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## Article

# From historical responsibility to carbon neutrality: A country classification

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## AT A GLANCE

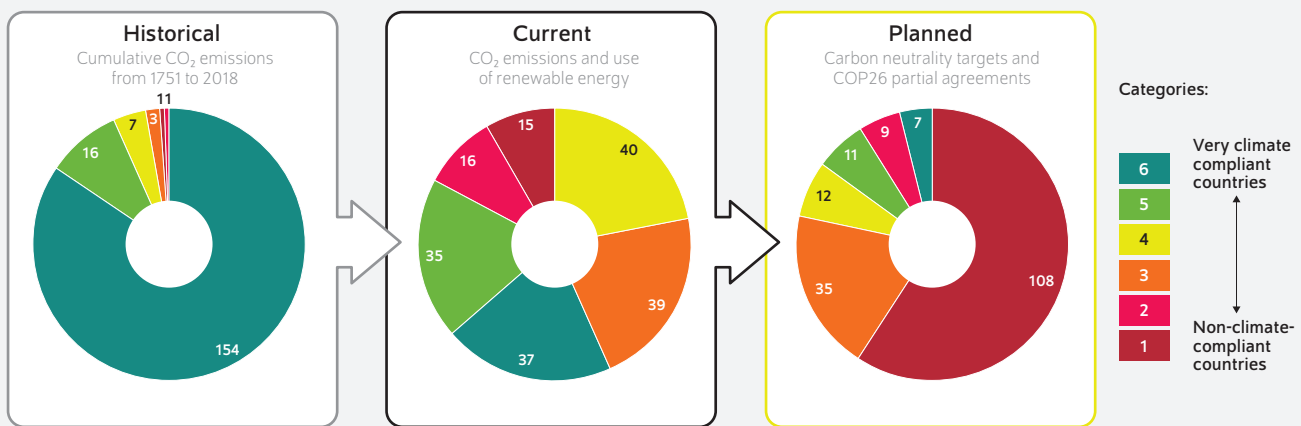
# From Historical Responsibility to Carbon Neutrality: A Country Classification

By Dawud Ansari, Wassim Brahim, Franziska Holz, and Claudia Kemfert

- Report highlights countries' different starting positions in regard to their carbon footprint and climate action policy
- Countries are grouped according to their past, current, and future emissions as well as their climate neutrality policy
- Diversity among the groups has less to do with geography and more to do with economic structures and policies
- Developing and even most emerging economies have a much smaller carbon footprint than industrialized economies
- So far, low-income countries have hardly been included in the climate neutrality agenda; smart climate diplomacy is needed

### Number of non-climate-compliant countries has markedly increased over time

Number of countries



Source: Authors' own depiction.

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## FROM THE AUTHORS

*"The differences between the groups of countries and, thus, the obstacles to reaching agreements at world climate summits remain large. Smart climate diplomacy that also considers non-European perspectives is imperative."*

— Dawud Ansari —

# From Historical Responsibility to Carbon Neutrality: A Country Classification

By Dawud Ansari, Wassim Brahim, Franziska Holz, and Claudia Kemfert

## ABSTRACT

The COP27 (United Nations Climate Change Conference) in November 2022 once again highlighted the fact that countries are starting from different positions when it comes to emissions and climate policy. This Weekly Report classifies countries into representative profiles based on their past, current, and planned future climate impact. There is a high degree of diversity between the profiles; they are not determined by geographical factors, but rather by economic patterns and policy decisions. This also applies to European Union member states: Levels of past CO<sub>2</sub> emissions vary, and some countries have no domestic carbon neutrality. Globally, most countries have not contributed to cumulative emissions but also have no plans to become carbon neutral.

The annual UN Climate Conferences (COPs) are considered the central forum for climate diplomacy. In 2015, the Paris Agreement established a landmark framework for ambitious global efforts to limit global warming to 1.5 to 2 degrees Celsius. Since then, however, it has become clear that the commitment to mitigating climate change and the willingness to deepen agreements are far from guaranteed. For example, under the leadership of then-president Donald Trump, the USA withdrew from the Paris Agreement. Although the country re-entered under the Biden administration, its fate under future administrations remains uncertain. In 2018, COP24 failed to approve the Intergovernmental Panel's report on climate change due to opposition from the USA, Saudi Arabia, Kuwait, and Russia.<sup>1</sup>

Overall, the public discourse tends to blame emerging economies—such as China, India, and other rapidly growing countries in the Global South—for global warming. But is this criticism accurate?

