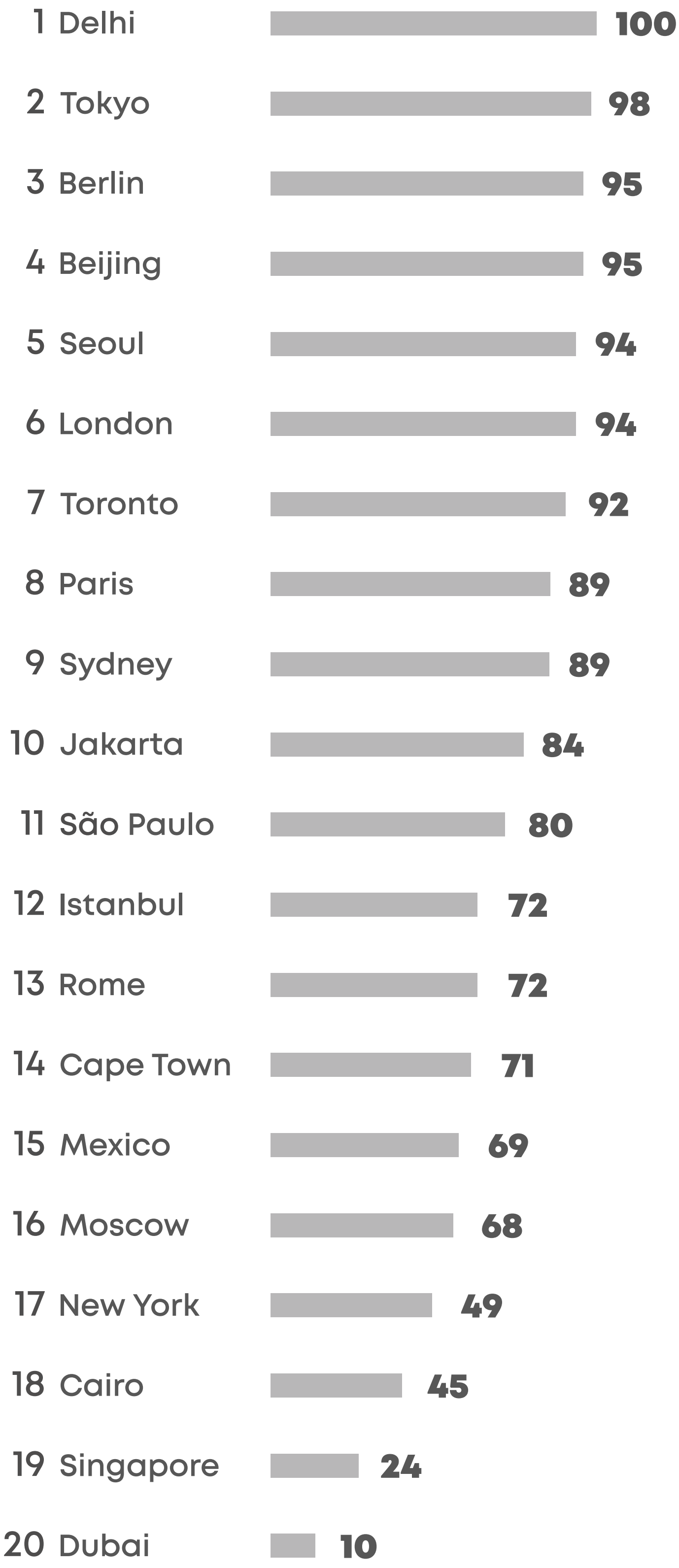
As MSW decomposes, it releases **methane** [38], a **greenhouse gas with a global warming potential 30 times higher than that of carbon dioxide** [1]. Despite the relatively small share of this gas in the total mass of anthropogenic emissions [39], achieving carbon neutrality goals is impossible without taking measures to limit waste generation. Therefore, reducing waste is an important part of the urban climate agenda.

In terms of its impact on climate, it is not only the total amount of waste produced by the city that is important, but also how it is managed. Recycling and reusing waste can significantly reduce greenhouse gas emissions, while waste disposal in landfills increases them [38].

This research assesses both of these aspects: waste generation and waste management.

To compare cities, per capita indicators were used, for both the total mass of MSW production and the mass of waste disposed of in landfills

City Ranking: Waste



Seoul

Since the mid-1990s, South Korea has had a system of waste disposal fees, where people have to pay a certain amount of money in proportion to the amount of waste they generate [40].

This system has made it possible to significantly reduce the volume of waste and increase the amount of recycled waste. In particular, the proportion of recycled waste in Seoul increased by 30% during the functioning of the system, and the amount of generated waste decreased by 8% in the very first year of the program alone [41].

The Seoul government did not stop there, launching a city program to extract metals from electronic waste in 2009 [42]. There is a center to receive scrap consumer electronics, office equipment and mobile phones, where they are disassembled into parts, with the metals then sent for further processing.

The program provides financial incentives for university students: the profits received from the recycling of their mobile phones are paid to students in the form of a stipend increase.

According to the estimates of the Seoul authorities, the program helped reduce greenhouse gas emissions by 120,000 t from 2009 to 2021 [43].

Points Scored by Cities in all Categories

City	Energy Sources	Energy Consumption	Transport	Green Spaces	Waste
1 London	70	87	91	50	94
2 Paris	99	74	85	42	89
3 Berlin	26	87	96	55	95
4 Moscow	40	75	72	78	68
5 Tokyo	30	54	100	58	98
6 Beijing	33	63	65	100	95
7 São Paulo	93	87	39	52	80
8 Seoul	46	75	78	35	94
9 New York	61	66	83	35	49
10 Toronto	100	64	49	38	92
11 Rome	63	70	35	89	72
12 Delhi	23	100	39	35	100
13 Mexico	50	97	14	65	69
14 Singapore	40	60	59	54	24
15 Jakarta	40	94	27	15	84
16 Istanbul	62	84	25	18	72
17 Cape Town	10	79	10	83	71
18 Cairo	45	91	15	10	45
19 Sydney	22	10	36	33	89
20 Dubai	44	43	16	15	10

City Features

Europe

London, #1

- The city has an extensive green transport system: the Tube and bicycle lanes
- 99% of solid waste is incinerated or recycled
- The London city government is implementing large-scale energy efficiency retrofit programs for residential and commercial buildings [44]

Paris, #2

- Most of the energy consumed by the city is produced from RESs or nuclear power plants
- Less than 5% of solid waste is disposed of in landfills
- More than 60% of residents use clean means of transport

Berlin, #3

- Clean means of transport are widely available, and more than a quarter of the residents regularly use bicycles to move around the city
- Less than 1% of solid waste is disposed of in landfills
- There are many green squares and parks and several forests covering an area of several thousand hectares

