

D4.1: GPC inventory data quality assessment report

Special Focus on Transport Sector

Carbon Track and Trace 2.0 (CTT2.0) Deliverable

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Contents

1. Preface.....	3
1.1. About LoCaL	3
1.2. About Climate KIC	3
1.3. About Carbon Track and Trace	3
2. Executive Summary	4
3. Intro.....	4
4. carbonn Climate Registry	5
5. GPC – Global Protocol for Community-Scale Greenhouse Gas Emission Inventories	6
5.1. Requirements description	6
5.1.1. BASIC type inventory	8
5.1.2. BASIC + type inventory	8
5.1.3. BASIC+ S3.....	9
5.1.4. Scopes.....	9
5.1.5. Selection criteria for GPC	9
6. Inventory Data Quality Review	11
6.1. Availability of inventories	11
6.2. Data quality assessment criteria.....	11
6.3. Data Analysis process	13
6.4. Transport Data Quality Review.....	16
6.4.1. On Road	16
6.4.1.1. Transport Emissions from fuel combustion on-road transportation occurring in the city Sector: Transportation	16
6.4.1.2. Emissions from grid-supplied energy consumed in the city for on-road transportation.....	17
6.4.2. Railways	17
6.4.2.1. Emissions from fuel combustion for railway transportation occurring in the city	18
6.4.2.2. Emissions from grid-supplied energy consumed in the city for railways	19
6.4.2.3. Emissions from portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy consumption	20
6.4.2.4. Emissions from fuel combustion for waterborne navigation occurring in the city	Error! Bookma
6.4.2.5. Emissions from grid supplied energy for waterborne navigation occurring in the city	35
6.4.2.6. Emissions from portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy consumption	36
6.4.3. Off-road transportation.....	21

6.4.3.1. Emissions from fuel combustion for off-road transportation occurring in the city 21

6.4.3.2. Emissions from grid-supplied energy consumed in the city for off-road transportation..... 21

7. Findings 22

8. Future work 23

9. Conclusion..... 23

10. References 24

Annex I: Summary of the Quality Assessment of cCR reported GPC-inventory reports..... 25

1. Preface

1.1. About LoCaL

This report was written through support from Low Carbon City Lab (LoCaL). LoCaL aims to reduce 1Gt of CO₂ and mobilize €25 billion of climate finance for cities annually by 2050. It is an innovation platform aiming to provide cities with better tools for assessing greenhouse gas emissions, planning, investing and evaluating progress. Started in 2015, LoCaL is a growing community of more than 20 organisations dedicated to unlocking climate finance for cities. This report was realized as part of the project Closing the Gap through Transformative LoCaL Action (CGTLA) under LoCaL. LoCaL is a Climate-KIC flagship programme.

<http://local.climate-kic.org>. Contact: victor.gancel@climate-kic.org

1.2. About Climate KIC

Climate-KIC is the EU's largest public private partnership addressing climate change through innovation to build a zero carbon economy. We address climate change across four priority themes: urban areas, land use, production systems, climate metrics and finance. Education is at the heart of these themes to inspire and empower the next generation of climate leaders. We run programmes for students, start-ups and innovators across Europe via centres in major cities, convening a community of the best people and organisations. Our approach starts with improving the way people live in cities. Our focus on industry creates the products required for a better living environment, and we look to optimise land use to produce the food people need. Climate-KIC is supported by the European Institute of Innovation and Technology (EIT), a body of the European Union.

1.3. About Carbon Track and Trace

The Carbon Track and Trace (CTT) project is intended to provide cities with real-time greenhouse gas (GHG) measurement capability. Traditional methods of building and maintaining municipal GHG emission inventories are expensive, time-consuming, and are of questionable utility for mitigation decision and planning support processes. CTT couples low-cost, open source sensors to a Big Data analytics platform that provides cities and regions with a unique capacity to directly measure the impacts of their policy and planning decisions and to develop a semi-autonomous system for building, maintaining, and reporting their annual GHG emissions.

2. Executive Summary

The carbon n Climate Registry¹ (cCR) is a city-dedicated platform that allows cities and other local or sub-national governments to register and report their achievements, actions, commitments and targets against climate change. Operated by the Bonn Center for Local Climate Action and Reporting in Germany, the cCR supports 15 initiatives around the globe which include both mitigation and adaptation aspects.

Thanks to the amount of data that can be captured, cCR has attracted the attention of all types of communities such as States, Mega Cities, Metropolitan regions, Mid-Size cities, Towns, villages and small size communities. GHG reduction targets, GHG inventories at community level, Adaptation and mitigation actions, Action plans and sources of financing are the highlights of captured data available in the platform. The carbon n Climate Registry (cCR) and The Carbon Track and Trace (CTT) project share common goals regarding the data quality assessment and collection for GHG inventories. The data availability for certain sectors is key factor for a comprehensive and accurate inventory that complies with the requirements of GPC - Global Protocol for Community-Scale Greenhouse Gas Emission Inventories². It is important to clarify that cCR captures all GHG Inventory standards and is not limited to GPC only, but due to the advantages provided by GPC for this particular study, such as allocation by sector and sub-sector, identification of methodologies for disaggregation and focus on city-induced/driven emissions, only reports based on this protocol will be studied.

3. Intro

Mitigation is the most influential scope of actions against climate change and in order to implement appropriate actions on key sectors, a GHG inventory must be developed to understand and track emissions. Currently there are several standards and protocols that could help a city to develop such documents; these include the GPC - Global Protocol for Community-Scale Greenhouse Gas Emission Inventories³. This particular protocol allows cities and regions to accurately communicate their emissions on pre-defined sectors and sub sectors, aligning and at times surpassing other existing inventories on data collection and reporting.

The cCR has agreed to collaborate with CTT in order to examine and provide a summary of data quality assessment based on cities' reported GPC Inventories as far as they are available for study. This includes the three main inventory sectors for reporting:

- Stationary Energy
- Transportation
- Waste

¹ Website: <http://carbonn.org/>

² Website: <http://www.ghgprotocol.org/city-accounting>

³ GPC inventories reported through carbon Climate Registry are reviewed as part of the requirements of compliance for Compact of Mayors

Throughout the present document all of the findings will be presented based on the city's own assessment and assertion as noted in the respective reports.

4. carbonn Climate Registry

The carbonn Climate Registry (cCR) was launched at the World Mayors Summit on Climate in Mexico City on 21 November 2010, as the global response of local governments to measurable, reportable and verifiable climate action.

Operated by the carbonn Center, the cCR has become the world's leading reporting platform to enhance transparency, accountability, and credibility of local and subnational climate action in 6 years.

Currently, the cCR supports 16 unique projects or initiatives, including as of 2014, serving as the designated central repository of the Compact of Mayors, supporting reporting to the Compact of States and Regions, and is prime data partner of the UNFCCC's Non-State Actor Zone for Climate Action Platform⁴.

The standard cCR reporting consists of 1 informative sheet and 9 reporting sections. Depending on the initiative or project participation, special questions might be added or omitted to the standard reporting sheet. A descriptive list is shown below; minimum required tabs are shown in italic:

1. ***Read me:*** Brief introduction of this reporting sheet
2. ***Account info:*** *collects identification information of the reporting entity and its government*
3. ***Profile:*** *collect material to build the geopolitical, economic and environment contexts.*
4. ***Target and commitments:*** where the reporting entity announces quantifiable targets to address mitigation and adaptation commitments
5. ***Action plan:*** provides a brief overview of its climate action plan.
6. ***GHG Inventory-GPC:*** Allows reporting government GHG inventory within its selected boundaries, according to the requirement of GPC (Protocol for Community-Scale Greenhouse Gas Emissions)⁵.
7. ***Energy performance:*** is the place reporting entity tracks energy generation and consumption performance
8. ***GHG Inventory-Government:*** Allows reporting for GHG-inventory of government related operations, a corporate inventory so to speak.
9. ***Adaptation & Resilience:*** Allows reporting of climate hazards and impacts, risk and vulnerability assessment
10. ***Action:*** tracks climate change mitigation and adaptation actions

⁴ Website: <http://climateaction.unfccc.int/>

⁵ If a city do not wish to report using GPC format, a Simplified GHG Inventory sheet can be downloaded to replace the GPC one

5. GPC – Global Protocol for Community-Scale Greenhouse Gas Emission Inventories

The GPC – Global Protocol for Community-Scale Greenhouse Gas Emission Inventories was developed by WRI – World Resource Institute in collaboration with ICLEI, C40 and UN Habitat.

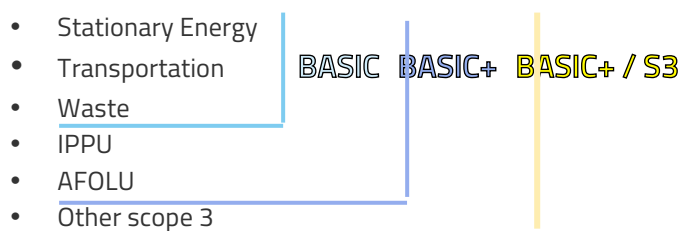
This standard is considered to provide a robust framework for data collection, accounting and reporting city-wide greenhouse gas emissions. Its main goals are:

- Help cities develop a comprehensive and robust greenhouse gas inventory in order to support climate action planning
- Help cities establish a base year emissions inventory, set reduction targets, and track their performance
- Ensure consistent and transparent measurement and reporting of greenhouse gas emissions between cities, following internationally recognized greenhouse gas accounting and reporting principles
- Enable city inventories to be aggregated at subnational and national levels
- Demonstrate the important role that cities play in tackling climate change, and facilitate insight through benchmarking – and aggregation – of comparable data⁶

A pilot test was taken in 2013, while the inclusion of global public comments was taken in 2014. This version takes over draft versions and overrides the International Local Government Greenhouse Gas Emissions Analysis Protocol (community section) published by ICLEI in 2009 and the International Standard for Determining Greenhouse Gas Emissions for Cities that was published by the World Bank, United Nations Environment Programme (UNEP), and UN-HABITAT in 2010.

5.1. Requirements description

The GPC provides a comprehensive overview of all of the emissions that take place within the boundaries of a city. Taking into account that Stationary Energy, Transportation and Waste are the core sectors for emissions; IPPU and AFOLU have also been included due to the great variety of city types that exist around the world and taking into consideration the level of industrialization of the city and/or the presence of national parks or massive green areas within the community boundaries.



⁶ Source: <http://www.ghgprotocol.org/city-accounting>

A colour-coded grid allows easy identification of the sub-sectors to be reported to provide description of the exclusion or inclusion of certain emissions depending on the desired type of inventory to be reported or compiled.

Sectors and sub-sectors	Scope 1	Scope 2	Scope 3
STATIONARY ENERGY			
Residential buildings	✓	✓	✓
Commercial and institutional buildings and facilities	✓	✓	✓
Manufacturing industries and construction	✓	✓	✓
Energy industries	✓	✓	✓
<i>Energy generation supplied to the grid</i>	✓		
Agriculture, forestry, and fishing activities	✓	✓	✓
Non-specified sources	✓	✓	✓
Fugitive emissions from mining, processing, storage, and transportation of coal	✓		
Fugitive emissions from oil and natural gas systems	✓		
TRANSPORTATION			
On-road	✓	✓	✓
Railways	✓	✓	✓
Waterborne navigation	✓	✓	✓
Aviation	✓	✓	✓
Off-road	✓	✓	
WASTE			
Disposal of solid waste generated in the city	✓		✓
<i>Disposal of solid waste generated outside the city</i>	✓		
Biological treatment of waste generated in the city	✓		✓
<i>Biological treatment of waste generated outside the city</i>	✓		
Incineration and open burning of waste generated in the city	✓		✓
<i>Incineration and open burning of waste generated outside the city</i>	✓		
Wastewater generated in the city	✓		✓
<i>Wastewater generated outside the city</i>	✓		
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			
Industrial processes	✓		
Product use	✓		
AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU)			
Livestock	✓		
Land	✓		
Aggregate sources and non-CO ₂ emission sources on land	✓		
OTHER SCOPE 3			
Other Scope 3			
<div> ✓ Sources covered by the GPC <div> + Sources required for BASIC+ reporting <div> ○ Sources included in Other Scope 3 </div> </div> </div> <div> <div> ● Sources required for BASIC reporting <div> ● Sources required for territorial total but not for BASIC/BASIC+ reporting (<i>italics</i>) </div> </div> <div> ● Non-applicable emissions </div> </div>			

Image 1 Colour-coded grid showing the main sectors to be reported on GPC⁷

⁷ Source: WRI. (2014) Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, page 13

5.1.1. BASIC type inventory

BASIC inventory request information for Scope 1 and 2 on the following sectors and sub sectors.

- I. Stationary Energy**
 - I.1. Residential buildings
 - I.2. Commercial and institutional buildings and facilities
 - I.3. Manufacturing industries and construction
 - I.4. Energy industries
 - I.5. Agriculture, forestry, and fishing activities
 - I.6. Non-Specified sources
 - I.7. Fugitives emissions from mining, processing, storage, and transportation of coal
 - I.8. Fugitive emissions from oil and natural gas systems
- II. Transportation**
 - II.1. On road
 - II.2. Railways
 - II.3. Waterborne navigation
 - II.4. Aviation
 - II.5. Off-road
- III. Waste (including Scope 1 and 3)**
 - III.1. Disposal of solid waste generated in the city
 - III.2. Biological treatment of waste generated in the city
 - III.3. Incineration and open burning of waste generated in the city
 - III.4. Waste water generated in the city

Allowed notation keys on BASIC

- IE Included elsewhere – including explanation on where can we find the value
- NO Not occurring
- C Confidential

5.1.2. BASIC + type inventory

A BASIC+ type inventory includes all of the emissions from BASIC and adds the following sectors and sub sectors.

- IV. Industrial processes and product use (IPPU)**
 - IV.1. Industrial processes
 - IV.2. Product use
- V. Agriculture, Forestry and Other land use (AFOLU)**
 - V.1. Livestock
 - V.2. Land
 - V.3. Aggregate sources and non-CO2 emissions sources on land

Allowed notation keys on BASIC+

- IE Included elsewhere – including explanation on where can we find the value
- NO Not occurring
- C Confidential

5.1.3. BASIC+ S3

A BASIC+ S3 type inventory includes all of the emissions from BASIC+ and adds the following sectors and sub sectors.

VI. Other Scope 3

5.1.4. Scopes

The scopes framework is based on the same principle used by the *GHG protocol Corporate Standard* which utilizes boundaries related to operations. In comparison, GPC uses the physical borders as the actual boundaries of the system to be managed.

The use of scopes defines which emissions are generated by the city and which emissions are generated by the city induced activities.

