MOSCOW ECONOMY

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Guangzhou Institute for Urban Innovation

BRICS Urban Climate Agenda Report

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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.

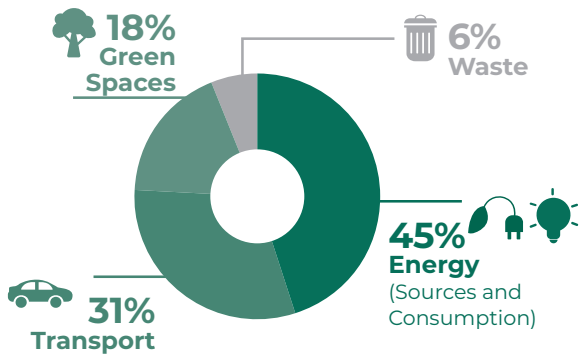
2. The share of waste disposed of in landfills is calculated: the data on the mass of MSW disposed of in landfills for the last available year are divided by the data on the mass of generated MSW for the same year.

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].