Moscow, #4

- About 50% of the city area is covered by green spaces
- Moscow is doing a lot to promote public transport: in 2023 it completed the construction of the longest metro circle line in the world [45]

Rome, #11

- Rome is one of the greenest urban centers in this research, with more than 60% of its territory covered by green spaces

Africa

Cape Town, #17

- Green spaces account for roughly 58% of Cape Town's territory

Cairo, #18

- The city consumes a relatively small amount of energy, about 2000 kWh per person per years

Asia, Australia and Oceania

Tokyo, #5

- Although relatively small, the Tokyo subway is very efficient, carrying more than 3.9 billion passengers per year [46]
- Residents of the city produce a relatively small amount of solid waste per capita (304 kg per year), 94% of which is incinerated or recycled
- More than a third of the city's territory is covered by green spaces

Beijing, #6

- Less than 10% of solid waste is disposed of in landfills
- Electric buses make up more than 50% of the municipal bus fleet

Seoul, #8

- Seoul's waste management system, based on segregated collection and volume-based pricing, helps reduce the amount of solid waste and improve recycling performance [40]
- The city has an extensive mass rapid transit system, which is regularly recognized by various international publications as one of the cleanest and most convenient in the world [47]

Delhi, #12

- The per capita energy consumption in Delhi is several times lower than the average for the 20 cities in the ranking

Singapore, #14

- More than 60% of the city residents use public transport for regular trips, and only 11% own a car [48]. This low figure is a result of the government's policy to limit the use of private motor vehicles, including a system of permits for the purchase of new cars [49]

Jakarta, #15

- Jakarta generates about 290 kg of municipal solid waste per capita per year, one of the lowest values among the ranked cities

Istanbul, #16

- The mass of solid waste generated by Istanbul is about 400 kilos per person per year, which is below average for these rankings

Sydney, #19

- Almost 10% of the energy the city consumes is generated by solar power plants, the highest percentage among all cities in the ranking

Dubai, #20

- All city energy requirements are completely met by natural gas and solar power plants

North and South America

São Paulo, #7

- The main sources of energy consumed by the city are hydroelectric power plants and biomass. They account for more than 70% of total energy consumption
- The city consumes moderate amounts of energy

New York. #9

- More than a third of the city's residents use the subway for their daily commute
- About 30% of the energy consumed by the city is produced from clean sources, among which nuclear power prevails

Toronto, #10

- More than 80% of electricity consumed by the city is generated by nuclear and hydroelectric power plants
- Toronto has about 300 kg of solid municipal waste generated per person per year, which is less than most cities in the ranking