In-boundary emissions physically generated within the city (Scope 1) and differ from all of the emissions from use of electricity, steam and/or heating /cooling supplied by grids which may or may not cross city boundaries (Scope 2). There is a third classification, those emissions occurring outside city limits but driven by actions occurring inside the city (Scope 3)

5.1.5. Selection criteria for GPC

The GPC has demonstrated that is an inclusive standard that allows logical reporting of emissions according to the most important sectors available on a city. It surpasses all of the publicly available standards in several key points such as:

- Allows accurate emissions allocation
- Includes all 7 GHG
- Offers variety of methodologies for data disaggregation
 - City induced
 - Sales volume

- Location and market based
- Can be applied independent from local regulations
- Allows the calculation of In-boundary and trans-boundary emissions
- Allows detailed aggregation for national level inventories

Such is the value of the GPC that has been adopted as the official standard for reporting for initiative such as the Compact of Mayors⁸ while many more are currently evaluating the adoption of the standard.

Compact of Mayors and the GPC

The Compact of Mayors is a global city initiative that relies on GPC inventories to publicize cities emissions. Cities should demonstrate commitment for taking action against climate change in both mitigation and adaptation. Cities must develop a BASIC inventory as minimum requirement for the first year and have further 2 years to reach BASIC + inventories.

GPC is the only accepted protocol for reporting community based inventories on this initiative, totals and sector final values are later made public on their website along with Adaptation related documentation such as Action Plan and Vulnerability Assessment.

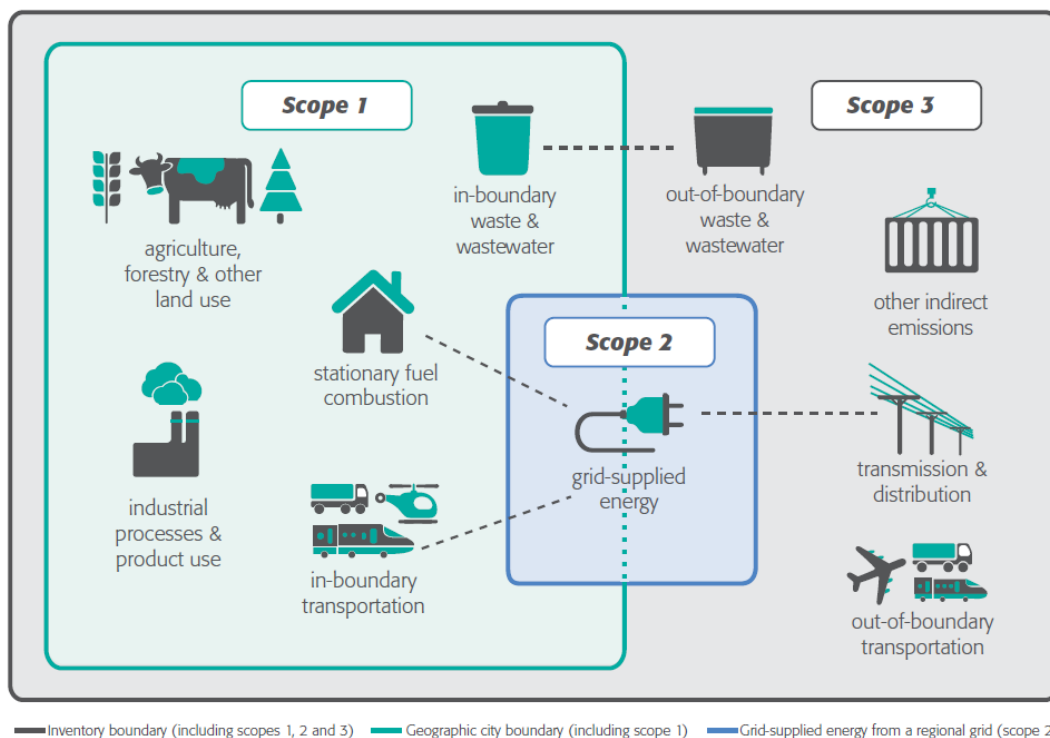


Image 2 sources and boundaries for city emissions⁹

⁸ Link: <https://www.compactofmayors.org/>

⁹ Source: WRI. (2014) Global Protocol for Community-Scale Greenhouse Gas Emission

6. Inventory Data Quality Review

Data quality is one item within GPC reports to be internally assessed by the reporting entity for each sector of emissions. The following presents the background and examines reported data quality in detail.

6.1. Availability of inventories

There are currently 22 GPC available inventories on cCR and 60+ inventories in process of upscaling and review. For the present exercise, inventories from 2 regions will be selected for studying their reporting criteria on data quality assessment with a focus on the transportation sector.

The selected regions were Europe and East Asia. The main criteria for this selection was the availability of inventories from these regions as Europe has 11 and East Asia 6; making this the two main groups with reporting and reviewed inventories and giving us 17 for analysis.

The available inventories in Europe are distributed as follows:

- Spain (10)
- Sweden (1)

The available inventories in East Asia are distributed as follows:

- Chinese Taipei (5)
- South Korea (1)

6.2. Data quality assessment criteria

Every reporting entity needs to provide an internal assessment for the quality of their data; this includes the reported activity data and emission factor. The present report examines these internal assessments as they are in the reports, based on the GPC reporting conventions detailed in Table 2 below.

Activity data (AD) defines all the volume of units that express the demand on certain service or activity and represents the activity that produces emissions; it can be represented on measuring units such as:

- kWh
- Cubic meters
- Gallons
- Joules

Emission factors (EF) represents the volume of emissions per unit, this means kg of CO₂ (or any other GHG) per unit of activity data, as represented below. The factor is important because depending for example on local energy systems, the amount of CO₂ produced will vary depending on the amount of renewable energy in the local mix. Similar factors can be applied to all sectors.

$$GHG\ emissions = Activity\ data * Emission\ factor$$

This means for example for electricity use:

$$kgCO_2 = kWh * (kgCO_2 / kWh)^{10}$$

The quality of the data can be assessed as high, medium or low; the interpretation differs between AD and EF and shown in the table below.

Data quality	Activity data	Emission factor
High (H)	Detailed activity data	Specific emission factors
Medium (M)	Modeled activity data using robust assumptions	More general emission factors
Low (L)	Highly-modeled or uncertain activity data	Default emission factors

Table 2 Data Quality Assessment¹¹

The criteria can be described with the following examples for electricity:

Activity data

- kWh consumed by a city, this value is obtained through the service provider directly from its local generation: Quality assessment is **H (HIGH)**
- kWh consumed by a city downscaled or modelled from national level using per capita intensity due to lack of data at local level: Quality assessment is **M (MEDIUM)**
- kWh consumed by a city downscaled modelled from regional/Global level using per capita intensity due to lack of data at local level with high uncertainty: Quality assessment is **L (LOW)**

Emission factors

- Emission factors developed locally based on the grid mix (including local generation): Quality assessment is **H (HIGH)**
- Emission factor used is the national average due to lack of means to develop a local EF: Quality assessment is **M (MEDIUM)**
- Emission factor used is global default with high uncertainty due to lack of means to develop a National/local EF: Quality assessment is **L (LOW)**

¹⁰ WRI. (2014) Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, Equation 5.1, page 48

¹¹ WRI. (2014) Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, page 53

The GPC provides a column on its reporting form that allows further explanation of the methodology for data collection or calculation, as well as a column for explaining exclusions; should these exist on the final report.

6.3. Data Analysis process

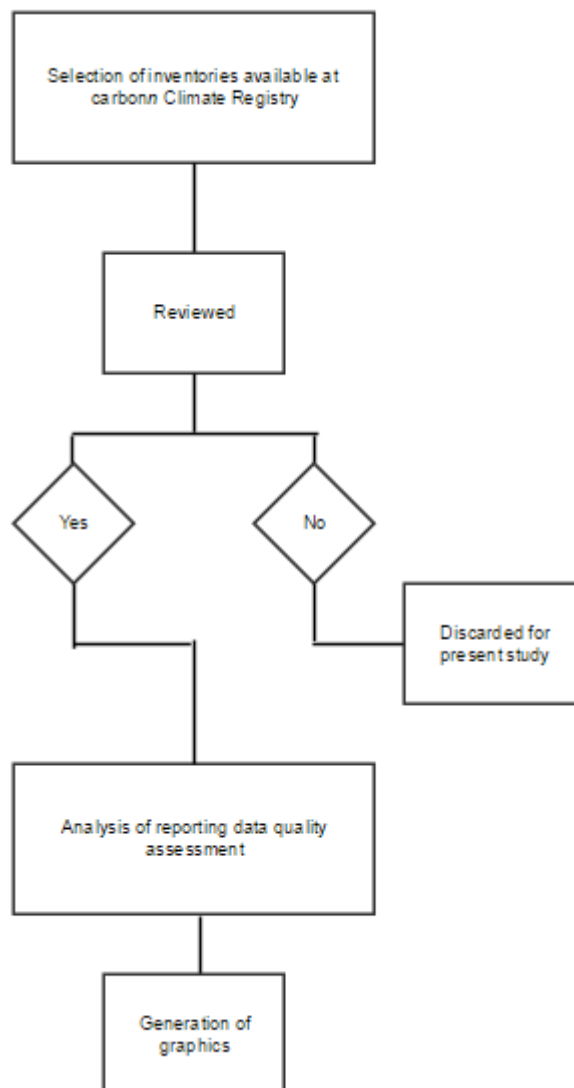
The data analysis process selects the group of inventories that have been already reviewed and that complies with data requirements for the BASIC level of reporting for GPC.

This group of reviewed inventories has provided the following support material in order to allow a review of the calculation process (sampling of equations):

- Activity data (.xls, .pdf or .word)
- Emission factors (.xls, .pdf or .word)
- Global Warming Potential (Assessment report number)
- Defined physical boundary of the inventory
- Defined time limits of the inventory (365 days)
- Supporting report

This has allowed a simplified review to trace back the source of the data as well as the criteria for data disaggregation and replication of calculations.

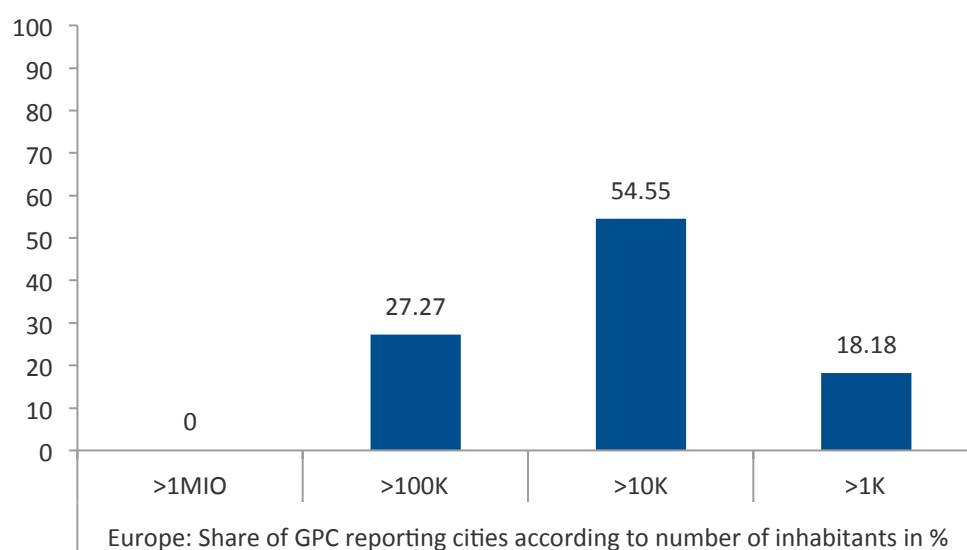
These inventories have been reported as compliant for the Compact of Mayors and are currently under their update process for year 2 which required further data requests and analysis.



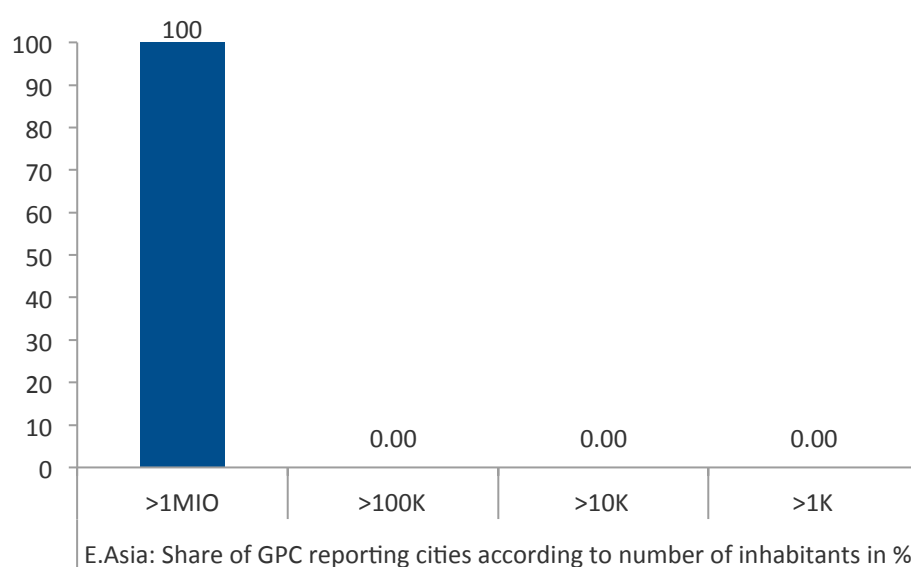
Flowchart 1 Process flow for data review

The workflow in this report is to map out the quality assessment of all sectors and sub-sectors of the GPC reported inventories, this means to account how many sectors identify their AD and EF as H, M or L.

This exercise will provide an overview of the degree of difficulty for obtaining High Quality data for specific sectors, highlighting the need of developing new methods and tools for such task.



12



13

Due to the scope of the project; only directly related sectors will be analysed, in this case Transportation. As CTT provides metering for street level emissions, only the On-Road, Railway and Off-road transportation will be the focal point of this document¹⁴. The selection was based on the following criteria: 1) GPC Aligned, 2) GPC revised and 3) regions with more inventories registered.

