IN EUROPE, MUNICIPALITIES COMMITTED TO CLIMATE ACTION HAVE BY AND LARGE MET THEIR 2020 EMISSION REDUCTION TARGETS

Among the Global Covenant of Mayors (GCoM)

GCoM, 2021

-1.9 $GtCO_2e$ ↓↓↓

ANNUAL GCOM EMISSIONS REDUCTION POTENTIAL

Based on current targets and action, compared to a BAU scenario.

GLOBAL COVENANT *of* MAYORS *for* CLIMATE & ENERGY

1.012 billion

POPULATION COVERED BY GCOM SIGNATORY CITIES

11,719

NUMBER OF GCOM SIGNATORY CITIES

GCoM is the largest global alliance of cities for climate action..

83%

SHARE OF EUROPEAN CITIES IN GCOM SIGNATORIES

The CDP-ICLEI Unified Reporting System: despite a slight slowdown in reporting, more cities are reporting reduced emissions from their previous inventories

Year	NUMBER OF CITIES HAVING REPORTED THEIR TERRITORIAL EMISSIONS ON THE CDP-ICLEI UNIFIED REPORTING PLATFORM (total)	↓ decrease	↑ increase	TOTAL GHG EMISSIONS REPORTED ($GTCO_2e$)	POPULATION COVERED (MILLIONS)	CITIES REPORTING EMISSIONS OUTSIDE BOUDARIES (SCOPE 3)	TOTAL EMISSIONS REPORTED OUTSIDE BOUNDARIES
2015	119	46	31	1.25			
2016	187	84	36	1.29	260		
2017	229	101	45	1.41	279		
2018	284	115	45	1.91	315		
2019	332	176	94	1.84	332	207	89 $MtCO_2e$
2020	401	191	120	2.19	367	253	233 $MtCO_2e$
2021	370	198	78	1.94	329	222	221 $MtCO_2e$

↓ *Cities having reported a decrease in their emissions compared to the previous inventory*

↑ *Cities having reported a increase in their emissions compared to the previous inventory*

Source: CDP, online database, downloaded on 12/11/2021

The latest tracking of the progress of the European Covenant of Mayors for Climate and Energy 2020 conducted by the European Comission's Joint Research Centre covers a sample of 1,643 municipalities within the EU-27 having at least one Monitoring Emission Inventory (MEI) following their accepted Baseline Emission Inventory (BEI) and Sustainable Energy Action Plan (SEAP). This covers 32.5% of CoM 2020 signatories, 63% of the population covered by the initiative, 19.2% of the EU-27 population. The significant heterogeneity in baseline years and monitoring years do not allow to draw comparisons or weigh CoM 2020 signatories responsability in the EU-27 emissions evolution from 1990 and 2019.

The EU is on a trend of structural decarbonization ...

European Environmental Agency, 2021

CO_2

-26%

i.e. a reduction in emissions of 464.6 $MtCO_2e$

EVOLUTION OF ANNUAL GHG EMISSIONS IN THE EU-27 FROM 1990 TO 2019

-3.4 tCO_2e

AVERAGE EVOLUTION OF EMISSIONS PER CAPITA IN THE EU-27 FROM 1990 AND 2019

From 11.2 tCO_2e in 1990, emissions per capita in the EU-27 decreased by more than a third (36.36%) to 7.8 tCO_2e in 2019.

... with Covenant of Mayors 2020 cities signatories mostly align with their target

Rivas, S. et al., 2022

CO_2

-20%

2020 MITIGATION TARGET

for CoM 2020 signatories from their baseline year of emission

-19.5%

AVERAGE EMISSION EVOLUTION IN COM 2020 SIGNATORY CITIES FROM THE EU-27

(from their Baseline Emission Inventory (BEI) to their last Monitoring Emission Inventory (MEI))

The 1,643 signatories of CoM with at least one MEI report an average 19.5% reduction from their baseline emissions.

Covenant of Mayors for Climate & Energy EUROPE

35%

EU-27 POPULATION COVERED BY THE COVENANT OF MAYORS IN 2020

As of December 31 2020, EU-27 had 6,620 cities signatories of CoM 2020, covering 160 million inhabitants.