Mexico, #13

- Green spaces in Mexico City occupy about 50% of the total area of the city

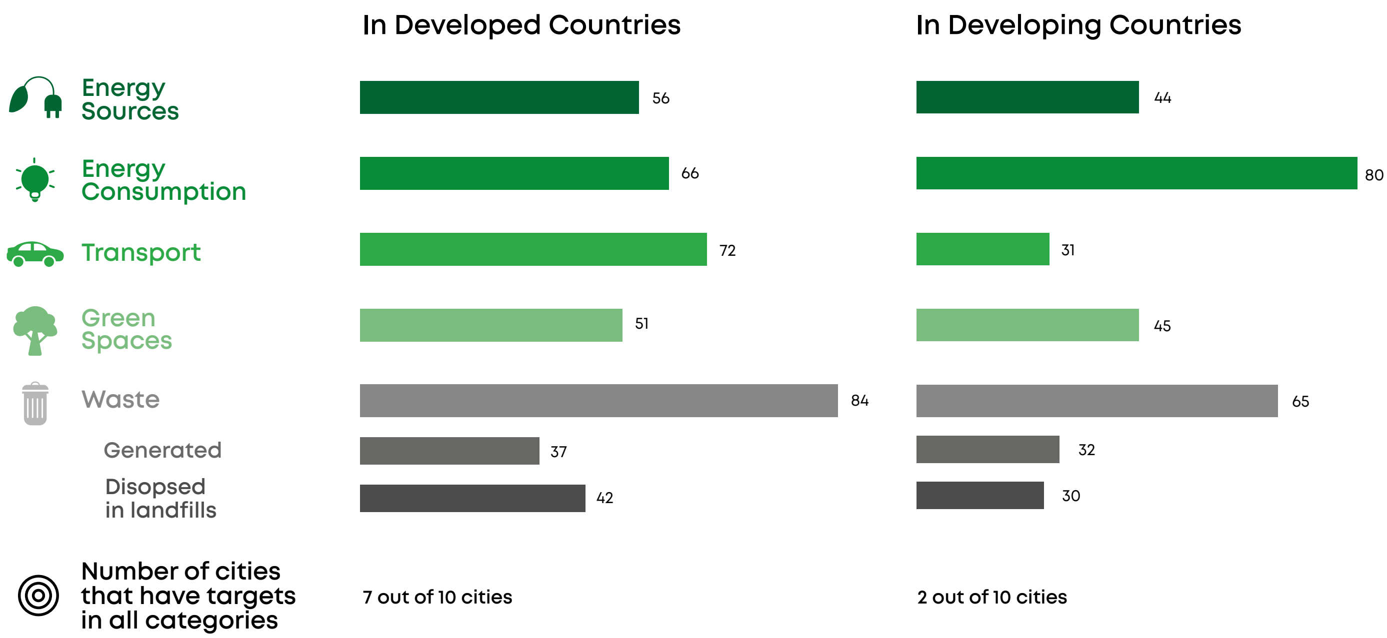
Trends

Cities in Developed and Developing Countries

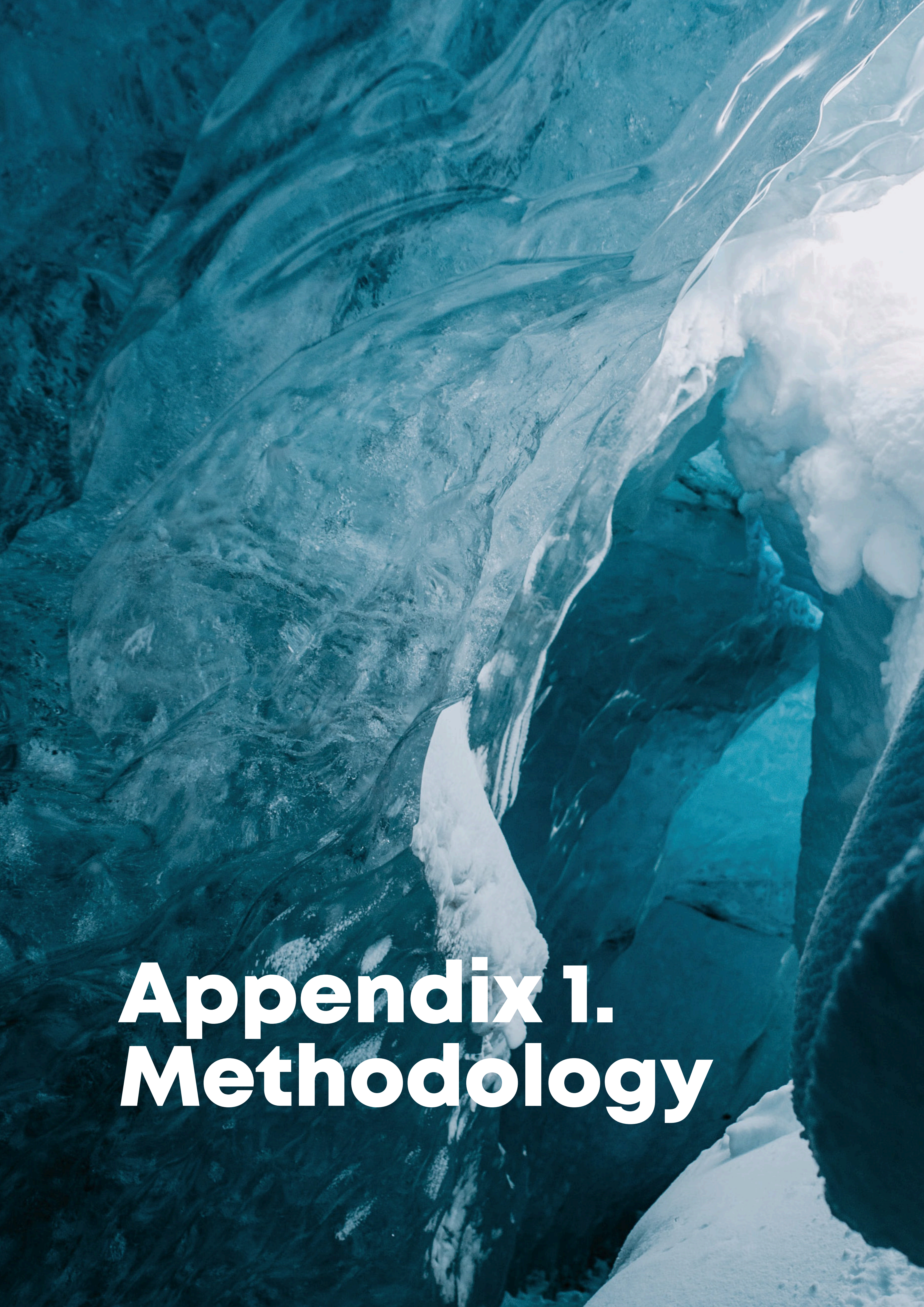
Our research has found some common features among the cities located in developed and developing countries.[1]

- Cities in developed countries show better performance in **clean energy sources**, but this indicator largely depends on the geographical location of the city and the national energy program.
- On average, cities in developing countries **consume energy** more economically than cities in developed countries.
- Cities in developing countries have a less developed **public transport systems** (including clean public transport).
- The average **proportion of green spaces** in total city area is similar in cities in developed and developing countries and equals 33% and 29%, respectively.
- The mass of generated waste does not differ much between cities in developed and developing countries, but cities located in developed countries perform better in terms of **waste management** and tend to increase the share of recycled waste and reduce the mass of waste sent to landfill.
- In cities in developed countries, **long-term climate planning** is more common. Most cities have goals and targets to achieve carbon neutrality, as well as targets in all areas considered in the research (increasing the share of renewable energy, switching to clean transport, etc.).

Average Scores of Cities in Developed and Developing Countries



[1]*According to the UN M49 Classification*



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 targets set by city governments as defined in and made public through their climate policies or other official documents.

Cities are compared according to 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: electricity consumption by generation sources (coal, oil and petroleum products, natural gas, nuclear, other nonrenewable energy sources, RESs), GWh

Period: 2019–2021, depending on data availability

Note: 17 out of 20 cities in the ranking provided data to the CDP database in 2022, and that information was used in the research. Three out of these 17 cities provide national-level energy mix.

For the 3 cities that did not provide data to the CDP, national level data of the International Energy Agency was used.

Adjustment factor: targets to raise the share of RESs

Methodology to calculate the initial score:

1. Each energy source 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 [50] to the volume of its combustion [51]. The generation of nuclear energy and energy from RESs does not have greenhouse gas emissions [52,53], 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 and thermal energy consumption per capita per year, kWh, adjusted for the average annual temperature.

Note: Due to data availability limitations, the research focuses on electricity and heat consumption, which comprises only part of total energy consumption of a city.

There are other ways energy resources like coal, oil, and gas can be used inside the city 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 and heat [54].

Period: 2019–2021, depending on data availability

Note: During the preparation for the research, the latest available data on electricity consumption by the ranked cities were collected: for 11 cities, the last available year was 2021; for 3 cities, 2020; and for 6 cities, 2019.

2020 was the year of the COVID-19 pandemic [55], when many countries imposed restrictive measures and lockdowns and partially suspended production, etc. [56]. We analyzed the impact of COVID-19 on electricity consumption in the world and in the ranked cities to determine the possibility of making a fair comparison between cities with the most up-to-date data in 2020 and cities with the most up-to-date data in other years.

According to the International Energy Agency, in 2020, global electricity consumption decreased by 1% compared to 2019 [57].

Data on electricity consumption dynamics in 2020 relative to 2019 available for the ranked cities showed a slight drop in electricity consumption (about 4% on average) in most cities and a slight increase (4%) in one of them.

The analysis did not produce conclusive evidence that the COVID-19 pandemic made a significant impact on electricity consumption, so, for the purposes of the research, the latest available data for any particular city were used without any adjustments.

Adjustment factor: targets to reduce energy consumption

Methodology to calculate the initial score:

1. Per capita electricity consumption is calculated as follows: the electricity consumption data by the city in the latest available year is divided by the city's population in the same year.

2. The thermal energy consumption is calculated: since in most cases the data on thermal energy consumption are available at the national level only (data from the International Energy Agency [58]), an additional calculation is made to measure thermal energy consumption

specific to a particular city. In cities where a central heating system is used, the value of thermal energy consumption at the national level is multiplied by a ratio of thermal energy consumption at city level to national level (such ratio is obtained when both city and national level data are available) and added to the indicator obtained in step 1.

3. To make sure comparable values are used for each city, the data from step 2 are adjusted for the average annual temperature: the actual consumption of electricity and thermal energy is divided by an "optimal energy consumption factor" (based on an equation showing the relationship between energy consumption and average annual temperatures in high- and middle-income countries according to the International Energy Agency [58]). The resulting value shows the city's energy efficiency adjusted for climate.