¹² Source: carbonn Climate Registry Database

¹³ Source: carbonn Climate Registry Database

¹⁴ Additional sectors and sub-sectors are available as annex on this document

6.4. Transport Data Quality Review

6.4.1. On Road

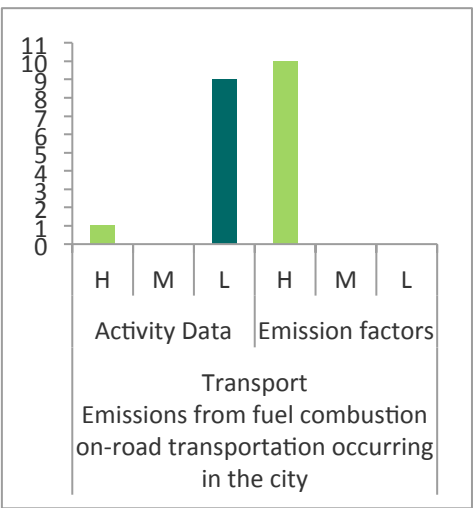
On Road emissions refer to all of the vehicles that use the entire public road of the city, this can be classified as:

- Public transport
- Private vehicles
- Commercial fleet

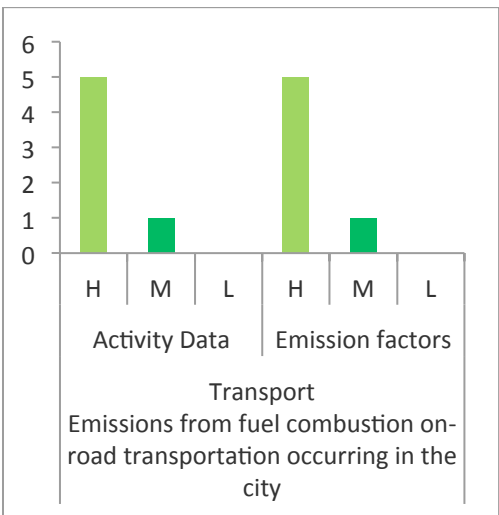
The sources of energy could be any type of fossil fuel (for scope 1) or grid-supplied energy (For scope 2). Scope 3 has a mixed approach as it its calculated based on the city boundary’s influence, meaning all of the measurable emissions occurring outside the city, e.g. buses leaving the city centre towards another city, or work commuters. This portion of the inventory can also be modelled using proxy data.

6.4.1.1.Transport Emissions from fuel combustion on-road transportation occurring in the city Sector: Transportation

Europe

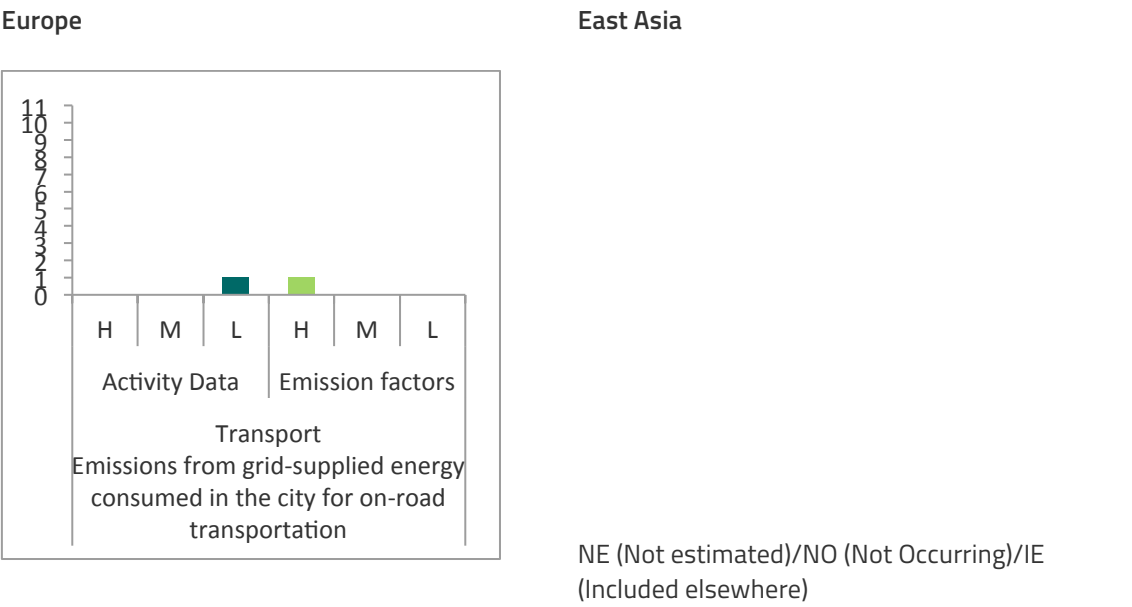


East Asia



10 inventories from Europe and 6 from East Asia reported this sub-sector. From this graphic, according to the assessment provided by the reported entities, European inventories show an apparent difficulty for collecting High Quality data for this particular sub-sector while East-Asia shows a significant difference on such criteria. This represents On-road public transportation such as buses, trams, or BRT.

6.4.1.2. Emissions from grid-supplied energy consumed in the city for on-road transportation



Only one inventory reported grid supplied energy used for On-road transportation in Europe, Activity data was reported as L while Emission factor was reported as H. East Asia did not reported emissions or there was no available methodology for data disaggregation for this particular sub-sector, follow-up is needed to establish if this is due to lack of data available or because the source is negligible. One of the European inventories reported it as Negligible.

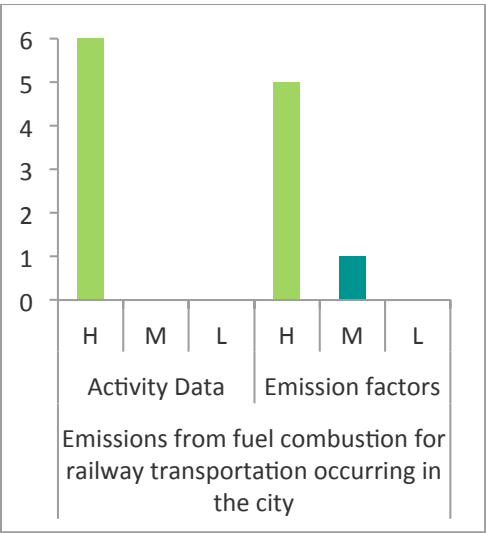
6.4.2. Railways

Railway related emissions refer to all of the emissions from transport means using railway such as passing trains and in-city mass transportation (Metro). This includes geographic, city induced and resident activity. The report of this particular sector could represent a challenge as some railway emissions are directly linked with the same fossil fuel used for On-road transportation and when trips occur at trans-boundary level, disaggregation can be a constraint.

6.4.2.1. Emissions from fuel combustion for railway transportation occurring in the city

Europe

East Asia

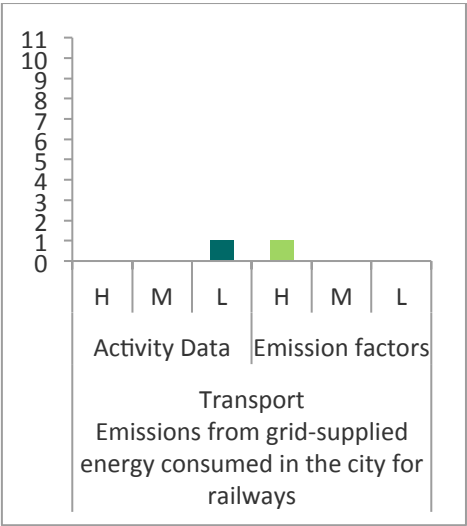


NE/NO/IE

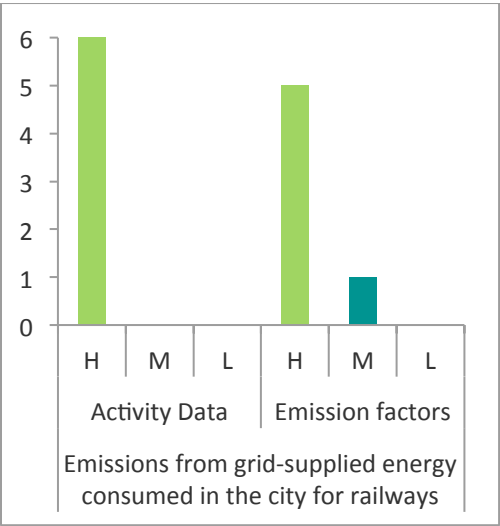
6 inventories by East Asia reported this sub-sector, No data from European cities was reported directly; all East Asian cities reported emission under this sub sector. All of the activity data was reported as H, for emission factors, 5 were reported as H while only one was reported as M. Once again this is highly influenced by the local traffic system; public transport using Railway; such as tram or metro is the main cause for this.

6.4.2.2. Emissions from grid-supplied energy consumed in the city for railways

Europe



East Asia

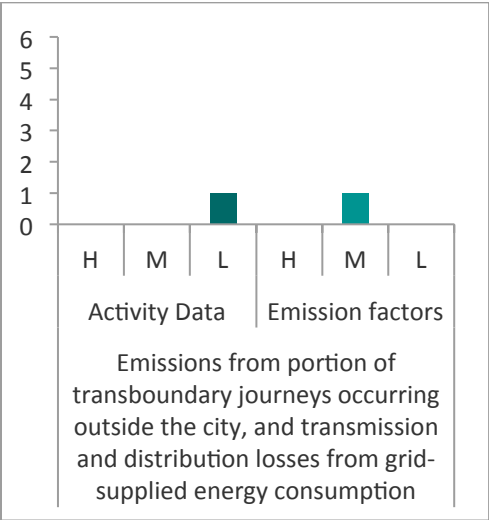


1 inventory from Europe reported this sub-sector while 6 inventories from East Asia reported it. This Sub-sector shows the influence of the number of inhabitants on the emissions of the city, as East Asian cities rely on Trams and Sub-ways for public transportation as well as performing as a hub for intercity railways. All 6 cities published their activity data with an assigned H qualification and 1 one out of 6 emission factors with M qualification for quality assessment, following the trend of Fuel Combustion. Once again this is highly influenced by the local traffic system; public transport using Railway; such as tram or metro is the main cause for this

6.4.2.3. Emissions from portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy consumption

Europe

East Asia



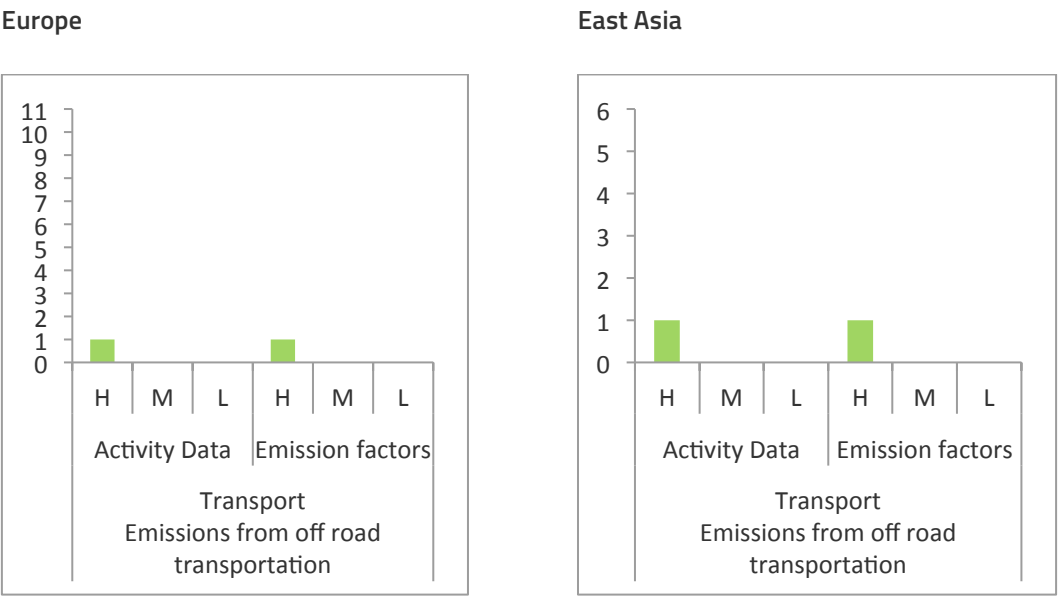
NE/NO/IE

Only one inventory reported Scope 3 on this sub sector, as this particular Scope is voluntary with exception of Waste which is mandatory for BASIC; none of the European inventories reported this particular section. East Asian cities follow the trend with only one exception, which in turn, decided to model the outcome. This decision could be influenced due to lack of data and difficulty to access the required first-hand information.

6.4.3. Off-road transportation

Off-Road transportation refers to all of the transport means that are use either within industrial premises, airports and farmlands located inside city boundary. This includes forklifts, buses for transport passengers from terminal to airplane within airport, tractors and trucks for heavy load within construction sites or farms.

6.4.3.1. Emissions from fuel combustion for off-road transportation occurring in the city



1 city per region reported off road emissions, assessing both with high quality for AD and EF.

6.4.3.2. Emissions from grid-supplied energy consumed in the city for off-road transportation

Europe	East Asia
NE/NO/IE	NE/NO/IE

7. Findings

The analysed inventories have provided a data quality assessment that allows identifying the main constraints for having accurate data and data disaggregation.

However, these initial findings should not be considered definitive as the reviewed inventories belong to small to mid-size cities in Europe (less than 0.5MIO inhabitants), and similarly cities in East Asia considered as small to mid-size, even though the population there surpasses the numbers compared to Europe. (Over 1MIO inhabitants).

Non-GPC inventories are available as well but since all of these are presented in different standards, they are more difficult to align and a comparison would prove more challenging.

The highlights of this study are listed below:

- Data availability for calculation seems to be the major constraint
- Disaggregation of emissions also presents challenges, as there is difficulty to allocate emissions from particular sources of combustions; e.g. how to allocate emissions from Stationary Energy Grid Supplied energy to Transport Grid Supplied energy for On-road transportation.
- This disaggregation issue occurs in the main transportation sectors On-Road, Railways and Off-road.
- In case of negligible emissions, cities consistently used Notation Key NO (Not Occurring), none used NE (Not Estimated)
- All of the cities reported BASIC level mandatory fields
- From East-Asian cities group, at least 1 city reported S3 for 4 sub-sectors in stationary energy and for Transport at least 3 sub-sectors reported S3. This does not occur with European group of cities
- Proper summary of inventory is still required, as most of the presentation required is hard to follow up to understand calculation process
- A technical description of the data collection process is necessary to understand the limitations/constraints on this stage of the Inventory development
- Constant improvement on first hand data is important to elaborate accurate values which reflect the current situation on particularly challenging sectors such as On-Road transportation.

8. Future work

GPC reporting cities are currently being requested for an update of their inventories by using the several available methodologies for On-Road calculation e.g. fuel sales volume or vehicle Kilometres travelled (VKT), each with their own advantages and disadvantages.

Data needs to be refined and further cleaned to identify the constraints per region and type of city. There exists the need of educate local governments in the importance of data management per-sector.

The availability of alternative ways to map out emissions and data to be used as proxy is a key factor for accurate GHG inventories. First-hand information relies on how much data is available on-site at the correct time period, the use of proxy is also important as an aiding factor for filling data gaps that might considerably cause deviation for the final result.