Countries and their climate impacts are diverse and change over time. Although the climate discussion focuses mainly on current, absolute greenhouse gas emissions, historical emission trajectories and per capita emissions play equally important roles.<sup>2</sup> The principle of common but differentiated responsibilities (CBDR) in climate change mitigation, formalized by the United Nations in 1992, was intended to address global inequalities. However, the nationally determined contributions (NDCs) agreed upon in the Paris Agreement have weakened this principle *de facto*, as countries can unilaterally set their climate targets.<sup>3</sup> Also, the emission reductions specified in the NDCs are hardly a long-term solution to the climate crisis.<sup>4</sup> Instead, “net zero” targets (carbon neutrality targets) are becoming increasingly

<sup>1</sup> See Erland A. T. Hermansen et al., “Post-Paris policy relevance: lessons from the IPCC SR15 process,” *Climatic Change* 169 (2021): 1–18 (available online; accessed on October 31, 2022. This applies to all other online sources in this report unless stated otherwise).

<sup>2</sup> See Robert Gampfer, “Do individuals care about fairness in burden sharing for climate change mitigation? Evidence from a lab experiment,” *Climatic Change* 124 (2014): 65–77 (available online).

<sup>3</sup> See Pieter Pauw, Kennedy Mbeva, and Harro van Asselt, “Subtle differentiation of countries' responsibilities under the Paris Agreement,” *Palgrave Communications* 5, no. 86 (2019) (available online).

<sup>4</sup> See the evaluation of some NDCs by the Climate Action Tracker (available online).

important and popular.<sup>5</sup> Under such targets, countries aim to reach a point where they emit only as much CO<sub>2</sub> as they remove by other means. This results in no net increase in the amount of CO<sub>2</sub> in the atmosphere.

This Weekly Report assesses the positions of all countries globally by preparing and analyzing data on national emissions and climate action. The results are not a simple emissions ranking but rather a descriptive analysis that allows a fresh look at emitters and groups thereof. Using hierarchical clustering, representative groups of countries are identified and their behavior over time is described. This occurs in two separate analyses: First, the countries are classified into groups and illustrative, archetypal emissions profiles are created. Second, the countries' development paths over time are tracked and assessed using various indicators for their climate compliance.<sup>6</sup> This Weekly Report differs from other emission rankings and classifications<sup>7</sup> due to its focus on climate justice<sup>8</sup> and carbon neutrality targets as well as its comprehensive inclusion of all countries.

### Eight archetypal emissions profiles

In the first analysis, hierarchical clustering is used to divide 182 countries into groups based on their historical, current, and projected emissions behavior (Box 1). These groups represent archetypal profiles of emitters and make it possible to discern generalizable patterns and identify similar countries. The variables used to form the groups (clustering variables) are cumulative past CO<sub>2</sub> emissions (historical dimension), current CO<sub>2</sub> emissions in absolute levels and per capita levels (current dimension), and the planned year of achieving carbon neutrality as well as the formalization of the carbon neutrality target (future dimension). Endogenous clustering yields a total of nine groups, plus the USA and China as stand-alone countries (Figure 1).

**The Transformers and the Advocates** are two similar profiles of Western industrialized countries with strong climate targets. Both the historic and current carbon footprints of the Advocates—such as Sweden and France—are rather low and they have ambitious climate action plans. The Transformers (countries such as Germany and Canada) have similar—albeit somewhat weaker—plans. However, their current and historical emissions are high. Although the per capita incomes of the Advocates and the Transformers are similar, their economic structures differ. The Transformers are large

industrialized economies, which makes decarbonization more difficult and more expensive for them. The Advocates, in contrast, have a relatively low share of carbon-intensive industries, which makes their climate plans easier to implement and more affordable. The Advocates have a very good balance on paper; however, they rely on carbon-intensive imports, often from the Transformers.

**The Hedonists and the Minimalists** have the highest emission intensity. The Hedonists—primarily small Middle Eastern oil exporters—include all the top five per capita emitters and, so far, have no plans whatsoever to become carbon neutral.<sup>9</sup> Despite very high per capita emissions and fossil fuel exports, the Hedonists are usually not at the center of the discussion, mostly due to their small size and low total effect on global CO<sub>2</sub> emissions. Most Minimalists are large energy exporters that rank right behind the Hedonists in terms of per capita emissions. However, whether out of compulsion or conviction, they support efforts toward carbon neutrality, albeit only halfheartedly (i.e., their target year is distant or lacks codification). Surprisingly, this group includes Saudi Arabia as well as Australia and Luxembourg, Europe's largest per capita emitter. A further characteristic that both groups have in common is a negligible amount of historical emissions.