6,620

2014

Average last emission monitoring year

Rivas, S. et al., 2022

40%

SHARE OF SIGNATORIES WITH MEI HAVING REACHED OR OVERSHOT THEIR TARGET

82%

82% ARE APPROACHING THEIR TARGETS

-0.986 tCO_2e

THIS AMOUNTS TO A TOTAL OF 127.7 $MTCO_2e$

AVERAGE EVOLUTION OF EMISSIONS PER CAPITA IN COM 2020 SIGNATORIES

(between their BEI and MEI)

ANALYSIS

Between harmonisation of practices and methodological innovations, the emission accounting and reporting from cities and regions are getting more robust

"***We need pledges to be implemented. We need commitments to turn concrete. We need actions to be verified. We need to bridge the deep and real credibility gap*"**. This statement by Antonio Guterres, Secretary-General of the UN General Assembly, in an address to COP26 delegates, preceded the announcement of the creation of a high-level panel of experts to measure and analyse the "zero" commitments of non-state actors (UN News, 11/11/2021). With two years to go until the Global Stocktake under the Paris Agreement (Article 14), the need to assess the progress of climate action is becoming ever more pressing.

Calculating the greenhouse gas (GHG) emissions of a territory, whether it is a State, a region or a city, is strategic to help the authorities steer mitigation efforts in the short and long term. Carbon accounting is as much a policy tool to drive evidence-based public policy as a political instrument for greater accountability and transparency towards citizens and the international community. As such, it is a cornerstone of the international cooperation under the Paris Agreement.

Naturally, it is easier to analyse the progress and results of the 193 States who signed the Paris Agreement together than of the countless local and subnational governments that make them up. This balancing act between the global viewpoint of assessing progress and the local origin of actions therefore invites us to turn to aggregation tools: voluntary reporting platforms, to which cities and regions communicate their GHG emission results. The **indicators (see below)** highlights that, despite progress in reporting practices, the aggregate impact of cities and regions on greenhouse gas emissions remains very difficult to quantify, due in particular to the great heterogeneity of inventory methods and practices. Moreover, individual monitoring of emissions at local level still falls short of data and robustness to provide a clear picture of emissions on the territory over time.

In the following analysis, we propose an overview of the practices and methodological innovations that contribute to the robustness of the monitoring of emissions by cities and regions.

Statistical carbon accounting, the basics for monitoring emissions of territories

Measuring one territory's carbon impact implies to delineate the boundaries that one stands in to observe emissions. Specifically, "*unlike the national accounts, cities home to 50% of world's population but comprise only approximately 3% of land mass, which means they have to outsource a large number of emissions to outside the city boundary*" (Chen et al., 2019). In this respect, there are two main instrument to carbon accounting for cities and regions that can be distinguished, according to their geographical and administrative limits:

• **The emissions inventory** is a statistical accounting instrument for direct emissions produced by activities *within the administrative or geographical boundaries* of a territory. It is used to identify their sources. The French Agency for Ecological Transition (Ademe) compares it to a "land register" for emissions, as it focuses on GHGs "physically" emitted in the territory. It can also include the production of electricity outside the territory used for its productive activities (Ademe, n.d.).

• **The carbon footprint** is another instrument used to aggregate direct emissions generated by the territory's production activities and indirect emissions induced by its production *outside its own boundaries*. In some cases, a carbon footprint can also include emissions induced by consumption activities, through the accounting of emissions embodied in imports and life-cycle assessments of products and services. Consumption-based or not, carbon footprint is a broader approach that aims to consider all the greenhouse gases that were necessary to support the territory's activities, regardless of their origin (Citepa, 2020).

Whatever the boundaries chosen, accounting systems and standards are based on the association of "emission factors" with the data on economic activities collected within the boundaries of the territory in order to obtain their carbon equivalent. Yet, there is a broad range of methodologies and standards to implement carbon accounting that have been developed by specialised agencies and global standards. They differ from each other in their scope of calculation, each with its advantages and disadvantages in terms of data access and aggregation, monitoring over time, translation into concrete policies, etc. These tools can be distinguished according to three "approaches" (**tab. 1**).