9. Conclusion

More completed and reviewed inventories are needed to allow comparison between similar cities; although constraints will be similar, budget could be one the main issues as at most basic level of reporting, inventories could take months¹⁵¹⁶ for data collection which in turn requires available workforce, data management and furthers resources for this purpose all before even stepping into the calculation and data cleaning phase. It is important to highlight the need of harmonized GHG Inventory standard so aggregation can be done following a smooth and integrated process.

The lack of means for physical measuring is a considerable factor, taking into account that it influences the GHG concentration at ground level, which has an important secondary impact on urban health. There is the need to pilot further strategies for data compilation, as the calculation process has already been defined.

The following points must be enhanced for increased data quality:

- Refined methodologies for data collection
- Harmonized data templates
- Alternative real-time metering for data extrapolation
- Centralized standard compliance data review

¹⁵ D. Ahlers and P. Driscoll. Understanding challenges in municipal greenhouse gas emissions inventories. In ICE ITMC Conference, 2016.

¹⁶ Cost-benefits of Greenhouse Gas (GHG) activity based and automated data gathering, CTT2.0 Carbon Track and Trace – Deliverable D4.3, Carsten Rothballer, Michele Zuin.

10. References

1. WRI, C40, ICLEI Global Protocol for Community-Scale GHG Emission Inventories – An Accounting and Reporting Standard for Cities (GPC), 2014.
2. D. Ahlers and P. Driscoll. Understanding challenges in municipal greenhouse gas emissions inventories. In ICE ITMC Conference, 2016.
3. Cost-benefits of Greenhouse Gas (GHG) activity based and automated data gathering, CTT2.0 Carbon Track and Trace – Deliverable D4.3, Carsten Rothballer, Michele Zuin.

Annex I: Summary of the Quality Assessment of cCR reported GPC-inventory reports

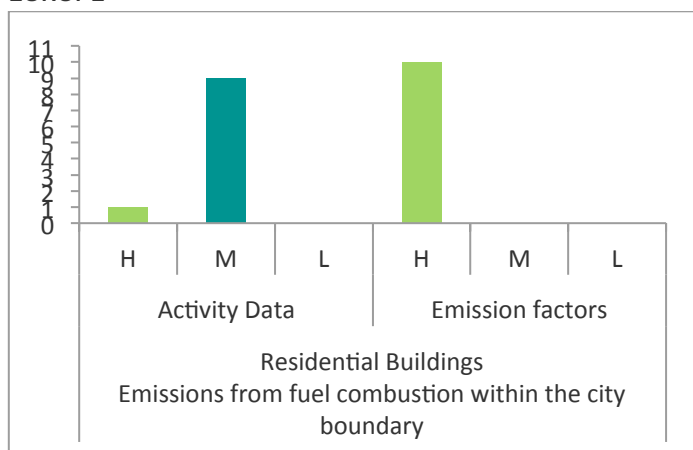
This annex summarizes all of the sectors and sub sector that were also available for analysis.

I. Stationary Energy

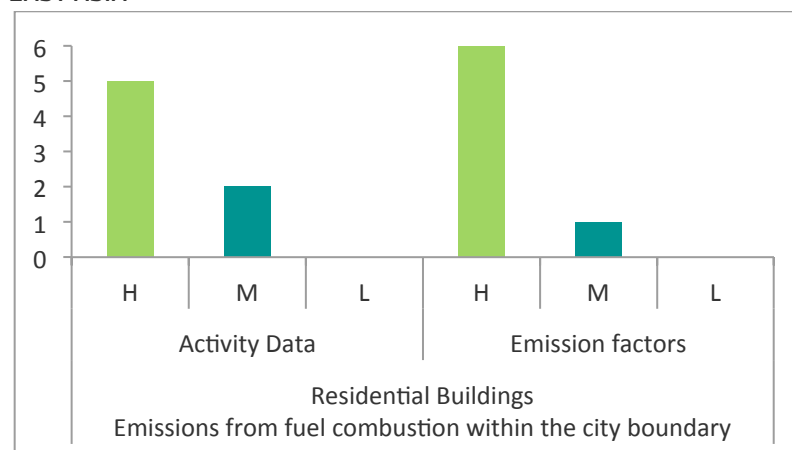
Residential buildings

I.1.1 Emissions from fuel combustion within the city boundary

EUROPE

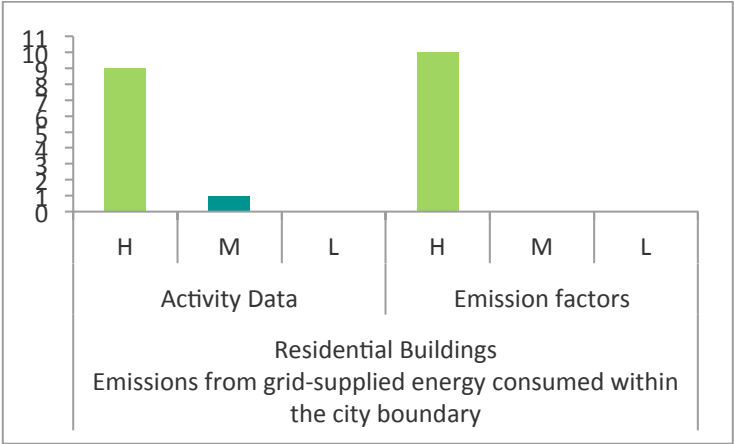


EAST ASIA

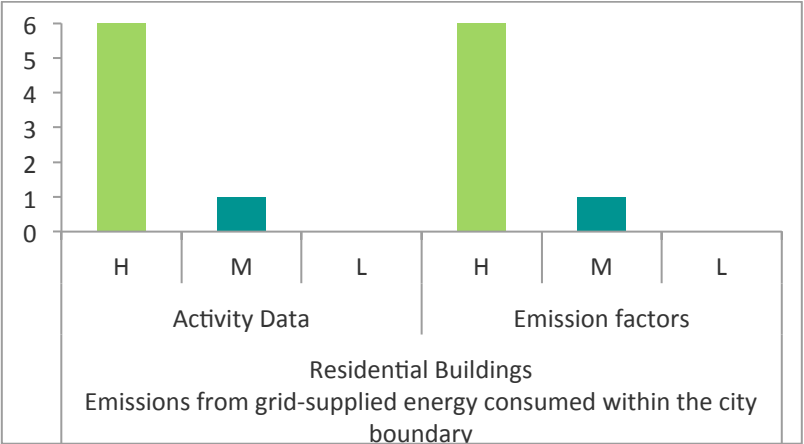


I.1.2 Emissions from grid-supplied energy consumed within the city boundary

EUROPE



EAST ASIA

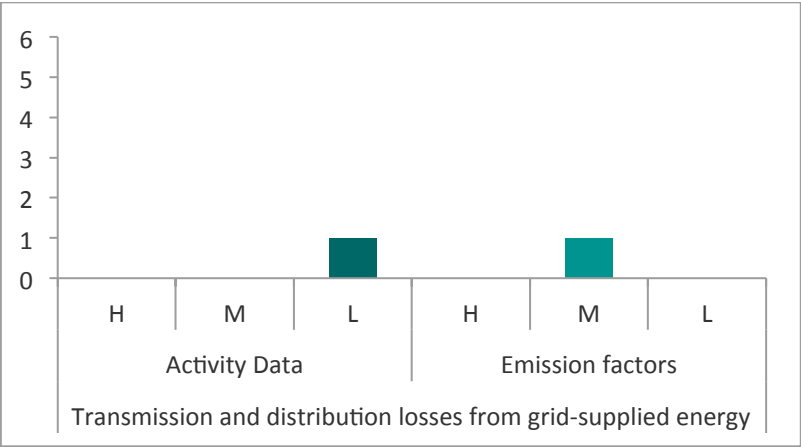


I.1.3 Transmission and distribution losses from grid-supplied energy

EUROPE

Not Reported/Not Occurring or Included under other sector

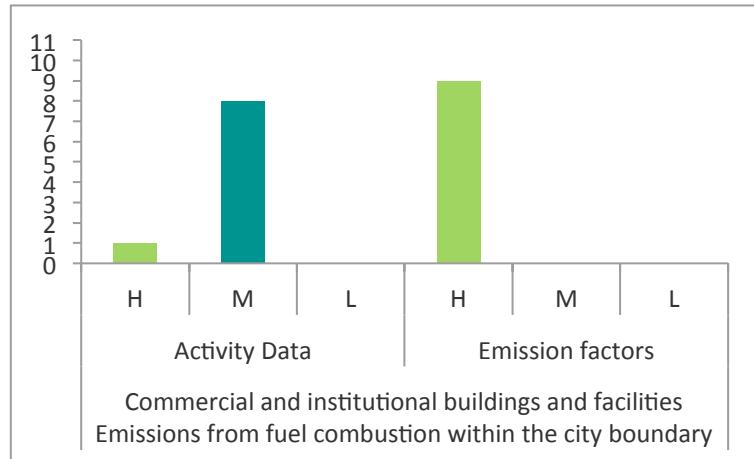
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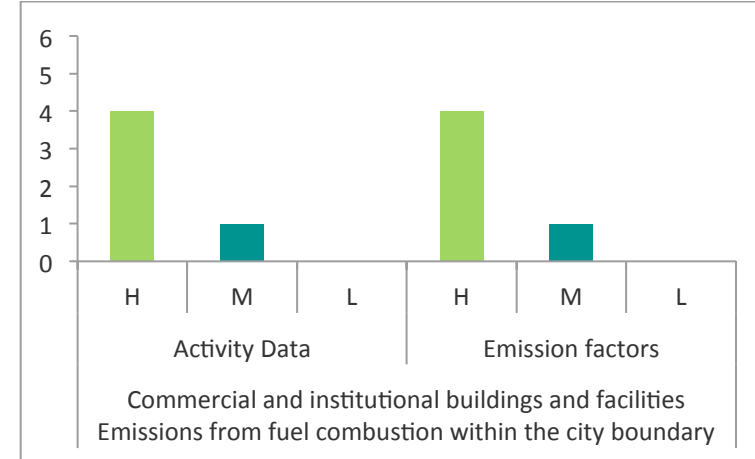
Commercial and institutional buildings and facilities

I.2.1 Emissions from fuel combustion within the city boundary

EUROPE

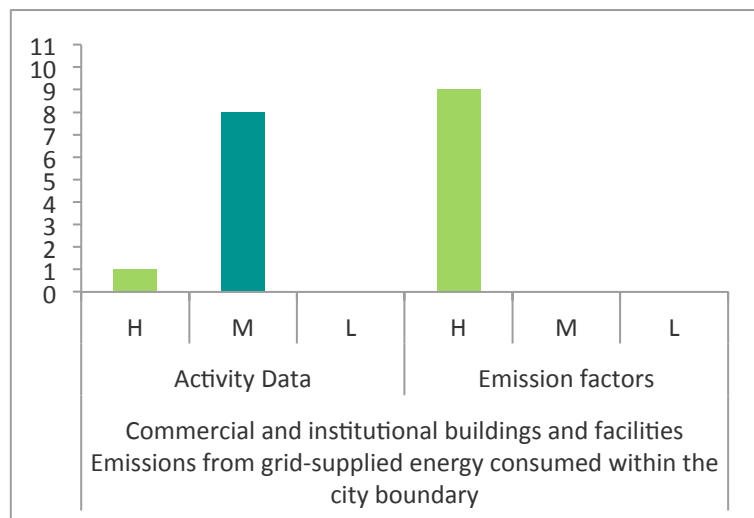


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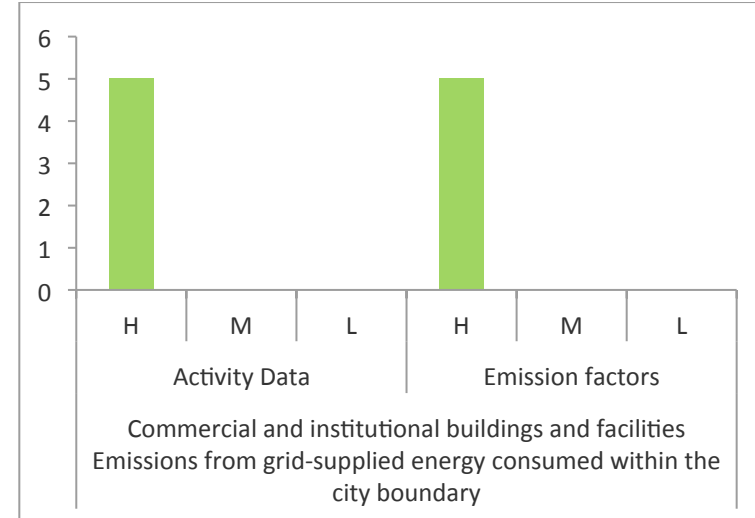


I.2.2 Emissions from grid-supplied energy consumed within the city boundary

EUROPE



EAST ASIA

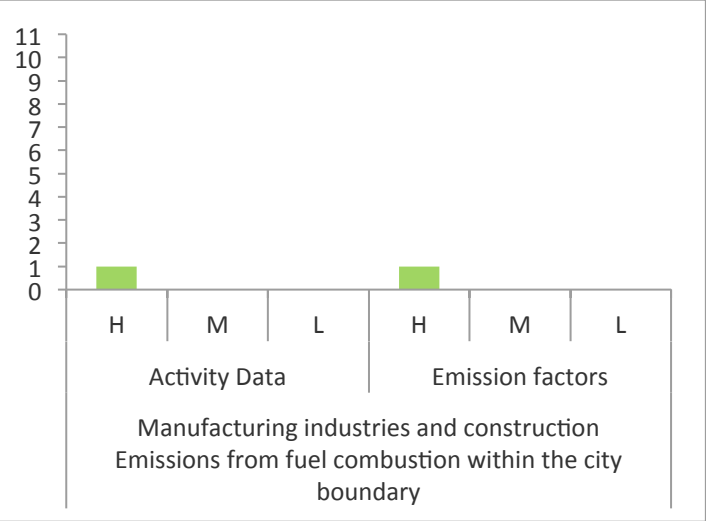


I.2.3 Transmission and distribution losses from grid-supplied energy
EUROPE

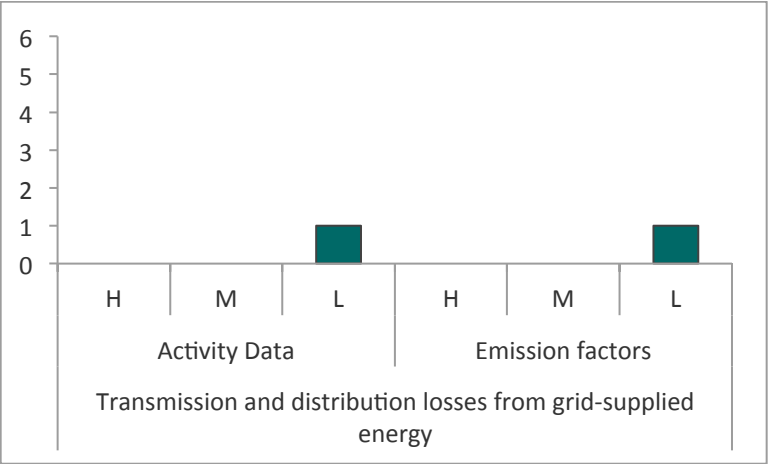
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Manufacturing industries and construction