4. Each city is assigned from 10 points to 100 points in proportion to the value obtained in step 3 (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: types of transport used by the residents on a daily basis, by type (metro, tram, bus, car, bicycle, pedestrians), %

Period: as of March 2023

Adjustment factor: targets to increase the share of clean transport

Methodology to calculate the initial score:

1. For each city, the proportion of the residents using clean transport or human-powered mobility for daily commute is calculated. For calculation purposes, clean transport includes metro, tram, bicycle, walking, and (partly) buses and private cars.

To account for clean buses, the share of the population using buses is multiplied by the share of clean buses in the city.

To account for private cars, the share of the population using private cars is multiplied by the share of private electric cars in the country.

Note: National level data are used to calculate the share of clean private cars due to the lack of relevant data at the city level.

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

Period: as of March 2023

Adjustment factor: targets to expand/ prevent the reduction of area of green spaces

Methodology to calculate the initial score:

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

2. The ratio of green space area to the total area of the city is calculated: the value obtained in step 1 is divided by the value of the city area.

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: 2020–2021, depending on data availability

Basic indicator 2: waste management: mass of municipal solid waste generated by businesses and households disposed of in landfill, kg per capita

Period: 2020–2021, depending on data availability

Adjustment factor: targets to reduce the mass of generated waste or to reduce the proportion or volume of waste that ends up in landfills

Methodology to calculate the initial score:

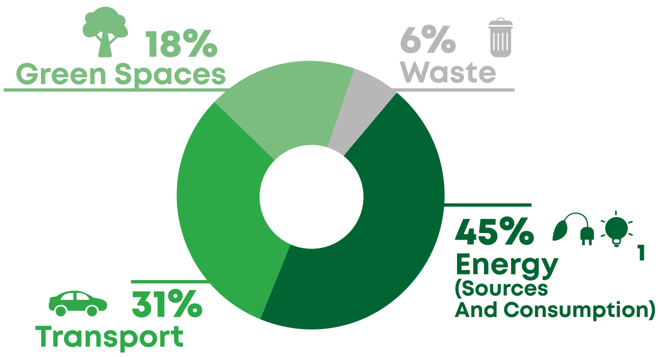
1. Per capita data on the mass of MSW and the mass of MSW disposed of in landfills are calculated: the data on the mass of MSW and the mass of MSW disposed in landfills for the latest available year are divided by the data on the population of the city in the same year.

2. Each city is assigned from 5 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).

3. The values obtained in step 2 for each of the basic indicators are summed up for each city and are normalized to a value between 10 and 100.

Assignment of weights

The following weights are used to calculate the final score:



All categories (except for Green Spaces) represent sectors responsible for greenhouse gas emissions. For the purposes of the research, their weights are calculated based on the structure of emissions as submitted by cities to CDP in 2022 [59] (using the most common methodology, the GCoM CRF reporting framework [60], with contributions from more than 200 cities):

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

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

[1]The weights of Energy Consumption and Energy Sources in the total weight of the Energy sector are distributed as 2/3 and 1/3, respectively, since cities have much more influence over the volume of energy consumption than they have over energy generation sources [61].

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

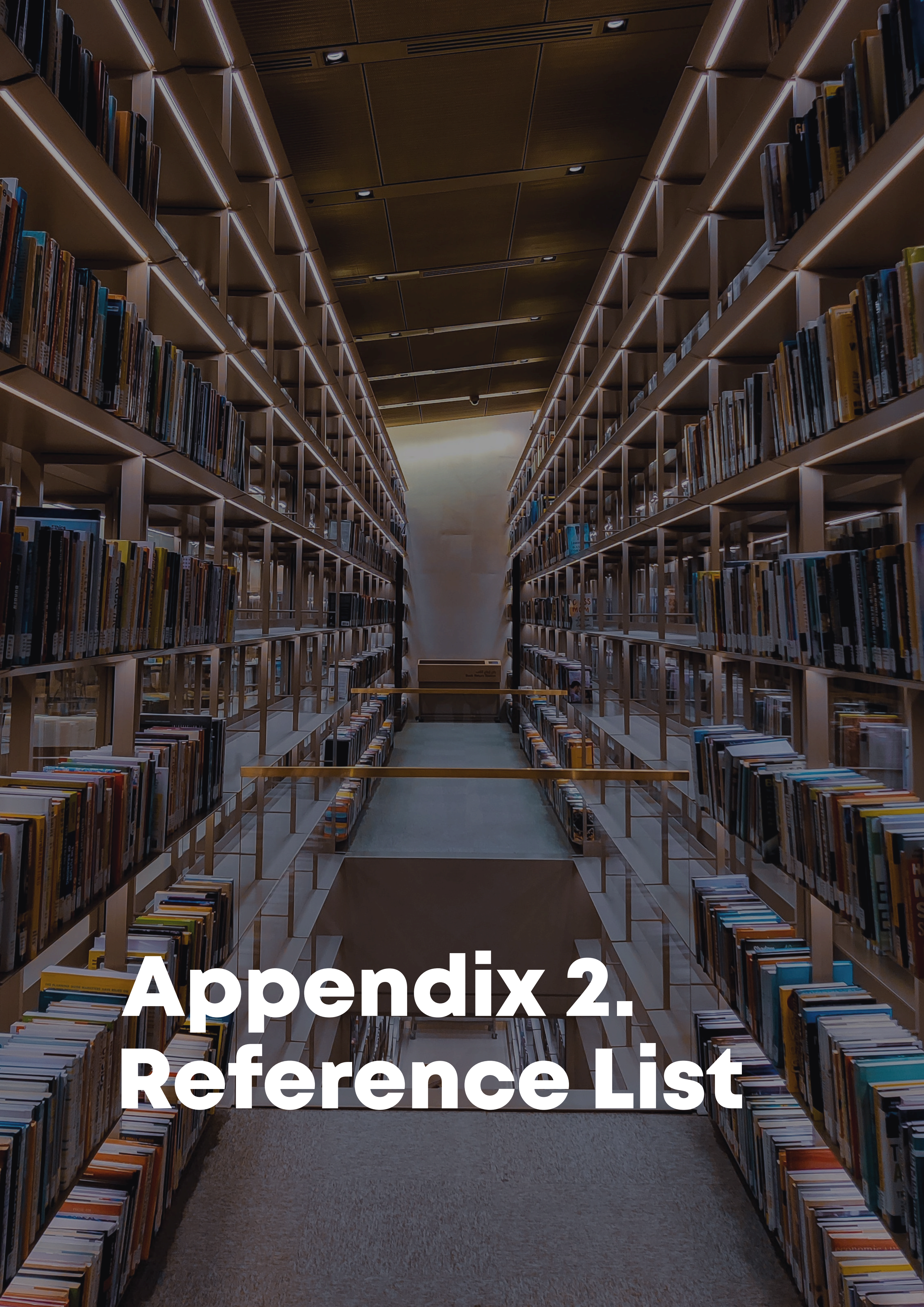
The calculation does not consider greenhouse gas emissions from sectors that fall outside the scope of this research: emissions from the wastewater treatment systems, aviation, etc.