**The Newcomers, the Pragmatists, and the Agnostics** are emerging and industrialized economies with differing emission levels and approaches to climate policy. The Newcomers (such as Oman, Turkey, and Finland) are predominantly emerging economies that have set out ambitious, albeit not yet fully formalized, carbon neutrality targets. The Agnostics have a similar level of economic development and emission histories on average, but they have made no efforts toward carbon neutrality.<sup>10</sup> It is striking that many Agnostics—Iran, Poland, and Norway, for example—are fossil fuel producers; however the Newcomers include resource exporters too (e.g., Brazil and South Africa).<sup>11</sup> The Newcomers and the Agnostics are similar in terms of their historical emissions and many economic characteristics, which suggests that with sufficient efforts, many Agnostics could turn into Newcomers. Between the Newcomers and the Agnostics are the Pragmatists—Russia and India—which oscillate between national development interests (and according emissions) and climate goals.

The vast majority of countries in the Global South are **Outsiders**: countries that neither have (historical) responsibility for climate change nor carbon neutrality targets for the future. For the Outsiders—almost half of all countries on Earth—enhancing domestic growth and living conditions

<sup>5</sup> See Sabire S. Evli, Anna Broughel, and Dawud Ansari, "Evaluation of Net-Zero Carbon and 100 % Renewable Energy Scenarios for 2050 and Beyond," in Geoffrey Wood et al. (eds.), *The Palgrave Handbook of Zero Carbon Energy Systems and Energy Transitions*. Palgrave Studies in Energy Transitions, (Palgrave Macmillan: 2022) (available online).

<sup>6</sup> The indicators include historical emissions, current emissions, the share of renewable energy sources, and climate neutrality plans. For emissions, no other greenhouse gases beyond CO<sub>2</sub> are included.

<sup>7</sup> See for example the Climate Action Tracker (available online) and GermanWatch's Climate Change Performance Index (available online).

<sup>8</sup> Climate justice is a normative understanding emphasizing the need for a just distribution of the cost of climate change. It is frequently based on historical responsibility as well as the per capita distribution of emissions. See Chukwumerije Okereke, "Climate justice and the international regime," *Wiley Interdisciplinary Reviews: Climate Change* 3 (2010): 462–474 (available online).

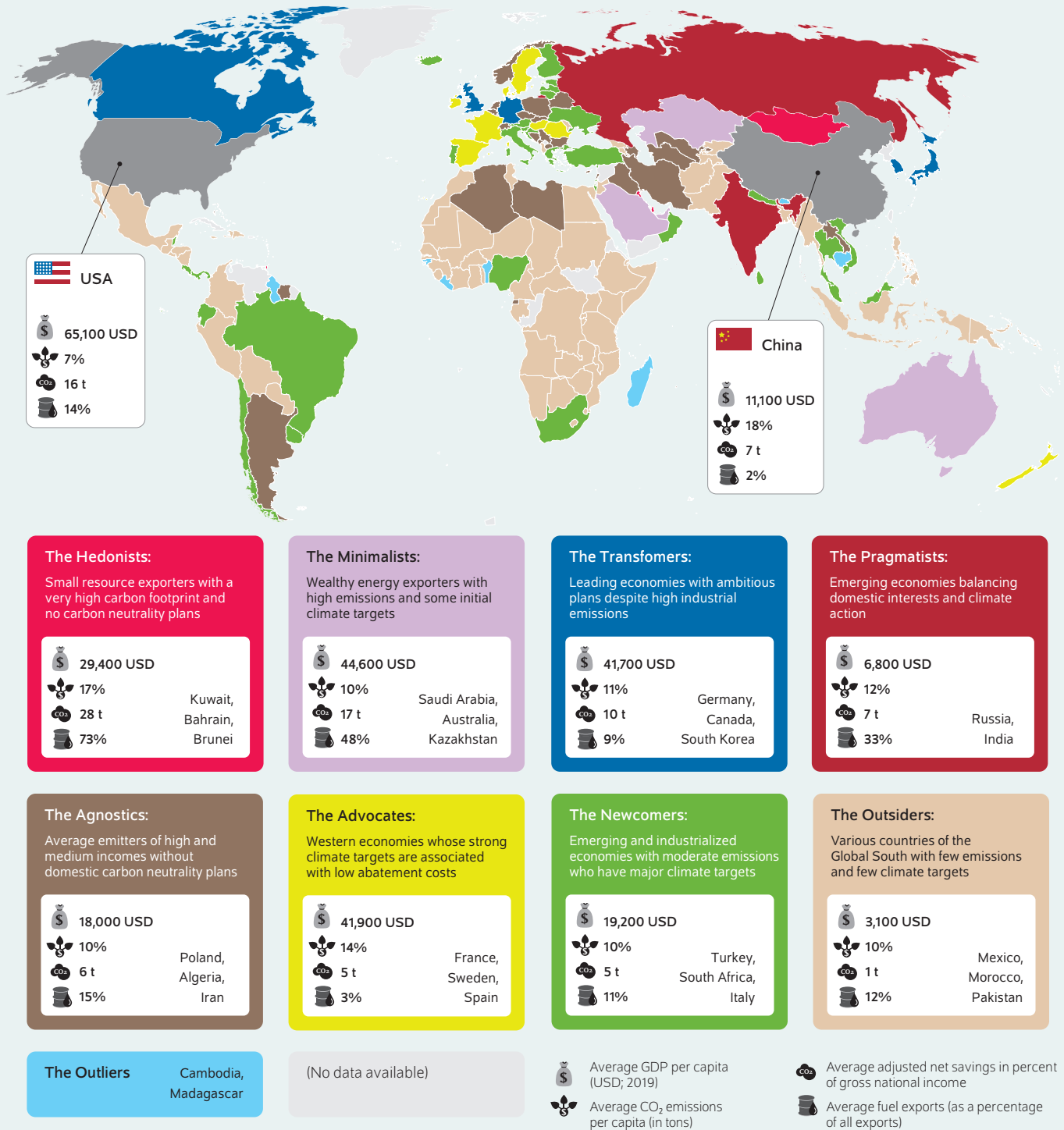
<sup>9</sup> The five largest per capita emitters are (in this order) Qatar, Trinidad and Tobago, Mongolia, Brunei, and Kuwait, cf. Global Carbon Project for 2019 (available online).