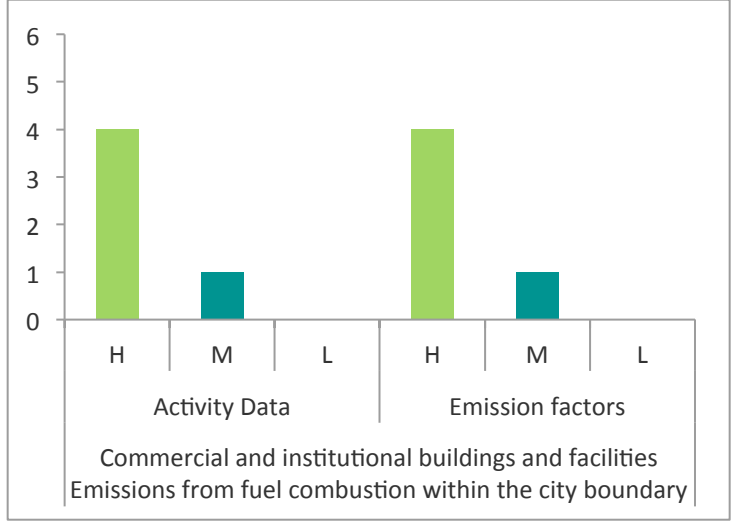
I.3.1 Emissions from fuel combustion within the city boundary
EUROPE



EAST ASIA

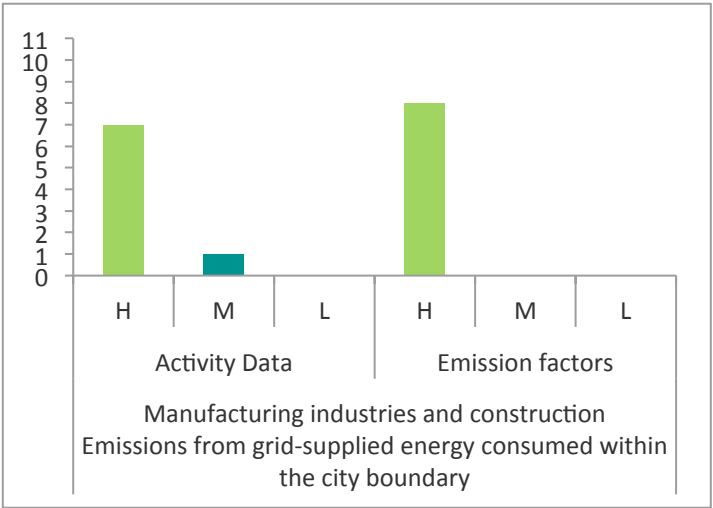


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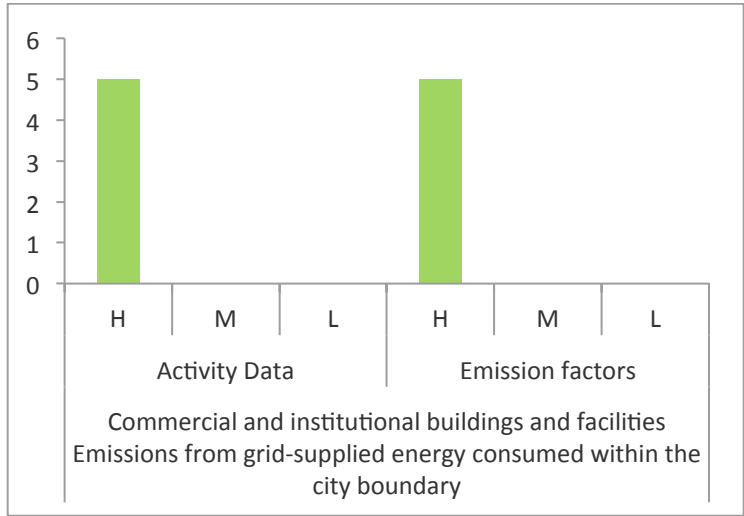


I.3.2 Emissions from grid-supplied energy consumed within the city boundary

EUROPE



EAST ASIA

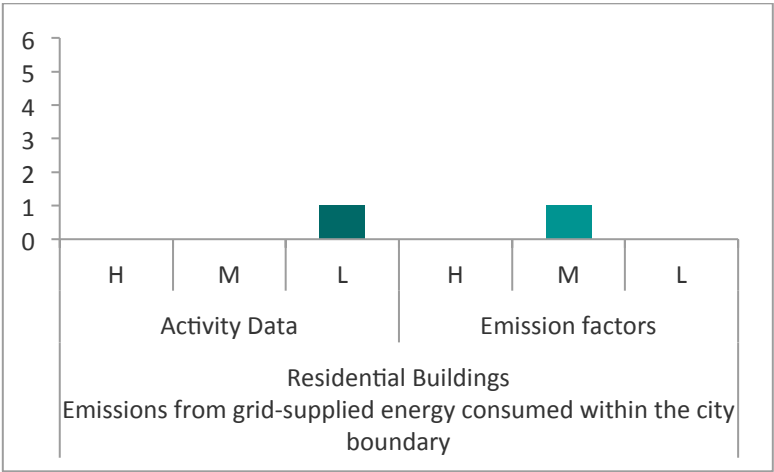


I.3.3 Emissions from grid-supplied energy consumed within the city boundary

EUROPE

Not Reported/Not Occurring or Included under other sector

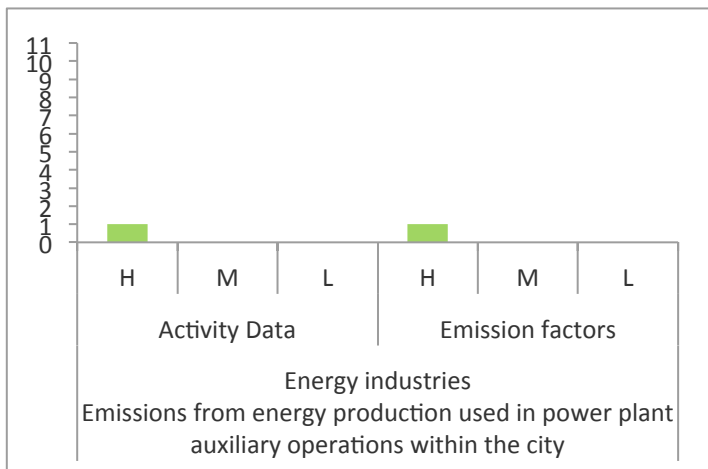
EAST ASIA



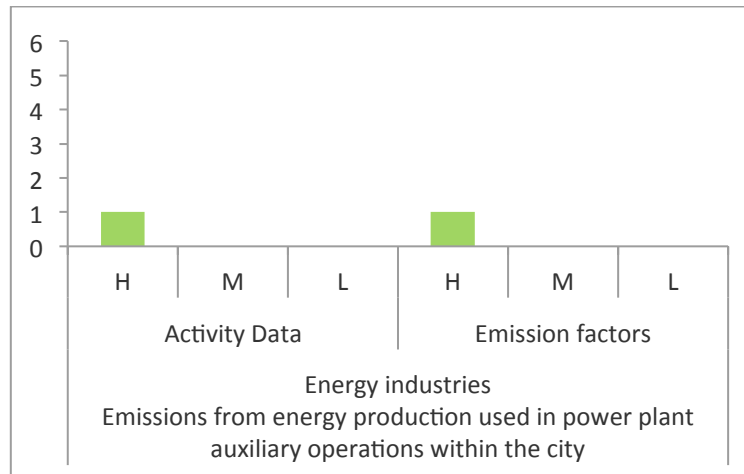
Energy industries

I.IV.I Emissions from energy production used in power plant auxiliary operations within the city

EUROPE



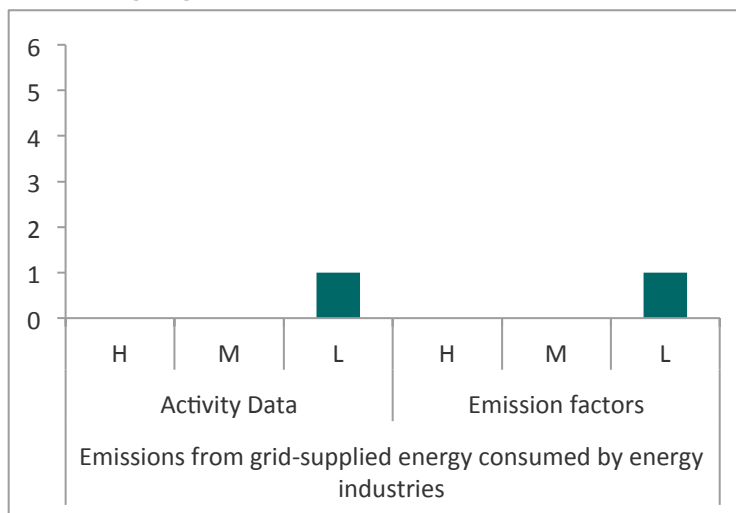
EAST ASIA



I.IV.II Emissions from grid-supplied energy consumed by energy industries

EUROPE

EAST ASIA



Not Reported/Not Occurring or Included under other sector

I.IV.III Emissions from transmission and distribution losses from grid-supplied energy used in power plant auxiliary operations

EUROPE

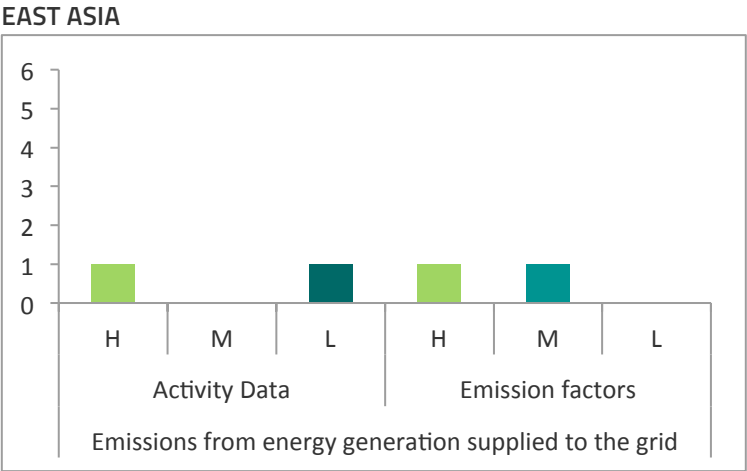
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EAST ASIA

Not Reported/Not Occurring or Included under other sector

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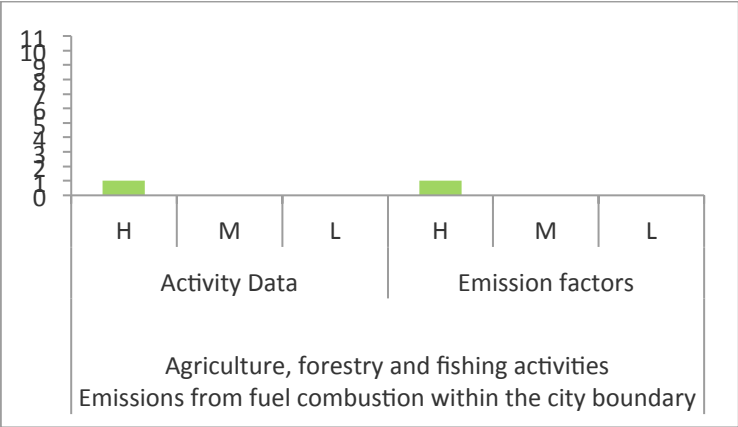
EUROPE



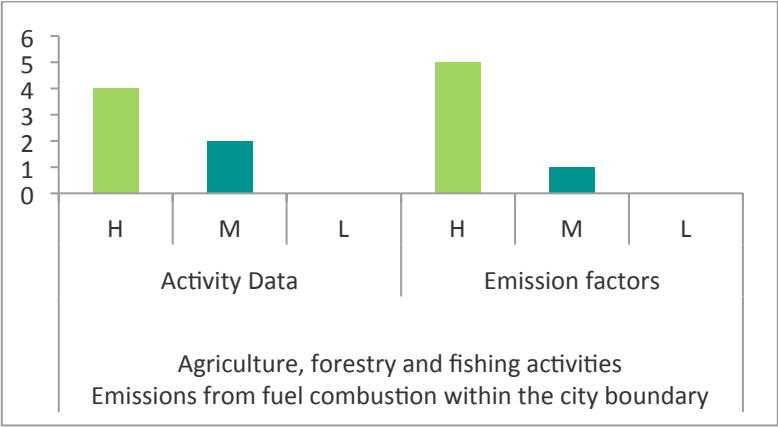
Agriculture, forestry and fishing activities

I.V.I Emissions from fuel combustion within the city boundary

EUROPE



EAST ASIA



I.V.II Emissions from grid-supplied energy consumed within the city boundary

EUROPE

Not Reported/Not Occurring or Included under other sector

EAST ASIA

Not Reported/Not Occurring or Included under other sector

I.V.III Transmission and distribution losses from grid-supplied energy consumption

EUROPE

Not Reported/Not Occurring or Included under other sector

EAST ASIA

Not Reported/Not Occurring or Included under other sector

Non-specified sources

I.VI.I Emissions from fuel combustion within the city boundary

EUROPE

Not Reported/Not Occurring or Included under other sector

EAST ASIA

Not Reported/Not Occurring or Included under other sector

I.VI.II Emissions from grid-supplied energy consumed within the city boundary

EUROPE

Not Reported/Not Occurring or Included under other sector

EAST ASIA

Not Reported/Not Occurring or Included under other sector

I.V.III Emissions from transmission and distribution losses from grid-supplied energy consumption