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 [62]. The climate targets of cities suggest that this figure is also relevant for large cities, where the estimates of residual emissions vary from 10% (London [63]) to 20% (Seoul [64] and Paris [65]).

The results of the city ranking using the assigned set of weights have been tested for stability, where the impact of 1 million random sets of weights on the positions of cities in the final ranking has been analyzed.

The stability test has been carried out using simulations that show how the positions of cities in the ranking change when the random sets of weights are “distanced” from the main set of weights.

The simulations have revealed that the positions of cities are stable: for example, if the Euclidean distance between sets of weights does not exceed 10 p.p., the rank correlation coefficient does not fall below 95.



Appendix 2. Reference List

1. IPCC. (2021). Climate Change 2021: The Physical Science Basis. URL: https://report.ipcc.ch/ar6/wg1/IPCC_AR6_WGI_FullReport.pdf
2. United Nations. (2015). Paris Agreement. URL: https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf
3. IPCC. (2022). Climate Change 2022: Mitigation of Climate Change. URL: https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf
4. IPCC. (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. URL: https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Full_Report_HR.pdf
5. IPCC. (2023). Climate Change 2023: Synthesis Report. Summary for Policymakers. URL: https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf
6. UNFCCC. (2021). Seven Ways Cities Can Take Climate Action. URL: https://unfccc.int/blog/seven-ways-cities-can-take-climate-action
7. OECD. (2023). Climate Action. Explore policy solutions by key economic sector. URL: https://www.oecd.org/stories/climate-action/key-sectors/
8. C40 Cities. (2021). C40 Strategic Recommendations guidelines. URL: https://www.c40knowledgehub.org/s/article/C40-strategic-recommendations-guidelines?language=en_US
9. Department for Energy Security and Net Zero. (2023). Energy Trends: UK, October to December 2022 and 2022. URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147249/Energy_Trends_March_2023.pdf
10. Transport for London. (2021). Annual Report and Statement of Accounts. URL: https://content.tfl.gov.uk/tfl-annual-report-2020-21.pdf
11. Transport for London. (2023). Ultra Low Emission Zone URL: https://tfl.gov.uk/modes/driving/ultra-low-emission-zone
12. Transport for London. (2023). Low Emission Zone. URL: https://tfl.gov.uk/modes/driving/low-emission-zone#:~:text=The%20Low%20Emission%20Zone%20(LEZ,every%20day%20of%20the%20year.
13. Berlin.de. (2023). Saving energy. URL: https://www.berlin.de/energie/en/saving-energy/
14. Clean Energy Wire. (2023) What German Households Pay for Electricity. URL: https://www.cleanenergywire.org/factsheets/what-german-households-pay-electricity
15. Moscow Complex of Urban Planning Policy and Construction. (2023). Metro. URL: https://stroi.mos.ru/metro
16. Moscow Mayor official website mos.ru. (2023). Sergei Sobyanin: The electric bus fleet has become one of the largest in the world. URL: https://www.mos.ru/mayor/themes/2299/8887050/
17. Timeout. (2023). Tokyo's public transport system ranked the third best in the world. URL: https://www.timeout.com/tokyo/news/tokyos-public-transport-system-ranked-the-third-best-in-the-world-041323
18. Tokyo Metropolitan Government. (2023). 3Rs. URL: https://www.kankyo.metro.tokyo.lg.jp/en/waste/strategy_3r/index.html
19. International Atomic Energy Agency. (2021). Nuclear Energy for a Net Zero World. URL: https://www.iaea.org/sites/default/files/21/10/nuclear-energy-for-a-net-zero-world.pdf
20. Apur. (2020). Atlas De L'énergie Dans Le Grand-Paris. URL: https://www.apur.org/sites/default/files/atlas_cartographique_schema_directeur_energie_grand_paris.pdf?token=7ubYg7GL
21. London City Hall. (2023). Energy Supply. URL: https://www.london.gov.uk/programmes-and-strategies/environment-and-climate-change/energy/energy-supply
22. Le Monde. (2015). En 2016, une électricité 100 % verte pour éclairer les rues de Paris. URL: https://www.lemonde.fr/planete/article/2015/11/12/en-2016-une-electricite-100-verte-pour-eclairer-les-rues-de-paris_4807736_3244.htm
23. Choose Paris Region. (2023). Renewable Energy. URL: https://www.chooseparisregion.org/industries/Renewable-energy
24. Government of the State of São Paulo. (2022). Balanço Energético do Estado de São Paulo 2022. URL: https://dadosenergeticos.energia.sp.gov.br/portalcev2/intranet/BiblioVirtual/diversos/BalancoEnergetico.pdf
25. Câmara Municipal de São Paulo. (2007). Lei nº 14459 de 03 de julho de 2007. URL: http://leismunicipa.is/datck
26. International Energy Agency. (2023). Emissions Savings. URL: https://www.iea.org/reports/multiple-benefits-of-energy-efficiency/emissions-savings

27. Chmutina, Goodier, Berger. (2012). Potential of Energy Saving Partnerships in the UK: an example of Berlin. Proceedings of the Institution of Civil Engineers: Engineering Sustainability 2013 166:6, 315-319. URL: https://doi.org/10.1680/ensu.12.00015

28. Heat Roadmap Europe. (2018). Business cases and business strategies to encourage market uptake. URL: https://heatroadmap.eu/wp-content/uploads/2018/11/HRE4_D7.11_Business-Cases-and-Strategies_web.pdf

29. C40 Cities. (2023). Transportation. URL: https://www.c40.org/what-we-do/scaling-up-climate-action/transportation/

30. Beijing Municipal Commission of Transport. (2020). The incentive effect of green travel has begun to show, serving a total of 2.45 million people. URL: http://jtw.beijing.gov.cn/xxgk/xwfbh/202011/t20201103_2127960.html

31. The People's Government of Beijing Municipality. (2023). Beijing MaaS travel platform will upgrade new energy vehicle travel and will receive carbon inclusive incentives. URL: https://www.beijing.gov.cn/ywdt/gzdt/202306/t20230630_3150638.html

32. Tokyo Metropolitan Government. (2019). Tokyo ZEV Promotion Strategy. URL: https://www.kankyo.metro.tokyo.lg.jp/en/about_us/zero_emission_tokyo/strategy.files/Full-ver.ZEV-strategy.pdf

33. Springer Nature Sustainability Community. (2023). City parks are a fundamental soil carbon reservoir worldwide. URL: https://sustainabilitycommunity.springernature.com/posts/the-role-of-our-parks-in-the-fight-against-climate-change

34. Zhang, Y., Meng, W., Yun, H. et al. (2022). Is urban green space a carbon sink or source? - a case study of China based on LCA method. Environ. Impact Assess. Rev. 94, 106766. URL: https://doi.org/10.1016/j.eiar.2022.106766