<sup>10</sup> According to the data, this includes EU member states that adhere to EU climate targets but do not have their own climate neutrality targets.

<sup>11</sup> The Newcomers are a rather heterogeneous group predominantly made up of countries with relatively new climate ambitions. Yet, there are also some countries with a long history of climate policy, such as Brazil and South Africa. The common factor is that they have all recently adopted climate neutrality targets.

Figure 1

## Overview of emissions profiles



Note: A full list of all countries and their profiles is available online.

Economic structure and policy decisions significantly influence emissions profiles.

is the top priority. The Outsiders do not consider themselves a part of the discourse on carbon neutrality. Notably, this group (still) includes emerging economies such as Morocco or Mexico. Despite a growing carbon footprint, these countries are only responsible for a fraction of historical and current global emissions and hardly drive the climate crisis.

Due to their unique emission profiles, the **USA** and **China** are the only two countries that cannot be grouped with any other countries.<sup>12</sup> The USA is the largest historical emitter, responsible for about 26 percent of all CO<sub>2</sub> emissions ever emitted. It is well ahead of China, which is responsible for 14 percent of all cumulative historical emissions. In absolute terms, China is currently the largest emitter, accounting for around 32 percent of annual global emissions. However, this is mainly due to its population size: At seven metric tons of CO<sub>2</sub> annually, its per capita emissions are at a moderate level when compared to others. The USA, in contrast, is one of the top ten per capita emitters at 16 metric tons CO<sub>2</sub> per capita.

### Emissions and climate compliance over time

The second analysis highlights the development of carbon footprints and carbon neutrality over time. In contrast to the emission profiles, we approach climate compliance here in three separate time dimensions (Box 2). For the historical dimension, we use the countries' cumulative CO<sub>2</sub> emissions from 1751 to 2018. Current climate compliance is measured by renewable energy shares as well as CO<sub>2</sub> emissions per capita and per US dollar of GDP. Future (i.e., planned) climate compliance is evaluated via carbon neutrality targets.<sup>13</sup> In a multi-step process, country groups are formed and ranked from 1 (very low climate compliance) to 6 (very high climate compliance) for each time dimension. The results demonstrate the temporal dynamics of the groups and their sizes. Moreover, they make it possible to track the climate compliance of (groups of) countries over time.

The resulting pathways show that, across all countries, climate compliance has developed very dynamically (Figure 2). While countries are distributed evenly across the "current" climate compliance ranks, they appear concentrated regarding historical accountability and future plans. Groups for current climate compliance are of nearly equal sizes; however, the majority of countries have no historical responsibility (nearly 85 percent, or 154 of 182 countries) nor their own carbon neutrality plans (nearly 60 percent, or 108 of 182 countries).

<sup>12</sup> A further special group are the Outsiders. These are low-income economies that are, at least on paper, already carbon neutral. However, their energy systems are usually underdeveloped (a large part of the population lives without electricity), and existing electricity is often generated by carbon-neutral hydropower. Since carbon neutrality in these countries is more situational and possibly temporary, they are not analyzed further in this study.

<sup>13</sup> This definition of climate compliance uses fewer indicators than other assessment projects, such as the Climate Action Tracker (available online) and the Climate Change Performance Index (available online). However, it enables a comprehensive look at all countries while also considering on climate justice and carbon neutrality as visionary concepts.