EUROPE

EAST ASIA

Not Reported/Not Occurring or Included under other sector

Not Reported/Not Occurring or Included under other sector

Fugitive emissions from mining, processing, storage, and transportation of coal

I.VII.I Emissions from fugitive emissions within the city boundary

EUROPE

Not Reported/Not Occurring or Included under other sector

EAST ASIA

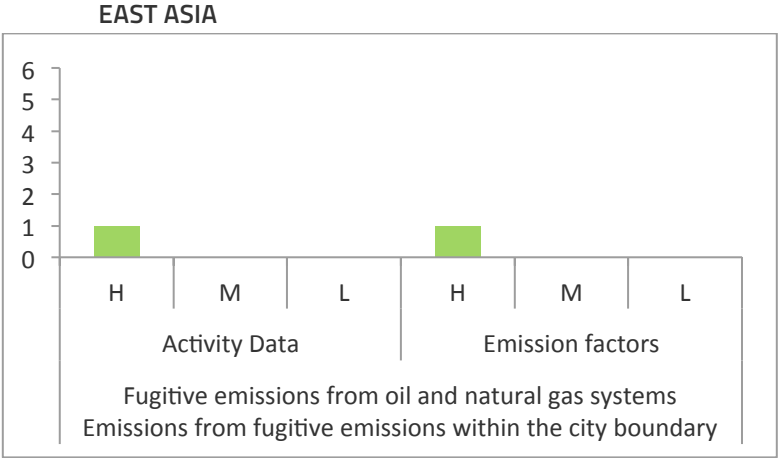
Not Reported/Not Occurring or Included under other sector

Fugitive emissions from oil and natural gas systems

I.VIII.I Emissions from fugitive emissions within the city boundary

EUROPE

Not Reported/Not Occurring or Included under other sector



II. Transportation

On-road transportation¹⁷

II.1.3 Emissions from portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy consumption

EUROPE

Not Reported/Not Occurring or Included under other sector

EAST ASIA

Not Reported/Not Occurring or Included under other sector

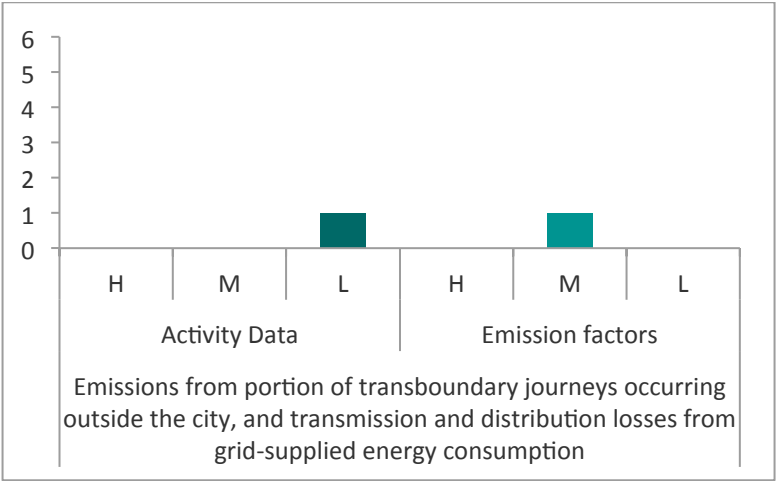
Railways¹⁸

II.2.3 Emissions from portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy consumption

EUROPE

Not Reported/Not Occurring or Included under other sector

EAST ASIA



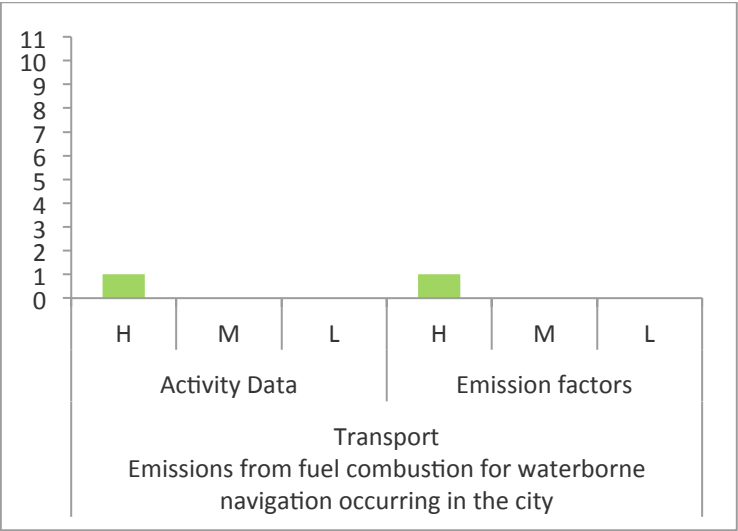
¹⁷ Scope 1 and 2 are included in the body of the document (Page 16)

¹⁸ Scope 1 and 2 are included in the body of the document (Page 17)

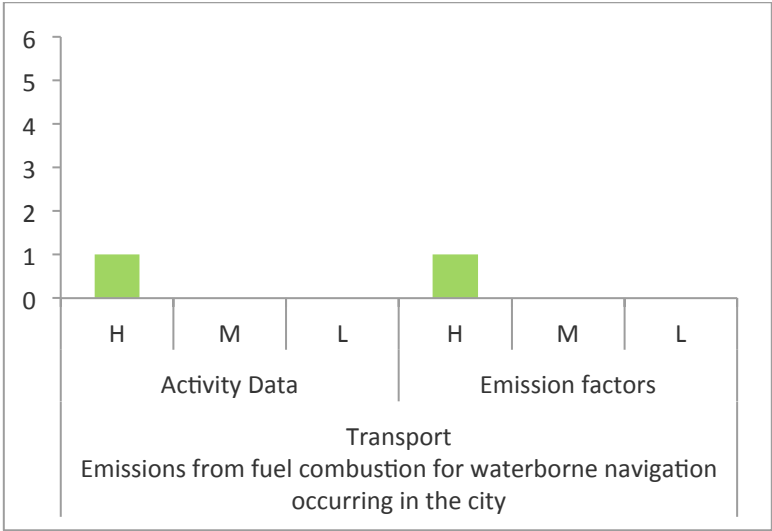
Waterborne navigation

II.3.1 Emissions from fuel combustion from journeys occurring inside the city

EUROPE



EAST ASIA



II.3.2 Emissions from grid supplied energy for waterborne navigation occurring in the city

Europe

Not Reported/Not Occurring or Included under other sector

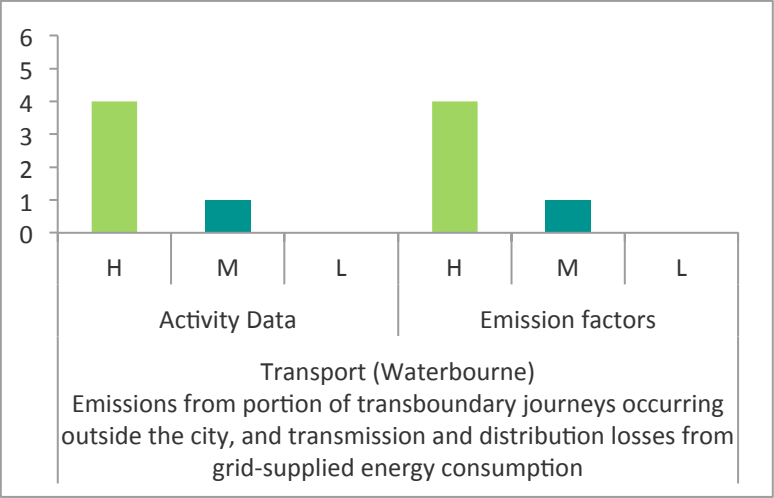
East Asia

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II.3.3 Emissions from portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy consumption

Europe

East Asia

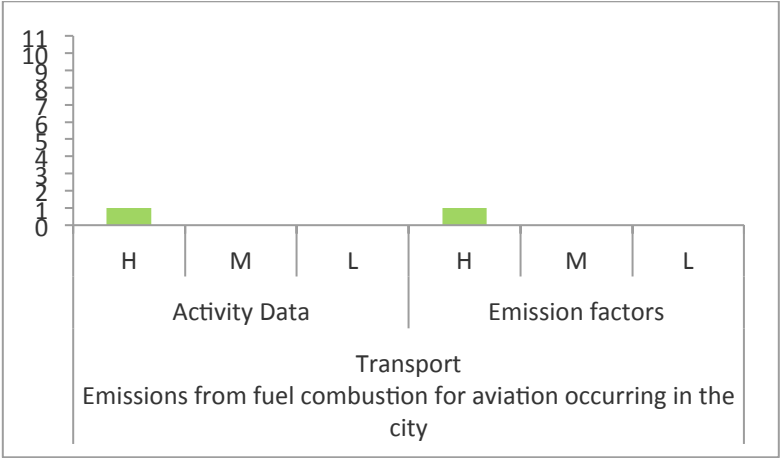


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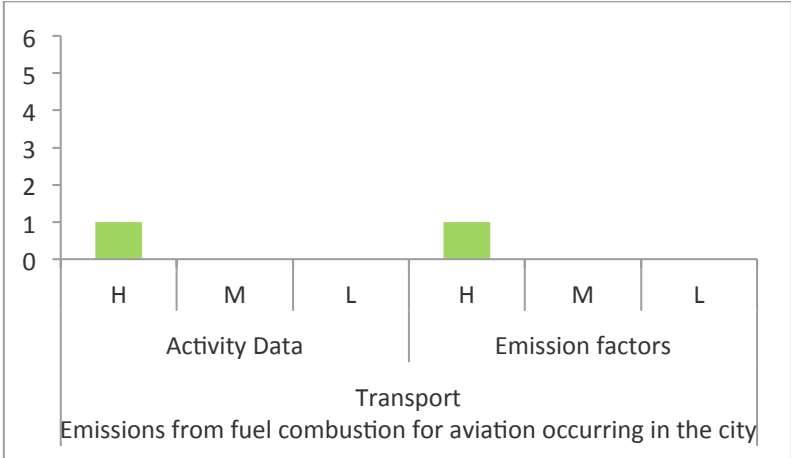
Aviation

II.4.1 Emissions from fuel combustion for Aviation occurring in the city

EUROPE



EAST ASIA



II.4.2 Emissions from grid-supplied energy consumed in the city for aviation

EUROPE

Not Reported/Not Occurring or Included under other sector

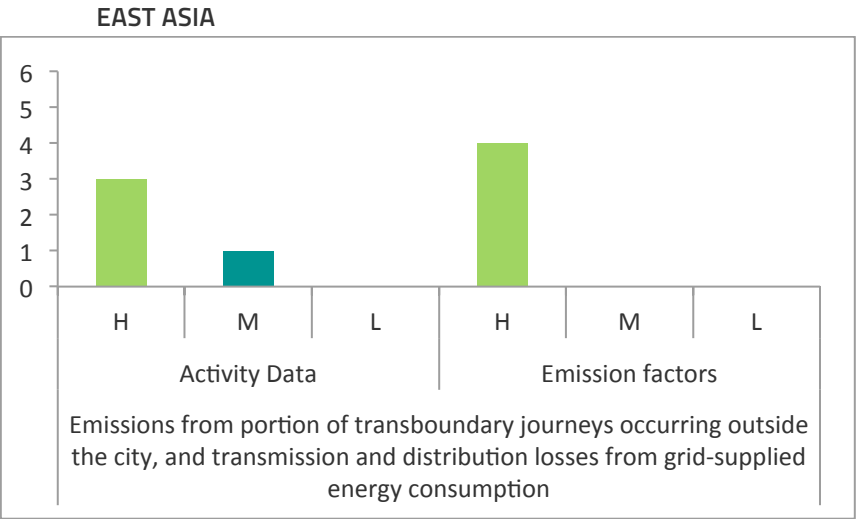
EAST ASIA

Not Reported/Not Occurring or Included under other sector

II.4.3 Emissions from portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy consumption

EUROPE

Not Reported/Not Occurring or Included under other sector



*Off-road transportation*¹⁹

II.5.3 Emissions from portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy consumption

EUROPE

Not Reported/Not Occurring or Included under other sector

EAST ASIA

Not Reported/Not Occurring or Included under other sector

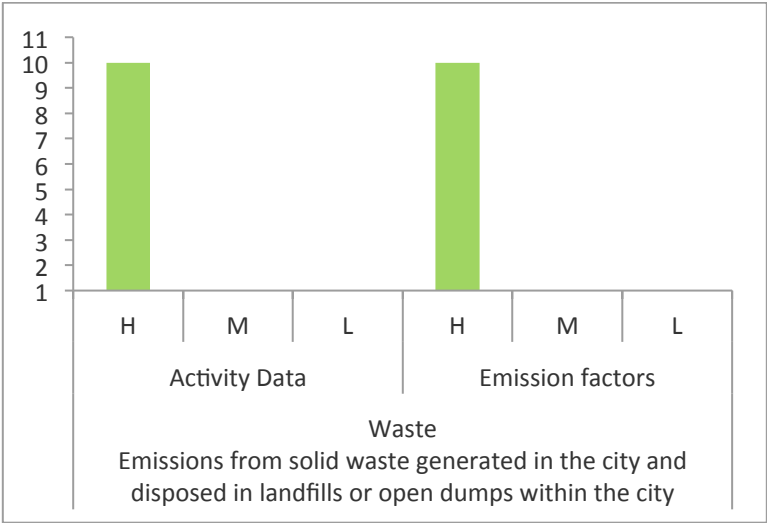
¹⁹ Scope 1 and 2 are included in the body of the document (Page 23)

III. Waste

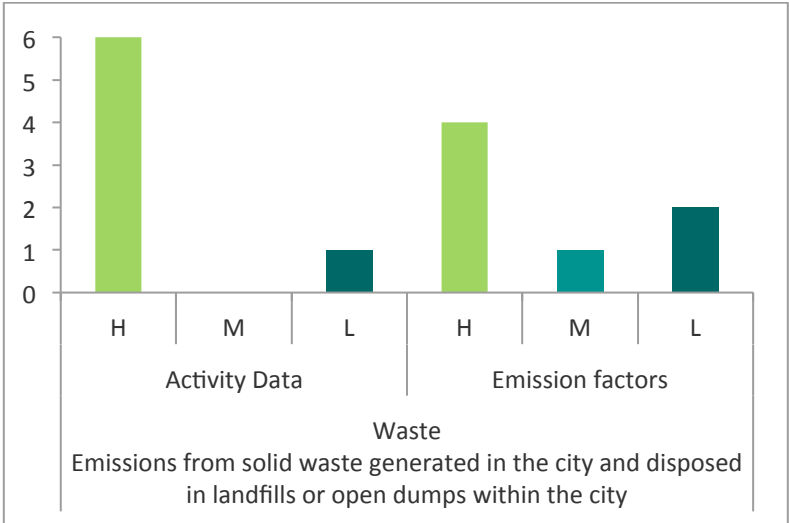
Solid waste disposal

III.1.1 Emissions from solid waste generated in the city and disposed in landfills or open dumps within the city