35. Chen, W.Y. (2015). The role of urban green infrastructure in offsetting carbon emissions in 35 major Chinese cities: A nationwide estimate. Cities 44, 112–120. URL: https://doi.org/10.1016/j.cities.2015.01.005

36. The Department of Natural Resources Management and Environmental Protection of Moscow (2023). The list of Moscow's SPNAs URL: https://www.mos.ru/eco/function/departament/oopt-moskvy/

37. Xinhua. (2022). Voluntary tree-planting adds greenery in Beijing. URL: https://english.news.cn/20220312/c486918458764d5bb98692829c4c9941/c.html

38. C40 Cities. (2023). Zero Waste Accelerator. URL: https://www.c40.org/accelerators/zero-waste/

39. C40 Cities. (2022). Methane: Why cities must act now? URL: https://www.c40knowledgehub.org/s/article/Methane-Why-cities-must-act-now?language=en_US

40. Greeneration Foundation. (2023). South Korea's Waste Management System is Exemplary! URL: https://greeneration.org/en/publication/green-info/south-koreas-waste-management-system/

41. Ground Report. (2023). Korea's Volume-based waste fee system, Explained! URL: https://groundreport.in/koreas-volume-based-waste-fee-system-explained/

42. Seoul Solution. (2015). Recycling Discarded Electronics (SR Center): Urban Mining, a Necessity for Resource-Scarce Country. URL: https://seoulsolution.kr/en/content/recycling-discarded-electronicssr-center-urban-mining-necessity-resource-scarce-country

43. Seoul Metropolitan Government. (2021). 11 years of Seoul's Urban Mining achieved 120,000 tons of greenhouse gas reduction. URL: https://world.seoul.go.kr/11-years-of-seouls-urban-mining-achieved-120000-tons-of-greenhouse-gas-reduction/

44. London City Hall. (2023). Energy in buildings. URL: https://www.london.gov.uk/programmes-strategies/environment-and-climate-change/energy/energy-buildings

45. Moscow Mayor official website mos.ru. (2023). Sergei Sobyanin: BKL has become the longest circular metro line in the world. URL: https://www.mos.ru/mayor/themes/2299/9056050/

46. UITP. (2022). World Metro Figures 2021. URL: https://cms.uitp.org/wp/wp-content/uploads/2022/05/Statistics-Brief-Metro-Figures-2021-web.pdf

47. VisitSeoul.net. (2023). Transportation. URL: https://english.visitseoul.net/transportation

48. Budget Direct Insurance. (2023). Car Ownership Singapore 2023. URL: https://www.budgetdirect.com.sg/car-insurance/research/car-ownership-singapore

49. Land Transport Authority. (2023). Certificate of Entitlement (COE). URL: https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/certificate-of-entitlement--coe-.html

50. International Energy Agency. (2023). Greenhouse Gas Emissions from Energy. URL: https://www.iea.org/data-and-statistics/data-product/greenhouse-gas-emissions-from-energy

51. International Energy Agency. (2023). World Energy Balances. URL: https://www.iea.org/data-and-statistics/data-product/world-energy-balances

52. World Nuclear Association. (2023). How can nuclear combat climate change? URL: https://world-nuclear.org/nuclear-essentials/how-can-nuclear-combat-climate-change.aspx#:~:text=Nuclear%20power%20plants%20produce%20no,electricity%20when%20compared%20with%20solar.

53. International Electrotechnical Commission. (2022). Zero carbon power system based primarily on renewable energy. URL: https://www.iec.ch/basecamp/zero-carbon-power-system-based-primarily-renewable-energy

54. International Energy Agency. (2021). Key World Energy Statistics 2021. URL: https://iea.blob.core.windows.net/assets/52f66a88-0b63-4ad2-94a5-29d36e864b82/KeyWorldEnergyStatistics2021.pdf

55. World Health Organization. (2020). WHO Director-General's opening remarks at the media briefing on COVID19 - March 2020. URL: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

56. PWC. (2020). Impact of COVID-19 on the supply chain industry. URL: https://www.pwc.com/ng/en/assets/pdf/impact-of-covid19-the-supply-chain-industry.pdf

57. International Energy Agency. (2021). Global Energy Review 2021. URL: https://www.iea.org/reports/global-energy-review-2021/electricity

58. International Energy Agency. (2023). Energy Statistics Data Browser. URL: https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource

59. CDP. (2023). 2022 City-wide Emissions Percent Split by Sector. URL: https://data.cdp.net/Emissions/2022-City-wide-Emissions-Percent-Split-by-Sector/rwfh-j7u2

60. Global Covenant of Mayors. (2018). Common Reporting Framework. URL: https://www.globalcovenantofmayors.org/wp-content/uploads/2019/04/FINAL_Data-TWG_Reporting-Framework_website_FINAL-13-Sept-2018_for-translation.pdf

61. UN-Habitat. (2023). Urban Energy. URL: https://unhabitat.org/topic/urban-energy

62. Buck, H.J., Carton, W., Lund, J.F. et al. (2023). Why residual emissions matter right now. Nat. Clim. Chang. 13, 351–358. URL: https://doi.org/10.1038/s41558-022-01592-2

63. London City Hall. (2018). Zero carbon London: A 1.5°C compatible plan. URL: https://www.london.gov.uk/sites/default/files/1.5_action_plan_amended.pdf

64. Seoul Metropolitan Government. (2021). 2050 Seoul Climate Action Plan. URL: https://cdn.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ab410faa2f42204838f7990/5b7fef43747820740c10fabd/files/2050_Seoul_Climate_Action_Plan_v1.pdf?1628511828

65. City of Paris. (2018). Paris Climate Action Plan: Towards a carbon neutral city and 100% renewable energies. URL: https://cdn.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ae2f905a2f4220ae645f026/5af7316614ad660b652531de/files/Paris_-_Paris_Climate_Action_Plan.pdf?1526890697