#### Box 1

### Hierarchical clustering and emission profiles

Hierarchical clustering is an unsupervised machine learning algorithm.<sup>1</sup> It classifies objects—in this case, countries—into endogenously determined groups. The agglomerative approach used here first considers each country as a separate cluster (group). It then successively combines the two clusters with the highest similarity into a new cluster (group) until all elements are linked. The result is a tree structure from which a cross-section is extracted and analyzed.

Ward's method<sup>2</sup> and the Euclidean distance are used to measure similarity between groups. In a preprocessing step, all variables are standardized, i.e., transformed to a distribution with mean value 0 and a standard deviation of 1. The algorithm is implemented using the Python library Scikit.<sup>3</sup>

To create emissions profiles, clustering with the following variables is applied:

- Cumulative CO<sub>2</sub> emissions<sup>4</sup> from 1751 to 2018
- Absolute CO<sub>2</sub> emissions in 2019
- Per capita CO<sub>2</sub> emissions in 2019
- The planned year of achieving carbon neutrality<sup>5</sup>
- The formalization of the carbon neutrality plans<sup>6</sup>

This Weekly Report uses 2019 as the "current" year to prevent artefacts from the asymmetric responses to COVID-19. Based on the research question and the resulting cluster hierarchy's properties, a cross-section of eleven clusters is selected for analysis. In this variable list, projected climate compliance is assessed solely through carbon neutrality targets. On the one hand, NDCs would be difficult to compare and corresponding data sets do not refer to all countries. On the other hand, the analysis deliberately focuses on carbon neutrality as the primary means to mitigate climate change.

<sup>1</sup> For details and applications of the method, see, e.g., Adnan Al-Akori et al., "Conflict, Health, and Electricity—An Empirical Assessment of the Electrification of Healthcare Facilities in Yemen," *EADP Discussion Paper 01* (2022) (available online).

<sup>2</sup> See Joe H. Ward Jr., "Hierarchical Grouping to Optimize an Objective Function," *Journal of the American Statistical Association* 58 (1963): 236–244 (available online).

<sup>3</sup> Fabian Pedregosa et al., "Scikit-learn: Machine learning in Python," *The Journal of Machine Learning Research* 12 (2011): 2825–2830 (available online).

<sup>4</sup> All emissions data used comes from the Global Carbon Project (available online).

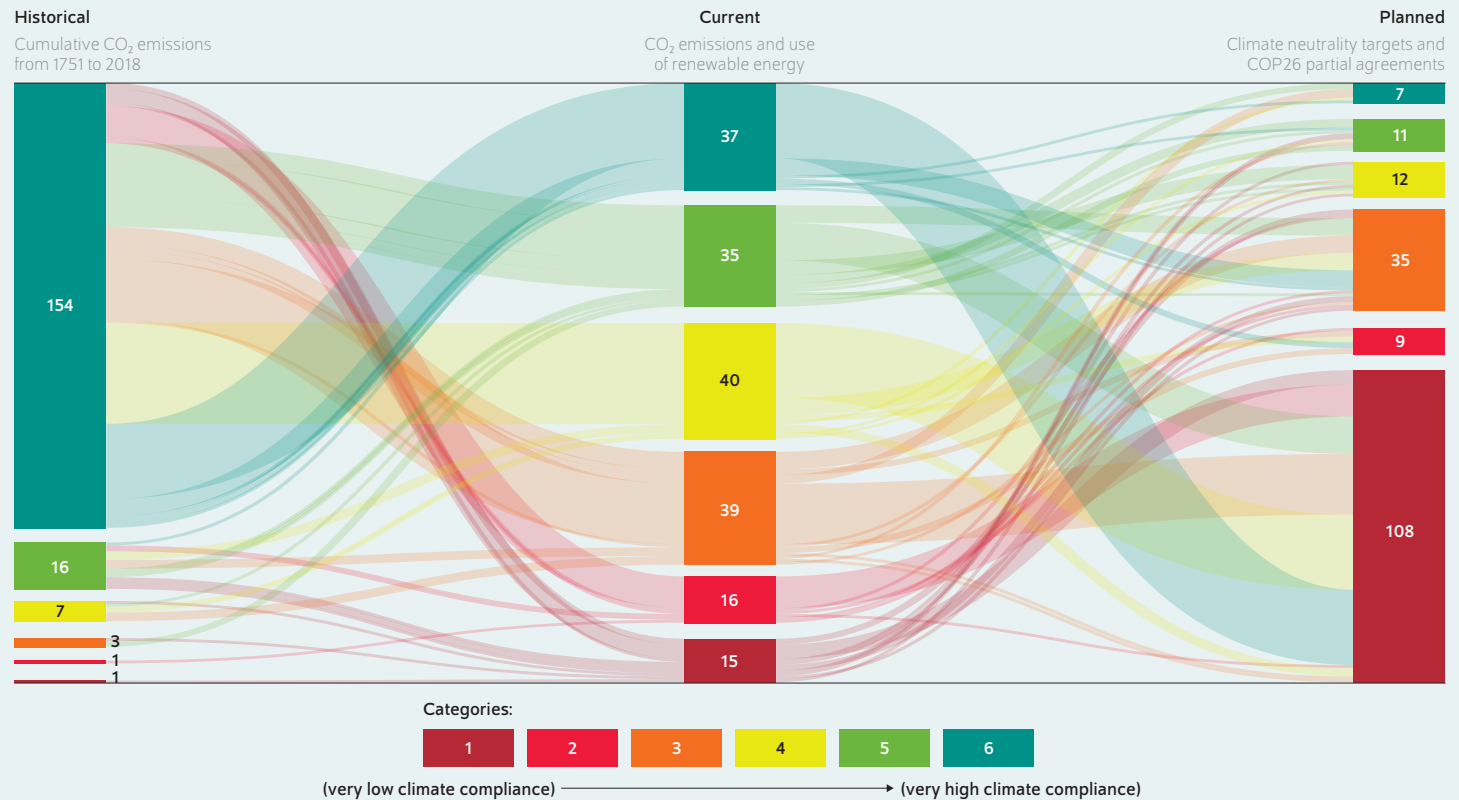
<sup>5</sup> The data on climate neutrality plans (last updated: October 2022) are from Oxford University's Net Zero Tracker (available online). For countries without a climate neutrality target, 2100 is defined as the target year.