TABLE 1

CHARACTERISTICS OF THE THREE ACCOUNTING APPROACHES RELATED TO EXISTING CARBON ACCOUNTING TOOLS

Source: Association Bilan Carbone

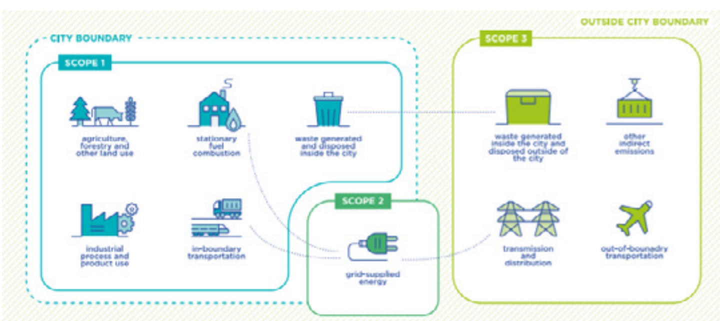
Approach	Territorial approach	Global approach	Consumption-based approach
Scope	*Scopes 1 and 2* This calculation of GHG emissions emitted directly on the territory by all actors by activity sector (Scope 1) does not take account of indirect emissions caused by meeting the needs of territories, other than indirect emissions linked to the consumption of energy originating in a production unit on its territory (Scope 2).	*Variable scopes 1, 2 and 3* Emission accounting taking account of all GHG emissions, whether direct or indirect, in other words, whether they are emitted by or for the territory. This is a more complex method because it requires a form of data collection that might prove difficult given the dispersed nature of information and a lack of statistical data at community level. A large degree of uncertainty is involved in accounting for indirect emissions. Finally, the use of scope 3, whose accounting methods are specific to each tool, renders comparisons impossible.	Accounting for all goods and services required by the territory (from internal production and imports) and therefore all sectors required for the final consumption by the inhabitants of the territory (sectors present on the territory or otherwise). This approach essentially takes account of the issue of consumption-based emissions as this is an emission source. As emissions are related to the end consumer, actions will naturally focus more on citizens and consumption-based behaviours and production and service companies.
Advantages	• More precise method • Reductions target based on this method • Robust • No double counting	• Comprehensive coverage of emissions • Raises all issues	• Easy to interpret • Communications oriented towards the citizen
Disadvantages	• It has a degree of bias in measuring emission reductions (e.g. outsourcing, electricity, etc.) • Excludes international maritime and air transport	• Not standardised • Complex to interpret • Double counting • Integrated approach with other territories: enables identification of the degree to which the activity of a different territory can impact its emissions count and vice versa	• Difficult to calculate • Calculations cannot be standardised
Uses	• International standard • Basis for all other methods • Permits aggregation to higher levels	• Design of a territorial action plan (PCET, PCTI etc.)	• Citizen mobilisation
methodologies and standards	• National inventory similar to UNFCCC or equivalent • Basemis	• Bilan Carbone® Territory • Global Protocol for CommunityScale • Greenhouse Gas Emissions Inventories (GPC) • BEI/MEI • US Community Protocol	• PAS 2070

FIGURE 1

SCOPES DEFINITION FOR CITY INVENTORIES IN THE GPC FOR CITIES

Source: GHG Protocol, 2014; C40, 2018

Scope	Definition
Scope 1	GHG emissions from sources located within the city boundary.
Scope 2	GHG emissions occuring as a consequence of the use of grid-supplied electricity, heat, steam and/or colling within the city boundary.
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.



Initiated by the World Resource Institute, C40 and ICLEI, the Global Protocol for Community Scale GHG Emission Inventories (GPC)[a] is the most globally used methodology for city-level carbon accounting. This framework was derived from the GHG Protocol Corporate Standard. To draw up the **carbon accounting of a territory**, the GHG Protocol for Cities uses three "scopes" to segment the boundaries of greenhouse gas sources (**fig. 1**).