EUROPE



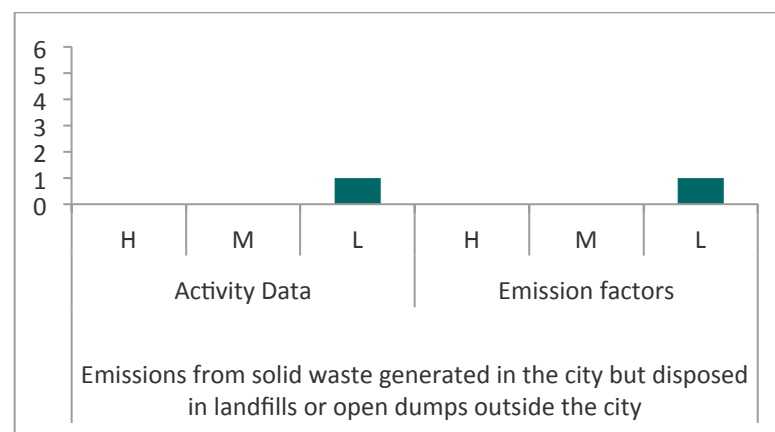
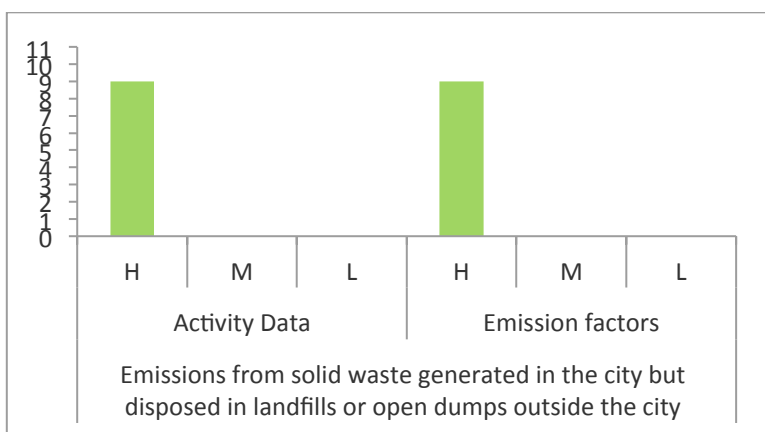
EAST ASIA



III.1.2 Emissions from solid waste generated in the city but disposed in landfills or open dumps outside the city

EUROPE

EAST ASIA



III.1.3 Emissions from waste generated outside the city and disposed in landfills or open dumps within the city

EUROPE

Not Reported/Not Occurring or Included under other sector

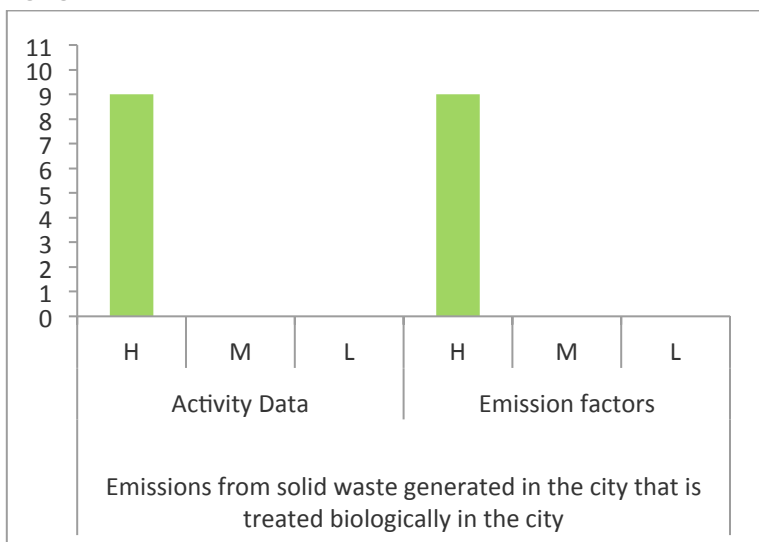
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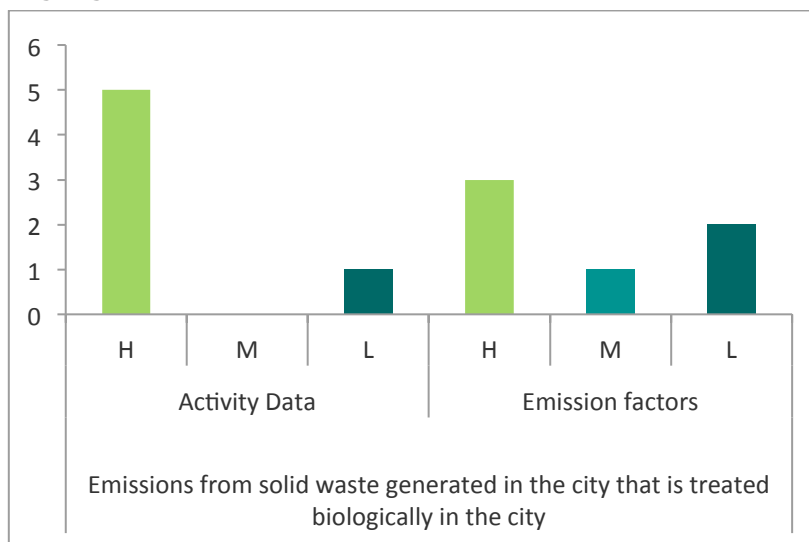
Biological treatment of waste

III.2.1 Emissions from solid waste generated in the city that is treated biologically in the city

EUROPE

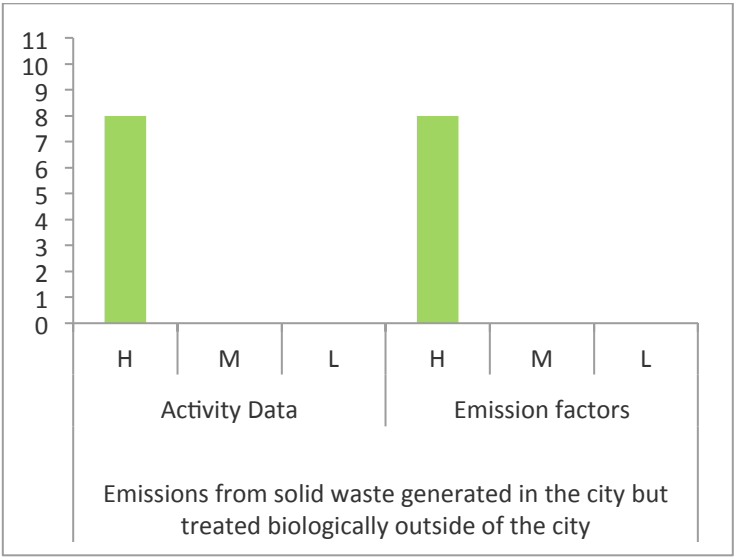


EAST ASIA

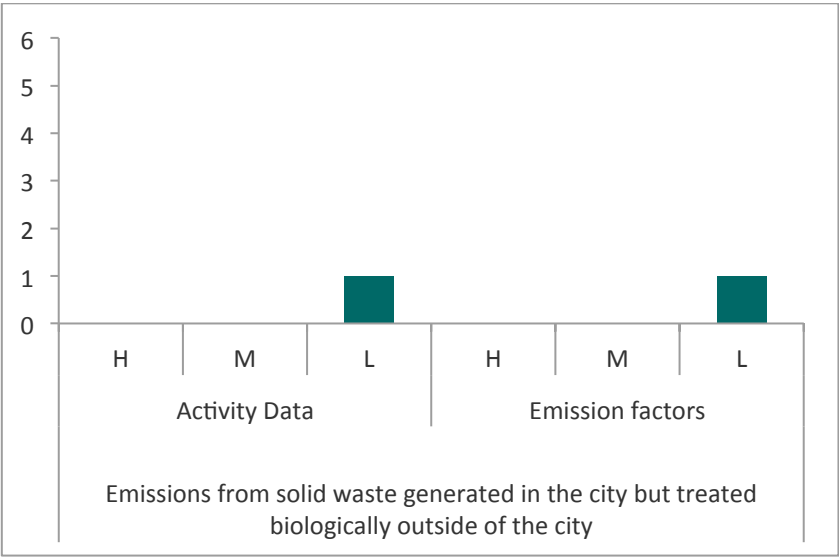


III.2.2.Emissions from solid waste generated in the city but treated biologically outside of the city

EUROPE



EAST ASIA



III.2.3 Emissions from waste generated outside the city boundary but treated in the city

EUROPE

Not Reported/Not Occurring or Included under other sector

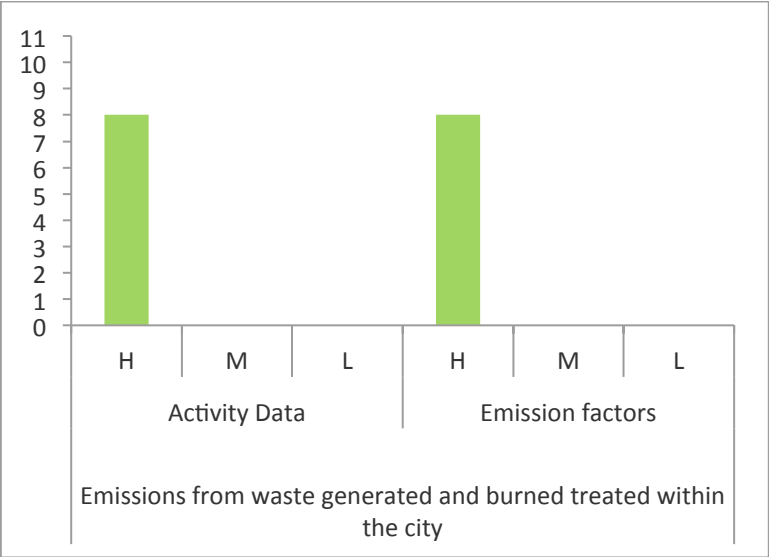
EAST ASIA

Not Reported/Not Occurring or Included under other sector

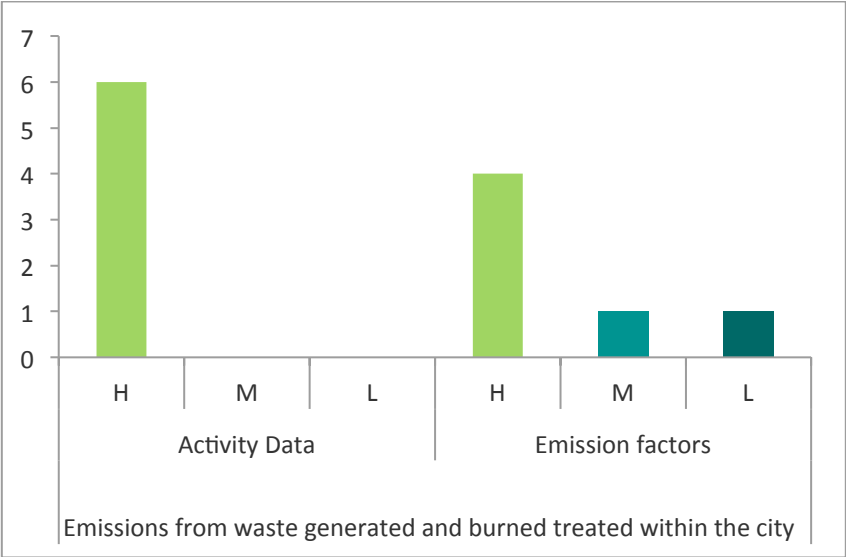
Incineration and open burning

III.3.1 Emissions from waste generated and treated within the city

EUROPE

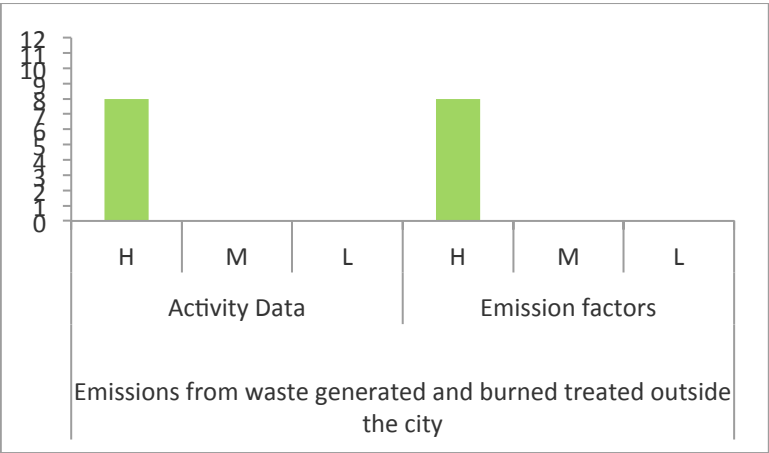


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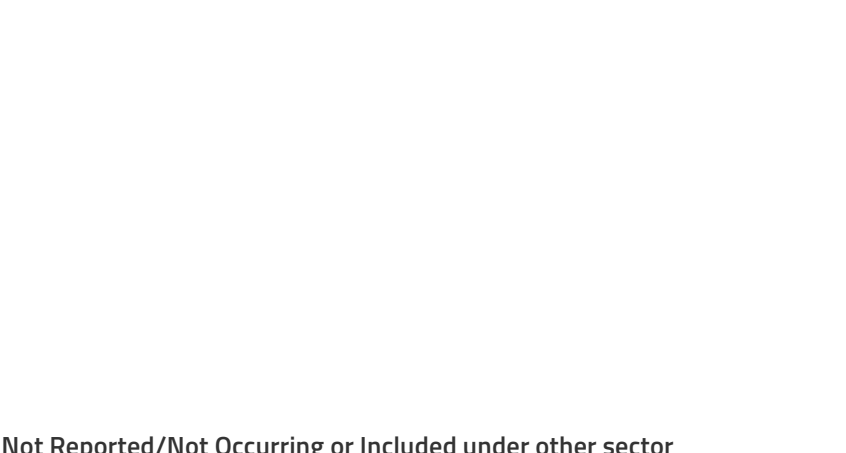


III.3.2 Emissions from waste generated within but treated outside of the city

EUROPE



EAST ASIA

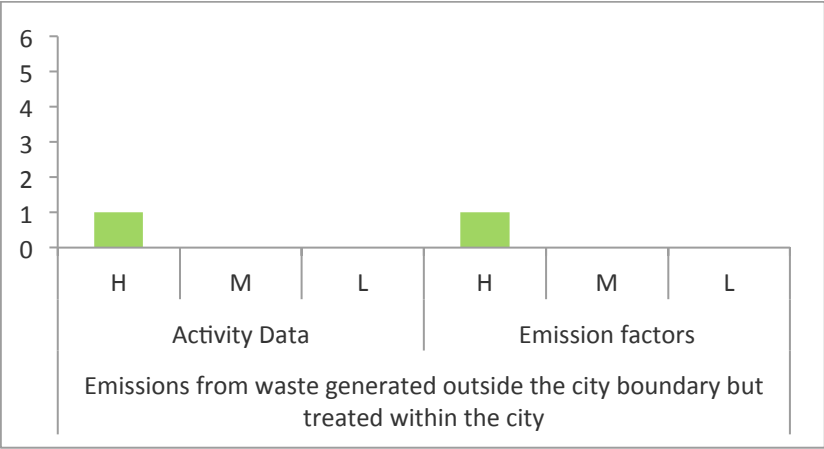


III.3.3 Emissions from waste generated outside the city boundary but treated within the city