Appendix 3. Data Sources for Indicators

№	City	Energy Sources		Energy Consumption		Transport				
		City energy mix	Goal	Electricity consumption	Goal	Types of transport used by the residents daily, by share of population	Number of buses	Number of EV-buses or hydrogen buses	Share of private EV-cars	Goal
1	Berlin	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	«Statistics Berlin Brandenburg» website, «Environment»	Strategic plan «BEK 2030»	«Numbeo Traffic» database	«Berliner-Linienchronik», page «Subcontractors», «BVG» website, «Bus» page	«BVG» website, «Bus» page	Publication on the «Focus.de» websote	Legal act «EWG Bln»
2	Delhi	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	Central Electricity Authority General Review Report	-	«Numbeo Traffic» database	Delhi Government Performance: Transport Report	Publication on the «Hindustan Times» website	Publication on te Ministry of Heavy Industries website	Delhi Electric Vehicles Policy, 2020
3	Jakarta	«CDP Cities Energy Mix» database	Jakarta Climate Action Plan	Central Bureau of Statistics DKI Jakarta website, «Energy» page	C40 website, «Jakarta Green Zone development» page	«Numbeo Traffic» database	«Sectoral statistics Jakarta DKI Province» website, «Transportation» page	Publication on the «Jakarta Smart City» website	Publication on the «The Diplomat» website	C40 website, «Fossil-Fuel-Free Streets Declaration» page
4	Dubai	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	Dubai Statistics Center website, «Total energy requirement and consumed» report	-	«Numbeo Traffic» database	Dubai Statistics Center website, «Public Transport Buses by Ridership» report	-	Publication on the «Emarat Al Youm» website, Publication on the «Al Bayan» website	Strategic plan «Roadmap to achieving zero-emission public transport by 2050»
5	Cairo	International Energy Agency website, «Country profile» page	-	«CAPMAS» website, «Electricity & Energy Release» page	-	«Numbeo Traffic» database	-	Publication on the «Egypt Independent» website	Publication on the «Bloomberg» website	-
6	Cape Town	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	«Cape Town State of Energy and Carbon» report	«CDP Cities Sector Targets» database	«Numbeo Traffic» database	«GABS Bus Services» website, «The company» page, «MyCITI Bus» website, «Media Releases» page	Publication on the «BYD» website	Publication on the «Techpoint Africa» website	CCT Climate Change Action Plan
7	London	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	London Datastore, «The London Energy and GHG Inventory» report	Strategic plan «London Net Zero 2030: An Updated Pathway»	«Numbeo Traffic» database	London Datastore, «Number of buses by type» database	London Datastore, «Number of buses by type» website	UK government website (gov.uk), «Vehicle licensing statistics data tables» database	London Environment Strategy
8	Mexico	«CDP Cities Energy Mix» database	-	«SENER Energy Information System» website, «Electricity consumption by state» page	Strategic plan «Climate Action Program of Mexico City 2021-2030»	«Numbeo Traffic» database	«E-bus Radar» website	«E-bus Radar» website»	Publication on the «Energy21» website	Strategic plan «Estrategia de electromovilidad de la Ciudad de México»
9	Moscow	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	Federal State Statistics Service website, «Energy Consumption by State Subject» report	City of Moscow program «Utilities infrastructure development and energy saving»	«Numbeo Traffic» database	GUP «Mosgortrans» website, «About us» page	Publication on the GUP «Mosgortrans» website	Publication on the «Autostat» website	Publication on the GUP «Mosgortrans» website
10	New York	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	The New York ISO Annual grid & markets report, Power trends 2019	Law 97 Implementation Action Plan 2021 report	«Numbeo Traffic» database	MTA website, «Transitioning to a zero-emissions bus fleet» page	MTA website, «Transitioning to a zero-emissions bus fleet» page	Publication on the «Car and Driver» website	Стратегия «OneNYC 2050 Efficient Mobility»

Green Spaces			Waste			Auxiliary indicators		
Green spaces area	City area	Goal	Mass of MSW generated	Mass of MSW disposed in landfills	Goal	City population	GHG emissions	Zero Carbon goal
Calculation based on «Google maps»	«CDP City-wide emissions» database	Charter for the Berlin City Green	«Berlin Waste Balance 2021» report	«Berlin Waste balance 2021» report	Berlin Land's Zero Waste Strategy	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	Strategic plan «BEK 2030»
Calculation based on «Google maps»	«CDP City-wide emissions» database	Delhi State Action Plan on Climate Change	Annual Report - Solid Waste Management	Annual Report - Solid Waste Management	-	«CDP Cities Disclosing to CDP» database	«GHG Platform India» database	-
Calculation based on «Google maps»	«CDP City-wide emissions» database	-	«National Waste Management Information System» database	«National Waste Management Information System» database	Jakarta Climate Action Plan	«CDP Cities Disclosing to CDP» database	«Emission Profile Inventory GHG DKI Jakarta» database	-
Calculation based on «Google maps»	«CDP City-wide emissions» database	Dubai 2040 Urban Master plan	Dubai Statistics Center report «Quantity of non-hazardous waste»	Dubai Statistics Center, «Quantity of non-hazardous waste» report	Publication on the «Government of Dubai News» website	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	-
Calculation based on «Google maps»	Calculation based on «Google maps»	-	Annual Bulletin of environment statistics	Calculation based on mean value of the developing countries included in research	-	«CAPMAS Egypt in Numbers» yearbook	-	-
Calculation based on «Google maps»	«CDP City-wide emissions» database	-	Annual State of Waste Management Report 2020	Annual State of Waste Management Report 2020	CCT Climate Change Action Plan	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	-
Calculation based on «Google maps»	«CDP City-wide emissions» database	London Environment Strategy	London Datastore, «Collected Waste Management London» database	London Datastore, «Collected Waste Management London» database	Strategic plan «The London Plan 2021»	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	Strategic plan «London Net Zero 2030: An Updated Pathway»
Calculation based on «Google maps»	«CDP City-wide emissions» database	-	«Solid Waste Inventory of Mexico City» report	«Solid Waste Inventory of Mexico City» report	Strategic plan «Programa de Acción Climática de la Ciudad de México 2021-2030»	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	-
Calculation based on «Google maps»	«CDP City-wide emissions» database	-	Legal act «Territorial waste management scheme of Moscow»	Report on program «Utilities infrastructure development and energy saving»	Legal act «Territorial waste management scheme of Moscow»	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	«CDP Cities Emissions Reduction Targets» database
Calculation based on «Google maps»	«CDP City-wide emissions» database	Strategic plan «OneNYC 2050 Thriving Neighbour-hoods»	Report on DSNY and non-DSNY collections	Report on DSNY and non-DSNY collections	Mayor's Office of Sustainability website, «Zero Waste Challenge» page	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	Strategic plan «One NYC 2050: A Livable Climate»