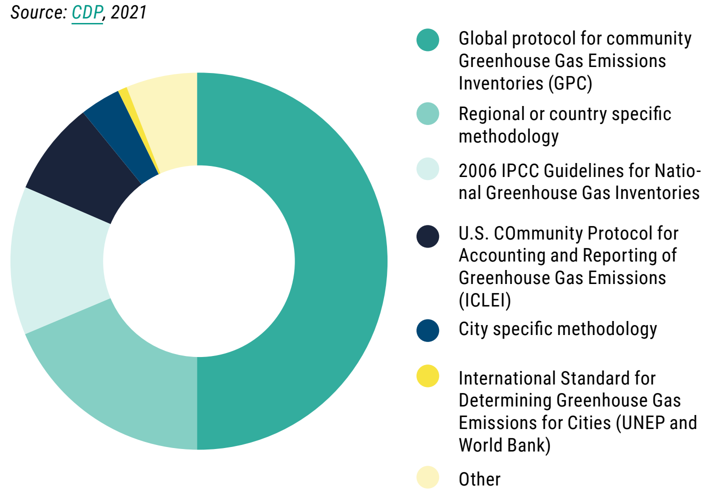
Most of carbon accounting systems are based on a territorial approach. These approaches only take account of emissions stemming from energy production and combustion located within the geographic or administrative boundaries of the territory (Scope 1) or include emissions from imported electricity necessary to in-boundary activities (Scope 2), territorial approaches fall short of reflecting emissions embodied in imported goods and services. Therefore, they do not take account of spatial, socio-economic inequalities embodied in the carbon footprint of consumption behaviours (Scope 3, consumption-based approach).

In practice, carbon accounting based on statistics rely on the ability of the decisionmakers to collect data on their territory's activities, as well as on the existence of carbon factors adapted to the local context. The reliability of inventories can therefore vary greatly (**ref. "Experience Feedback"**), and there is currently no universal standard for harmonising the rules and controlling the quality of emission inventories. Thus, within the same voluntary reporting database such as those of the CDP or the Covenant of Mayors, one may find very different calculation practices depending on the methodologies used (**fig. 2**), the selected year for the baseline inventory, the date of the monitoring inventory, the scopes covered, the available data, etc. In view of monitoring emissions, this poses a problem of aggregation and comparison between cities. Furthermore, the time required to collect data and build inventories often results in a time lag of several years between the date of publication of the inventory and the emission period covered. This time lag is at odds with the political time of the elected representatives' mandate and can weaken the steering and continuity of public policies. Therefore there is a whole field of research aimed at developing tools for better short-term monitoring of emissions.

FIGURE 2

SHARE OF EMISSION INVENTORY METHODOLOGIES USED BY REPORTING CITIES ON CDP PLATFORM IN 2021

Source: CDP, 2021



a The Global Protocol for Community Scale GHG Emission Inventories (GPC), also called GHG Protocol for Cities, was created in 2014 by WRI, ICLEI and C40 to provide cities with robust emission accounting standards and methodologies.

EXPERIENCE FEEDBACK

THE UNDER-REPORTING OF EMISSIONS IN AMERICAN CITIES RAISES THE ISSUE OF THE ACCURACY IN CARBON ACCOUNTING

On average, U.S. cities underestimated their fossil fuel related CO_2 emissions by 18.3%. This is the result of a recent study that compared voluntary GHG emissions inventories from 48 of the 100 highest emitting cities in the U.S. with data produced by Vulcan, a tool which aggregates emissions data from national public databases between 2010 and 2015. The largest differences observed by the authors of the study and developer of Vulcan, range from -145.5% to 63.5%. Cumulatively, these underestimated emissions represent 129 $MtCO_2$, or 25% more than the emissions of the State of California. Taken together, the 48 cities surveyed represent 13.7% of city emissions and 17.7% of the US population in 2015. The article points out that there is no systematic, peer-reviewed methodology to assess the quality of a voluntary emissions inventory. Consequently, they are likely to present large differences in approach that can lead to significant gaps in the consideration of certain emission sources in a territory. The most common differences concern the omission of petroleum fuel use, industrial and commercial emissions on site ("point source emissions"), differences in the consideration of marine and aviation emissions, and methodological differences for estimating road emissions. Such discrepancies are meaningful, as a miscalculation of emissions from a territory can distort one local government's judgement when adopting mitigation strategies. However, cities are not to be blamed, say the authors: inventories are perfectible, and could be improved by further documenting the boundaries of the urban system. They suggest that one solution could be to combine these voluntary bottom-up reporting systems with atmospheric observation and modelling systems.

Source: Gurney et al., 2021

From real-time monitoring to atmospheric measurements, ground-breaking tools emerge to complement statistical accounting, yet in their pilot phases

In addition to **statistical inventory** systems, new tools are emerging to measure and monitor emissions through spatialization. Per se, **mapping emissions** through spatialized inventories is not new: it consists in linking emissions estimated in statistical inventories to their geographical origin in order to map them on the scale of administrative or geographical boundaries (Citepa, n.d.).