<sup>6</sup> Target formalization is ranked using a five-level scale from 0 to 4 (0: no announcement, 1: announcement, 2: policy document, 3: adopted as law, 4: climate neutrality achieved), the indicator is subsequently normalized.

Figure 2

## Overview of all countries' climate compliance over time

Number of countries



Note: A complete list of all countries is available online.

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Of the 154 climate-compliant countries in the past, 37 still have a high level of climate compliance in 2022. Most of them, however, do not have any carbon neutrality plans.

Overall, 42 percent of all countries—mainly those with very low per capita incomes—follow a path from high historical to low future climate compliance. Notably, no low-income country and, in general, barely any developing economies are in the groups with high future climate compliance (above level 3).

The countries with the lowest current levels of climate compliance originate from all levels of historical climate compliance equally. Current behavior is also a poor indicator of future plans: The group of highly climate-compliant countries disperses into almost all levels of future climate compliance.

A closer look at four selected country groups reveals further details (Figure 3). The current **top ten emitters** are extremely diverse: They contain countries from both the Global South and the Global North and they range from low to high income. Their climate compliance scores reflect this diversity. Four of the countries share barely any historical responsibility for climate change (Saudi Arabia, Iran, Indonesia, and South Korea), whereas the United States alone constitutes the bottom rank of historical climate compliance.