EUROPE

Not Reported/Not Occurring or Included under other sector

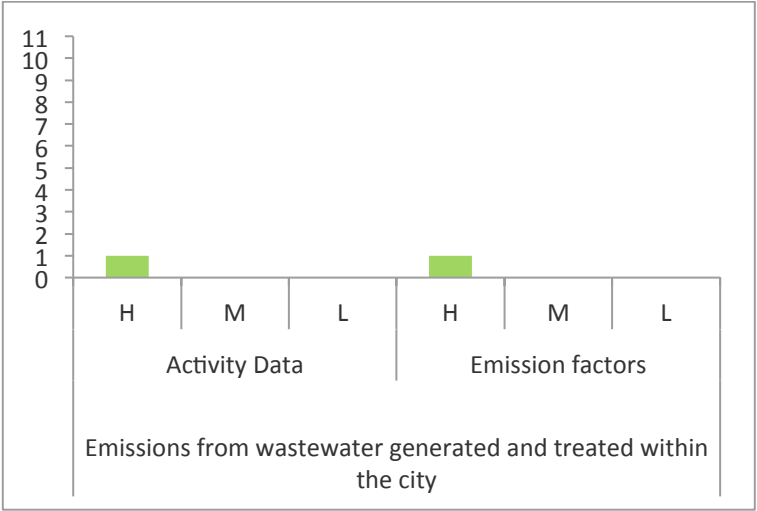
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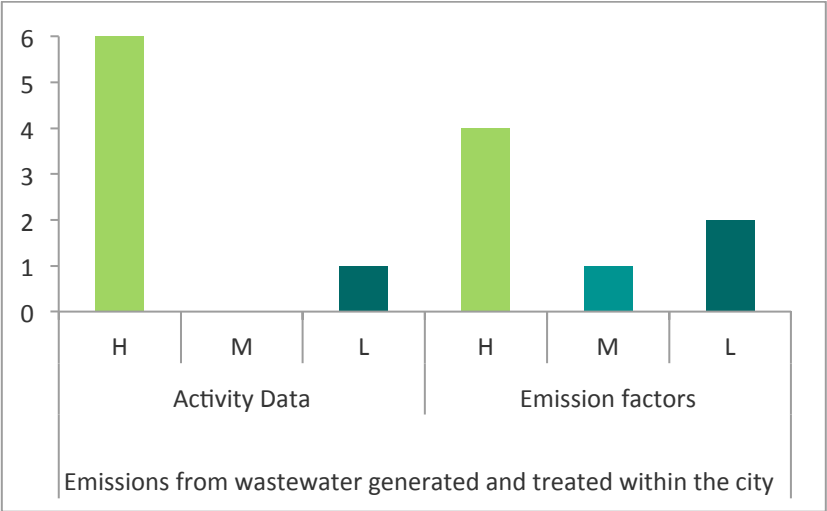
Wastewater treatment and discharge

III.4.1 Emissions from wastewater generated and treated within the city

EUROPE



EAST ASIA



III.4.1 Emissions from wastewater generated within but treated outside of the city

EUROPE

Not Reported/Not Occurring or Included under other sector

EAST ASIA

Not Reported/Not Occurring or Included under other sector

III.4.3 Emissions from wastewater generated outside the city boundary but treated within the city

EUROPE

Not Reported/Not Occurring or Included under other sector

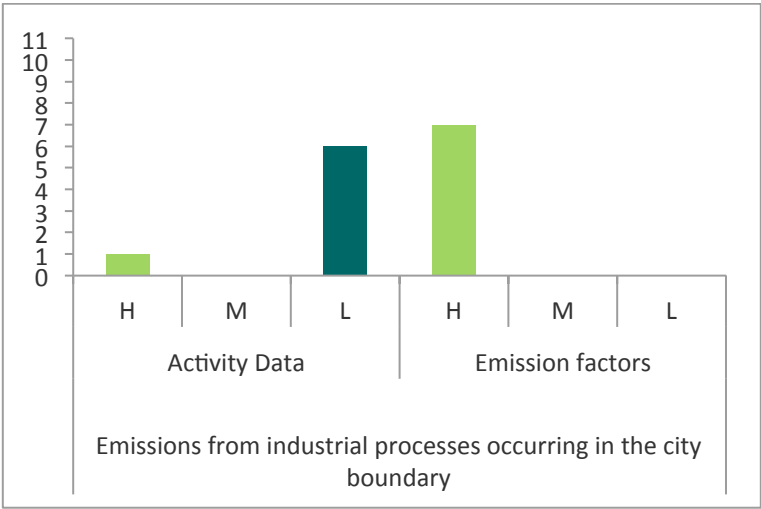
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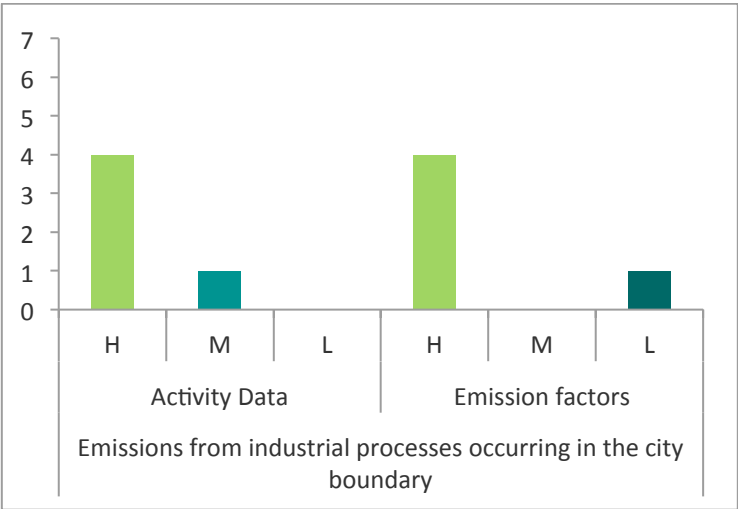
IV. INDUSTRIAL PROCESSES and PRODUCT USES (IPPU)

IV.1.1 Emissions from industrial processes occurring in the city boundary

EUROPE



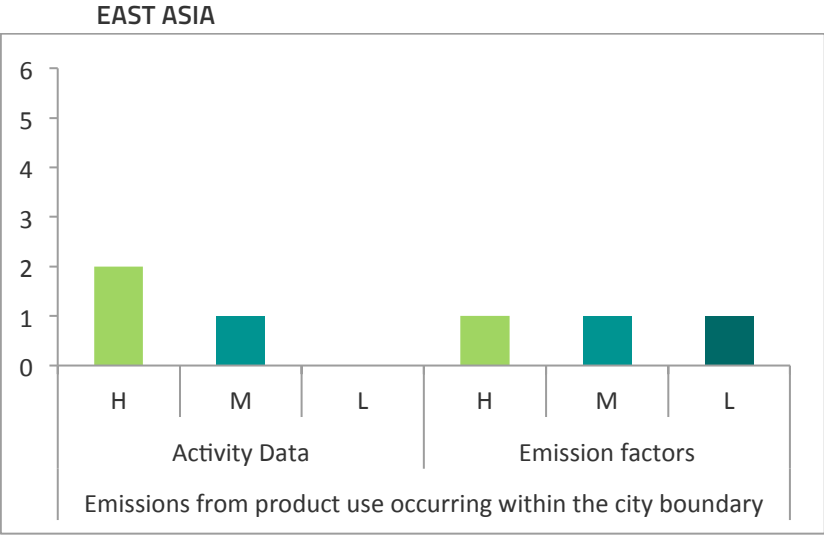
EAST ASIA



IV.1.2 Emissions from product use occurring within the city boundary

EUROPE

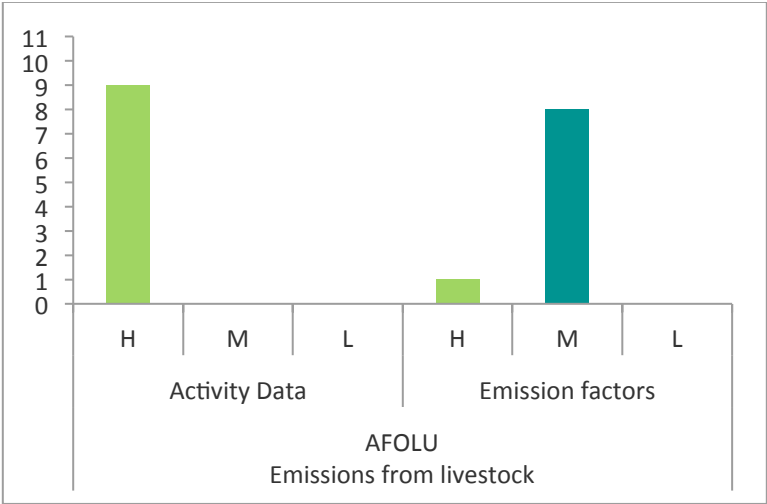
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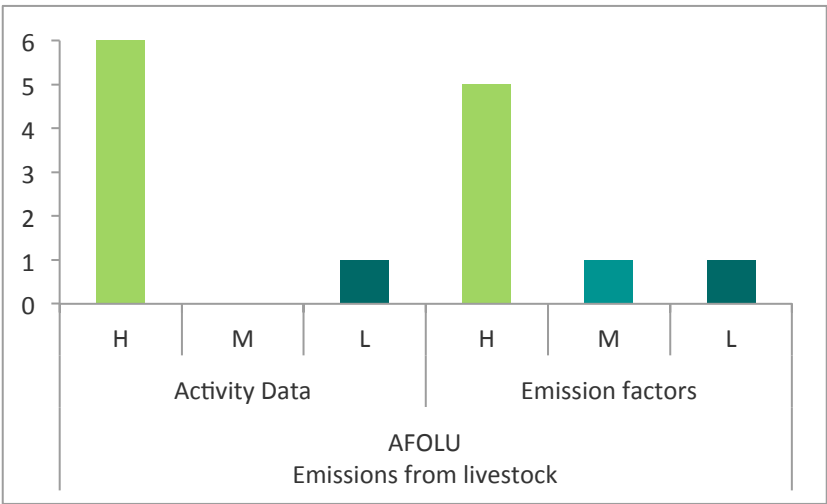
V. AGRICULTURE, FORESTRY and OTHER LAND USE (AFOLU)

V.1.1 Emissions from livestock

EUROPE



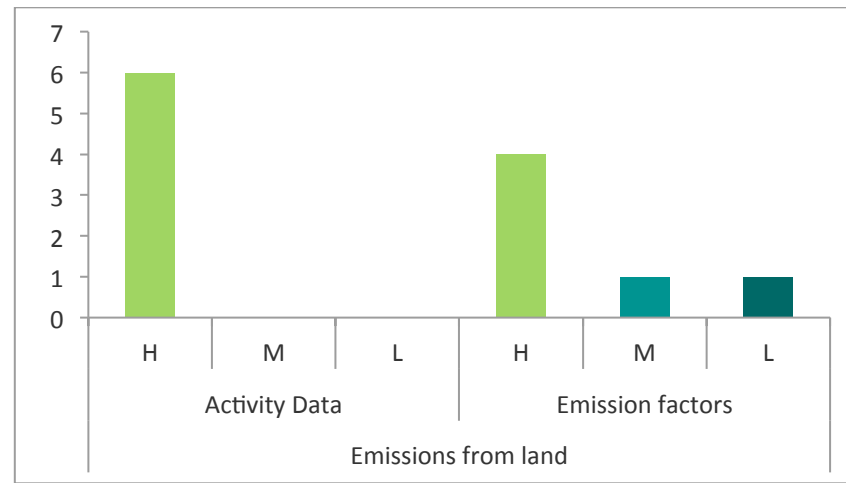
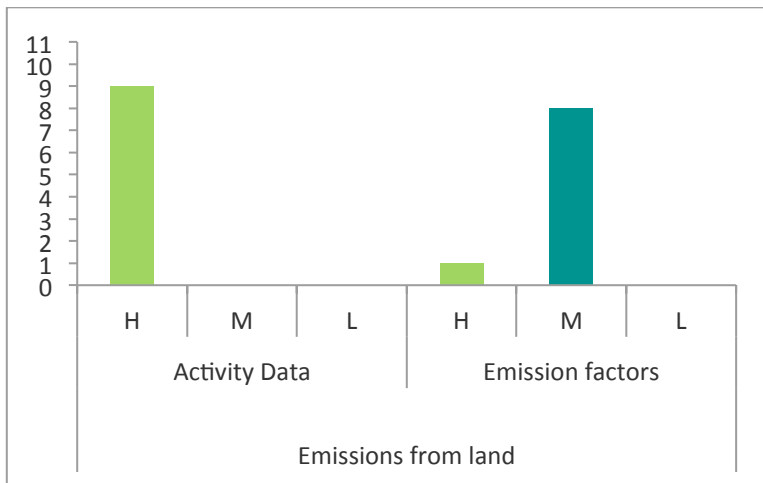
EAST ASIA



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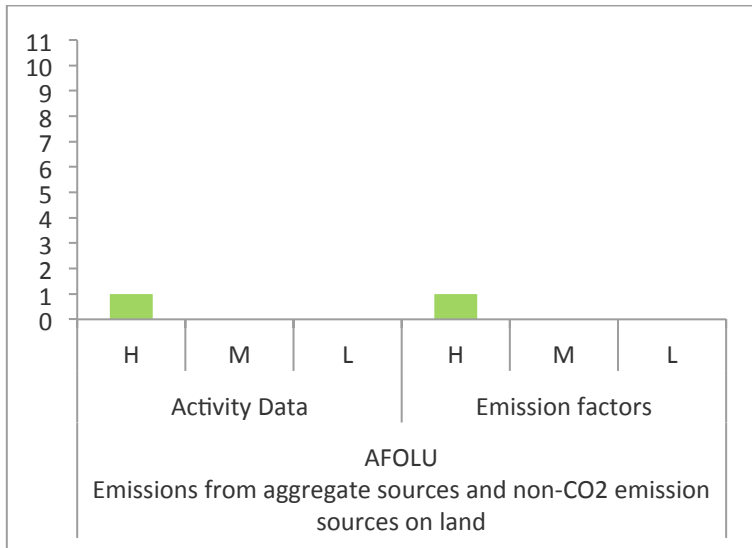
EUROPE

EAST ASIA



V.1.3 Emissions from aggregate sources and non-CO2 emission sources on land

EUROPE



EAST ASIA