For instance, in France, spatialized inventories are carried out at the regional level by the "recognized associations for air quality monitoring" (AASQA), provided for by the 1996 Law on Air and the Rational Use of Energy (known as the LAURE Law). As an example, in the Brittany region, Air Breizh, the regional air quality observatory, produces every two years a spatialized inventory of atmospheric emissions (ISEA) for about thirty pollutants (PM10, PM2.5, NOx, SO_2, NH_3, heavy metals, greenhouse gases, etc.) generated by nine sectors of activity (Energy industry, Residential, Tertiary, Non-energy industry, Road transport, Other transport, Waste, Agriculture & Forestry and Biotic). The ISEA spatializes the emissions at regional, departmental and local levels and presents them on an online platform in the form of maps and emission inventories (Air Breizh, n.d.).

This practice is pushed further by new tools being developed to enhance spatialized inventories with high frequency, localized and cost-effective data. By optimising the use of these data sets produced by all sorts of actors as administration, national statistic agencies, satellite monitoring systems, researchers and entrepreneurs propose to move towards "real-time" monitoring of emissions, in order to bring the inventory exercise closer to the time of policymaking.

The **City Climate Intelligence** (CCI) is an open platform which aims to provide "*high-resolution, near real-time CO_2 monitoring to increase citizen buy-in, support decision-making, and drive CO_2 emissions reduction investments within cities.*" This umbrella project promotes a "nested approach" to deliver emission data on three levels of spatial resolution: country and city level (Tier-1), district-level (Tier-2) and street or building-level (Tier-3). Currently in development and pilot phase, CCI is compounded of the Rocky Mountain Institute, an American think-tank, NEXQT, a young company working on climate data, the HESTIA Project (Northern Arizona University), which quantifies fossil fuel CO_2 emissions for individual cities in the US at street and building level, IG3IS (Integrated Global Greenhouse Gas Information System), an initiative led and hosted by the World Meteorological Organization, and Carbon Monitor.

At the country level (Tier-1), the **Carbon Monitor** provides regularly updated daily estimates of CO_2 emissions from fossil fuel use and cement production, using statistical and geospatial data. For example, to measure road transport activity and derive emissions based on national fleet characteristics, Carbon Monitor uses congestion data from GPS navigation system manufacturer TomTom (Liu, Z., Ciais, P., Deng Z., et al., 2020). In October 2021, the **Carbon Monitor Cities** platform was launched using the same principles to track the emissions of forty-seven major cities (Tier-1) around the world, including Paris, Berlin, Copenhagen, Sydney, Guangzhou, London, Mexico City, New York, Osaka, Rome, Seoul, Stockholm, Tokyo, Toronto and Johannesburg. Paris and Los Angeles currently are the only two cities to have a Tier-3 level of information at street and building-level. The Tier-3 project in the Paris region is also supported by Ai4Cities, an EU city-led initiative to harness the power of artificial intelligence to accelerate urban CO_2 emission reductions. Carbon Monitor Cities is due to scale up to nearly 1,500 cities over the world, with the contribution of CDP as for the convergence with their reporting system time series. CCI is also foundational for the work on standardizing science-based GHG monitoring services for cities and businesses.[b]

Among the datasets used by these projects, **atmospheric measurement** using ground sensors and satellite observations consists of mapping greenhouse gas flows in a geographical area at a certain moment in time and observing their evolution over time. It offers several advantages:

- By comparing the data collected by atmospheric measurement with the city's statistical inventory, it is possible to pinpoint sectors where the data do not match, and then to look for ways to improve the statistical method.
- At high spatial resolution, it makes it possible to locate emission sources precisely at the scale of a city, a district or a street, and thus to better target the public action decisions to be taken accordingly.
- At high frequency, the rapid updating of the data collected allows near "real-time" monitoring (from a few weeks to a few months) of emission trends, much closer to the time of the political decision than inventories, which always require several years to collect the data.
- Finally, atmospheric measurement can help verify the effectiveness of CO_2 reduction measures taken by city authorities.