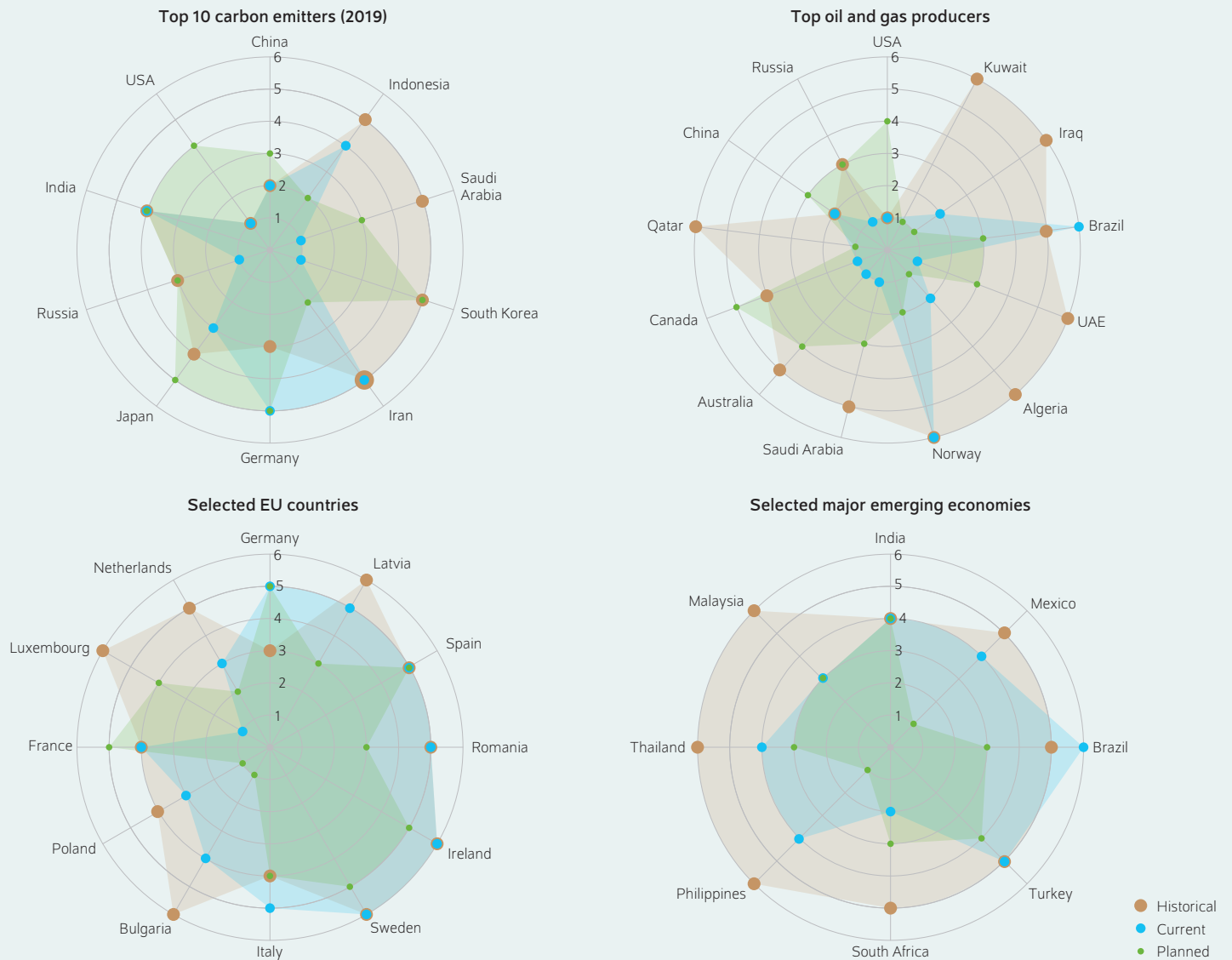
Compared to the other countries, Iran and Indonesia have good ratings due to low CO<sub>2</sub> emissions per capita and per unit of GDP. Germany scores high thanks to its high share of renewable energy. Apart from Indonesia, all countries in this group have carbon neutrality plans; Japan and Germany even have quite well-developed plans. The group provides further evidence that carbon neutrality targets tend to correlate with historical trends: Countries whose emissions levels have increased only recently set hardly any climate neutrality targets.

Among the **top oil and gas producers**, historical climate compliance is noticeably high (apart from the USA, Russia, and China). Yet current numbers indicate the opposite. The only exceptions are Norway and Brazil; both produce large shares of their electricity from hydropower. Middle Eastern producers are quite similar and have either no neutrality targets or weak ones. Only Saudi Arabia and the United Arab Emirates exhibit moderate scores for future climate compliance. Western energy exporters (except Canada) score low on historical and current climate compliance, yet they set moderate carbon neutrality targets.

Figure 3

### Historical, current, and planned climate compliance of selected countries

Ranked between 1 (not climate compliant) and 6 (very climate compliant) for each dimension



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Most countries had higher climate compliance in the past than they have today or plan to have, with the exception of Germany and the USA.

Although **EU Member States** appear heterogeneous, several groups can be identified. Poland, Bulgaria, and the Netherlands started with low historical carbon footprints but grew into some of the EU's largest current emitters—and they do not have their own plans for carbon neutrality. Spain, Ireland, and Sweden exhibit high levels of climate compliance over the entire period. Romania and Latvia show high climate compliance so far, but their future plans lack ambition. Europe's largest economies—Germany, France and Italy—share similar ranks of climate compliance, and they have ambitious carbon neutrality targets. These comparisons indicate that intra-EU differences in carbon neutrality

plans are not primarily caused by geography or geology but rather by policy. Bulgaria and Romania have similar economic structures, but the two countries diverge in terms of climate compliance, primarily due to Romania's high share of renewable energy sources. Both Poland and Germany are coal producers, their climate action plans vary, nonetheless.

**Emerging economies** share the same past (i.e., high historical climate compliance), but their pathways diverge thereafter. Overall, it turns out that—contrary to public opinion—most emerging economies demonstrate medium to high current climate compliance. They are neither the historical

## Box 2

**Climate compliance paths over time**

A multi-step procedure is used to calculate climate compliance over time. First, countries are grouped according to their historical, current, and future climate compliance (see Box 1). The analysis uses variables emphasizing historical responsibility, climate justice, the energy system transition, and carbon neutrality. While the variables overlap partially with those used to form the emissions profiles, they are not completely congruent:

Historical dimension:

- Cumulative CO<sub>2</sub> emissions from 1751 to 2018

Current dimension:

- CO<sub>2</sub> emissions per capita in 2019
- CO<sub>2</sub> emissions per US dollar of gross domestic product in 2019
- Renewable energy sources<sup>1</sup> as share of generated electricity in 2019
- Renewable energy sources as share of electricity generation capacities in 2019

Future (planned) dimension:

- Planned year of carbon neutrality
- Degree of formalization of carbon neutrality targets
- Number of partial agreements supported at COP26<sup>2</sup>

In a second step, the groups are ranked within each time dimension by their climate compliance. A principal component analysis<sup>3</sup> for each dimension makes it possible to compute a standardized value of climate compliance for each group. Based on this value, the groups are ranked from 1 (very low climate compliance) to 6 (very high climate compliance).