№	City	Energy Sources		Energy Consumption		Transport				
		City energy mix	Goal	Electricity consumption	Goal	Types of transport used by the residents daily, by share of population	Number of buses	Number of EV-buses or hydrogen Buses	Share of private EV-cars	Goal
11	Paris	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	Ministry of Ecological transition Data and statistical studies website, «Energy consumption» page	Paris Climate Action Plan	«Numbeo Traffic» database	Publication on the «Sustainable-bus» website	Publication on the «RATP» website	Publication on the Ministry of Ecological transition, Data and statistical studies website	Paris Climate Action Plan
12	Beijing	International Energy Agency website, «Country profile» page	Beijing Implementation Plan for Peaking Carbon Emissions	China Statistical Yearbook	Beijing Implementation Plan for Peaking Carbon Emissions	«Numbeo Traffic» database	«Ceicdata» website, «Number of public transit vehicle» page	Publication on the Chinese Government Official Portal	China Statistical Yearbook, «IEA Global Vehicle Outlook 2022» report	Beijing Implementation Plan for Peaking Carbon Emissions
13	Rome	International Energy Agency website, «Country profile» page	Action Plan for Energy and Climate	«Rome Capital» website, Statistical Report 2019	«CDP Cities Sector Targets» database	«Numbeo Traffic» database	«Rome Capital» website, «Local public transport» page	ATAC Contract, vehicle fleet data	Publication on the «Sicurauto» website	Strategic plan «Piano d'Azione per l'Energia e il Clima»
14	São-Paulo	«CDP Cities Energy Mix» database	Strategic plan «PlanClima SP»	Yearbook of energy subjects by municipality	-	«Numbeo Traffic» database	«E-bus Radar» website	«E-bus Radar» website	Publication on the «IBGE» website, publication on the «Neo Charge (EV)» website	Strategic plan «PlanClimaSP»
15	Seoul	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	Seoul Open Data Portal, «Electricity usage» database	Strategic plan «Promise of Seoul: Taking Action Against Climate Change»	«Numbeo Traffic» database	Seoul Open Data Portal, «Seoul city bus status statistics» database	Publication on the «Seoul Solution» website	Publication on the «Business Korea» website	2050 Seoul Climate Action Plan
16	Sydney	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	City of Sydney Data Hub, «Electricity consumption by suburb» page	-	«Numbeo Traffic» database	NSW Government website, «Zero Emission Buses» page	Publication on the «TeslaRati» website	«BITRE Motor Vehicles» report, «Electric Vehicle Industry Recap» report	-
17	Singapore	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	Singapore Energy Market Authority website, «Singapore Energy Statistics» page	Strategic plan «Take action today for a carbon-efficient Singapore»	«Numbeo Traffic» database	Land Transport Authority website, «Annual Vehicle Statistics» report	Publication on the Land Transport Authority website	Land Transport Authority website, «Annual Vehicle Statistics» report	Singapore Climate Action Plan
18	Istanbul	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	Turkish Statistical Institute website, «Regional Statistics» page	Istanbul Climate Change Action Plan	«Numbeo Traffic» database	«IETT Istanbul» website, «Public Transportation» page	-	Publication on the «TRT Haber» website	«Istanbul Climate Change Action Plan
19	Tokyo	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	Tokyo Statistical Yearbook	Zero emission Tokyo Strategy 2020 Update	«Numbeo Traffic» database	Tokyo Government website, «TOEI Bus Vehicle Ledger» page	Publication on the «Time to Act» website	«Statista» website, «Japan passenger cars in use» page, publication on the AIRIA Japan	Publication on the «Time to Act»
20	Toronto	«CDP Cities Energy Mix» database	«CDP Cities Renewable Energy Targets» database	«CDP Cities Energy Mix» database	-	«Numbeo Traffic» database	«Toronto Transit Commission Service Summary» report	«Toronto Transit Commission Service Summary» report	Publication on the «Automotive Statistics Canada» website	TransformTO Net Zero Strategy

Green Spaces			Waste			Auxiliary indicators		
Green spaces area	City area	Goal	Mass of MSW generated	Mass of MSW disposed in landfills	Goal	City population	GHG emissions	Zero Carbon goal
Calculation based on «Google maps»	«CDP City-wide emissions» database	Paris Climate Action Plan	Paris Annual Report RPQS Dechets	Paris Annual Report RPQS Dechets	Paris Climate Action Plan	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	Paris Climate Action Plan
Calculation based on «Google maps»	Calculation based on «Google maps»	Beijing Implementation Plan for Peaking Carbon Emissions»	China Statistical Yearbook	China Statistical Yearbook	Beijing Implementation Plan for Peaking Carbon Emissions	Beijing Statistical Yearbook	«Belfer Center Environment and Natural Resources Program» report	-
Calculation based on «Google maps»	«CDP City-wide emissions» database	Strategic plan «Piano d'Azione per l'Energia e il Clima'»	ISPRA Urban Waste Reduction Report	Legal act «Rome Waste Management Plan»	Strategic plan «Piano d'Azione per l'Energia e il Clima»	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	-
Calculation based on «Google maps»	«CDP City-wide emissions» database	Strategic plan «Cidade de Sao Paulo Programa de Metas 21/24»	City Hall website, «Waste collected in the municipality» page	City Hall website, «Waste collected in the municipality» page	Strategic plan «PlanClima SP»	«CDP Cities Disclosing to CDP» database	City hall website, publication «SVMA Report of GHG Emissions»	-
Calculation based on «Google maps»	«CDP City-wide emissions» database	Strategic plan «Promise of Seoul: Taking Action Against Climate Change»	«Korea Resource Circulation Information System» website, «Environmental Statistics» page	«Korea Resource Circulation Information System» website, «Environmental Statistics» page	2050 Seoul Climate Action Plan	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	2050 Seoul Climate Action Plan
Calculation based on «Google maps»	«CDP City-wide emissions» database	City of Sydney Environmental Strategy 2021-2025	Local Government Waste and Resource Recovery Data Report	Local Government Waste and Resource Recovery Data Report	City of Sydney Environmental Strategy 2021-2025	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	Strategic plan «Sustainable Sydney 2030–2050 Continuing the Vision»
Calculation based on «Google maps»	«CDP City-wide emissions» database	-	NEA, Government of Singapore website, «Waste and Recycling Statistics» database	NEA, Government of Singapore website, «Waste and Recycling Statistics» database	Singapore's Climate Action Plan	«CDP Cities Disclosing to CDP» database	NEA, Government of Singapore website, «GHG Inventory» page	-
Calculation based on «Google maps»	«CDP City-wide emissions» database	Istanbul Climate Change Action Plan	«Istanbul Open Data» website, «Annual Domestic Waste Amounts by District» database	Publication on the «Istanbul Environmental Protection and Control Department» website	Istanbul Climate Change Action Plan	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	«CDP Cities Emissions Reduction Targets» database
Calculation based on «Google maps»	«CDP City-wide emissions» database	Strategic plan «Tokyo's New Green Initiatives»	E-Stat Japan Statistics Dashboard	«Waste Disposal in Japan 2020 Version» report	Zero Emission Tokyo Strategy	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	Zero Emission Tokyo Strategy
Calculation based on «Google maps»	«CDP City-wide emissions» database	TransformTO Net Zero Strategy	Solid Waste Reports and Diversion Rate	Solid Waste Reports and Diversion Rate	TransformTO Net Zero Strategy	«CDP Cities Disclosing to CDP» database	«CDP City-wide emissions» database	TransformTo Net Zero Strategy

urbanclimate.moscow