However, the spatialization of emissions by atmospheric measurement has some limitations:

- By definition, it is limited to the Scope 1 of the territory observed, whereas a statistical carbon accounting will make it possible to measure the emissions linked to Scope 2 and 3, and thus to assess the territory's carbon footprint;
- In dense urban areas, it may be difficult to distinguish the territorial origins of emissions due to wind flows;
- Not yet industrialised, the most accurate measuring stations are expensive (up to €100,000). However, some basic sensors can be more affordable (up to €5,000);
- To be operational over time, these methods require a highly qualified expert to master modelling software, as well as political support from the local authority.[c]

  The atmospheric approach to urban CO_2 emissions is relatively new, most often in pilot phase and focused on large cities. As a result, only a few cities around the world are experimenting with these technologies to measure and monitor their emissions:

- In Mexico City, Mexico City Regional Carbon Impacts (MERCI-CO2) is a Franco-Mexican research project that aims to measure CO_2 concentration gradients and their evolution over time by deploying a dense network of ground-level and upper-air CO_2 sensors in the Metropolitan Area of the Mexico Valley. It involves the Laboratoire des sciences du climat et de l'environnement (LSCE) of the Institut Pierre-Simon Laplace (IPSL) on the French side, and the Grupo de Espectroscopía y Percepción Remota (EPR), Centro de Ciencias de la Atmósfera (CCA) of the Universidad Nacional Autónoma de México (UNAM) on the Mexican side. Funded by a call for tenders launched by the French National Research Agency (ANR), the project is supported by the Secretariat for the Environment (SEDEMA) in Mexico City. It began in early 2017 and was expected to finish by the end of 2021; yet the pandemic has caused some delays.[d]
- In Paris, the city council has unanimously voted to set up a system for the continuous measurement of CO_2 emissions in the city. To this end, a partnership agreement was signed with the LSCE and Origins.earth, a start-up belonging to Suez, in order to deploy a Météo Carbone®, an Origins.earth service combining data processing, atmospheric measurement of CO_2 concentration, emissions mapping and the publication of monthly indices to monitor the evolution of emissions and measure the gap with low-carbon objectives. Measurements started in July 2020.

Thus, these new methodologies open up prospects for increasing the robustness and credibility of territorial carbon accounting, but are not yet ready to be deployed on a large scale. Local government networks and initiatives are therefore striving to harmonise the different methodologies currently used by their members, in order to gain transparency and be able to aggregate results.

Harmonisation of emission reporting practices to strengthen the frameworks for transparency, monitoring and steering of the territories' action

Faced with the heterogeneity of emission accounting methodologies and perimeters, international networks of local governments have for several years been harmonising the rules and standards of voluntary reporting platforms in order to align practices.

The Global Covenant of Mayors for Climate & Energy (GCoM), the world's largest alliance for city climate leadership, has established the Common Reporting Framework (CRF) to streamline local government measurement and reporting procedures and ensure robust climate action planning, implementation, and monitoring across three pillars: mitigation, adaptation,

b This information was provided by Fouzi Benkhelifa, city climate action expert and founder of Nexqt.

c All of these points were made during an interview conducted in February 2021 with Michel Ramonet, CNRS researcher at the Laboratoire des sciences du climat et de l'environnement (LSCE) of the Institut Pierre-Simon Laplace (IPSL), coordinator of the MERCI-CO_2 project, and Thomas Lauvaux, CNRS researcher in atmospheric and carbon cycle sciences at LSCE-IPSL.

d Find the full case study in the Global Synthesis on Local Climate Action 2021 and energy access and poverty. facilitate comparison and aggregation of results to "assess the collective impact of GCoM cities in addressing climate change". Presented at the Global Climate Action Summit in San Francisco in September 2018 and in place since January 2019, the CRF facilitates global aggregation and comparison of city climate action to assess the collective impact of GCoM signatories in the fight against climate change.

Three levels of reporting requirements are set: mandatory (minimum level required by the initiative), recommended (recommended good practice) and supplementary (voluntary acceptable options). The common framework is intended to be flexible, to take into account local needs and situations such as the use of different methodologies, access to data, limited capacity of smaller governments and geographical locations. It also allows for adaptation to existing national and sub-national frameworks.