<sup>1</sup> Data on renewable energy sources are from the International Renewable Energy Agency (available online).

<sup>2</sup> These are individual partial agreements for accelerated decarbonization overall as well as in the electricity, land transport, steel, and hydrogen sectors (available online).

<sup>3</sup> Principle component analysis (PCA) is a common technique for dimension reduction. In this statistical procedure, the results of several variables are combined into one or a few values ("principal components"). Due to numerical peculiarities, a weighted average (2:2:1 between the climate neutrality year, the target's formalization, and the support of COP26 breakthroughs) is used for the future dimension.

drivers of climate change, nor do their current per capita emissions compare to those of most industrialized economies. However, the data also show that none of the emerging economies (except for South Africa) have set ambitious carbon neutrality goals. Malaysia and India have adopted carbon neutrality targets roughly equivalent to their current climate compliance. The future climate compliance of Mexico and the Philippines, on the other hand, has so far been well below current levels. Thus, emerging economies are neither the cause of the climate crisis nor leaders in climate action. Asian countries do not differ significantly from South American ones in this regard.

**Conclusions: Historical and current differences must not impede future climate action**

Assessing the role of different countries in climate change solely by means of absolute emission numbers is a one-dimensional perspective, since historical emissions and climate goals also matter. This Weekly Report identified and analyzed eight archetypical emission profiles as well as different pathways of climate compliance.

The results showcase that similarities in economy and policy determine contributions to climate change more than geographical proximity. For instance, there are significant differences across the EU, which stem from national policies rather than different starting points. The USA and China, the two largest emitters, have completely unique profiles. Oil and gas producers, along with their fuel exports, also stand out: They tend to have very high domestic carbon footprints and only weak carbon neutrality targets.<sup>14</sup> Generally, high emissions go hand in hand with a lack of climate goals, making incentives for even small emission reductions important. Since most oil and gas producers share a common trajectory, there are large potential benefits from turning some of them into role models, as others might follow suit.

Climate behavior rarely stays constant over time. Current major emitters differ in both their past behavior and future goals. For example, some previous polluters (such as Germany and Canada) show that a high degree of industrialization does not preclude ambitious climate action. However, most countries around the globe are low-income economies that have almost no historical or current emissions and are expected to contribute only modestly to global greenhouse gas emissions. Even most of today's emerging economies only bear a small share of the responsibility for climate change. At the same time, most emerging and almost all developing economies have no or only weak carbon neutrality goals. Hence, their future climate compliance cannot be taken for granted. These countries' focus is on improving living conditions and catching up to the industrialized economies. In line with the Sustainable Development Agenda, wealthy countries should therefore finance low-carbon growth in developing economies such that it combines both climate and development goals. Constructing new fossil fuel infrastructure, e.g., in oil and gas production countries such as Senegal, should not be supported from this perspective. For emerging economies, the analysis suggests that climate diplomacy and development policy can stimulate countries from the group of the Agnostics to develop progressive climate action plans.

Notably, these analyses are only relative: They only present countries in comparison with each other. However, even the climate goals of many ambitious countries are (still) incompatible with the 1.5-degree target.<sup>15</sup> The emissions data used here also ignore the fact that many emissions

<sup>14</sup> See Karen Pittel et al., "Chances and Obstacles to Strengthening the Paris Agreement – The Case of Resource-Rich Countries," *Background Paper Forum Climate Economics 9* (available online).

<sup>15</sup> See the Climate Action Tracker (available online).

are embedded in export goods. For example, a considerable share of China's emissions results from producing goods for the Global North—a form of outsourcing emissions.<sup>16</sup> Even within Europe, the unevenly distributed industry

distorts the true carbon footprint of consumption and decarbonization costs.

The differences between the groups and, thus, the obstacles to reaching agreements at world climate summits will remain very large. Smart climate diplomacy that also considers non-European perspectives is imperative.

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<sup>16</sup> See Ying Liu, Kankesu Jayanthakumaran, and Frank Neri, "Who is responsible for the CO<sub>2</sub> emissions that China produces?" *Energy Policy* 62 (2013): 1412–1419 (available online).

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