In particular, with regard to emissions reporting, the city is required to submit a first GHG inventory within two years of joining the GCoM, and then to update its GHG inventory every two years after submitting its climate plan.

The CRF applies to the two official reporting platforms that feed the GCoM:

- The "**CDP-ICLEI Unified Reporting System**". Since 2019, the merger of the CDP Cities reporting process and ICLEI's carbon*n*® Climate Registry (cCR) has created a single reporting space for cities, especially for GCoM signatories (72% of cities using the unified reporting system). In concrete terms, cities now fill out only one form on the CDP platform, whose data is automatically transferred to the cCR.

- "**My Covenant**". The extranet platform of the European Covenant of Mayors for Climate and Energy gathers data from the cities of CoM Europe, the Mediterranean, Eastern Europe, Central Asia, and Sub-Saharan Africa Convenants. The platform allows signatories to report all the documents required by the European Covenant of Mayors: baseline and monitoring emissions inventory, Sustainable Energy Action Plan, Adaptation Plan.

In 2021, an increasing number of cities contributed to the annual reporting on the CDP platform, from 770 cities in 2020 to 989 in 2021. However, not all these cities are reporting quantitative greenhouse gas emissions data. There has even been a decrease in the number of cities reporting their territorial emissions data from 401 to 371 (-7.5%), including a larger share of cities reporting a decrease in their emissions (198 in 2021 compared to 191 in 2020, i.e. 53.4% of the reporting cities). 56 cities reported their first inventory that year.

In view of the heterogeneity of the responses, it is difficult to clearly identify the reasons behind the decrease in emissions. "Technological change" is the first factor mentioned by more than a quarter (26.2%) of the municipalities reporting a decrease in emissions, followed by "behavioural change" (11.5%) and "policy change" (8.9%). It should be noted that a total of 13.6% (25) of respondents attribute their emissions decrease to a change in accounting methodology or in the quality of data access (CDP 2021 City-wide Emissions, 2021).

As for My Covenant platform, the latest analysis available from the Joint Research Centre shows that cities committed to the CoM 2020 targets of reducing emissions by 20% in 2020 from their baseline have nearly reached their targets (19.5% in average). This includes 40% of EU-27 cities signatories having presented their monitoring emission inventory who reached or overshot the target. However, the average latest monitoring emissions inventory was produced in 2014, which underlines the time gap between reporting practices and policymaking (**indicators**; Rivas, S. et al., 2022).

KEY TAKEAWAYS

Six years after the signing of the Paris Agreement, the emissions inventory and reporting practices of cities and regions are improving. The continued growth of local and sub-national governments' participation in voluntary initiatives such as the Covenant of Mayors and its regional chapters demonstrates a willingness to make a long-term commitment to a collective effort to reduce greenhouse gas emissions. However, the analysis of emissions data reported by local levels still suffers from heterogeneous methods and practices.

Emissions reporting by local and sub-national governments to major international platforms is largely based on voluntary engagement. Although there are a number of rules and methodological principles that underpin these commitments, the voluntary engagement of actors with major international climate initiatives relies on a form of flexibility in reporting rules to accommodate the disparate methodologies and means of cities and regions. Methodological diversities and uncertainties on the quality of inventories, absence of a universal standard and control and voluntary nature of reporting to international initiatives thus make it difficult to obtain an aggregation of emissions results communicated by local and regional authorities. Going beyond the contingencies of accounting and bottom-up reporting would allow to present aggregated results that can account for the effectiveness of government action and reinforce the credibility of these commitments.

We have identified three pathways opened up in recent years in the research community and in climate cooperation initiatives to strengthen the robustness of the data. First, the "real-time" monitoring of emissions through a more refined use of activity data available in all sectors brings the inventory exercise closer to the time of policymaking. Second, the spatialization of emissions through atmospheric measurement by satellite and ground sensors facilitates the geographical identification of greenhouse gas sources at a precise scale, while also reducing the temporal gap between information and decision. By revealing discrepancies with statistical inventories, atmospheric measurement also helps to identify areas where data collection can be improved. Finally, the harmonisation of emission reporting methodologies and platforms initiated by the GCoM's common reporting framework and the unified CDP-ICLEI reporting system over the past few years is part of this movement to steer players towards homogenised practices, with a view to enabling comparisons, facilitating aggregation, and improving transparency.