UNITED ARAB EMIRATES
MINISTRY OF CLIMATE CHANGE
& ENVIRONMENT

UAE National Air Emissions Inventory Project

Final Results

2019

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Foreword

The UAE's first ever National Air Emissions Inventory Report will guide our future policies on air quality management and aims at meeting local, national, and international objectives, as well as providing useful, up-to-date and comprehensive data on pollutant sources.

The United Nations considers air pollution a public health emergency. Globally, more than 90% of people are exposed to indoor and outdoor air pollution, leading to more than seven million deaths every year. Improving air quality is essential to help achieve the Sustainable Development Goals (SDGs). Under the guidance of our wise leadership, the United Arab Emirates (UAE) supports this global aspiration by including air quality as a key development priority in the UAE Vision 2021, in which we aim to raise our Air Quality Index from its current level to 90% by 2021.

The first step toward improving air quality is to understand the geographic and economic sources of air pollutants and develop a baseline of their quantities. Thus, the Ministry of Climate Change and Environment (MOCCAE) began developing a national air emissions inventory in 2017 to serve as the cornerstone for policy-making on air quality control, air quality modelling, and setting of emission limits and reduction targets.

As a pioneer initiative at the federal level, the UAE's national air emissions inventory uses a unified methodology for all emirates in line with international standards. Building on the work already undertaken in Abu Dhabi and Dubai, the inventory involved a rigorous consultation and data collection process, and covers major air pollutants, namely carbon monoxide, nitrogen oxides, sulphur dioxide, particulate matter (PM10 and PM2.5), and non-methane volatile organic compounds. It provides baseline information on emissions from the key sectors of energy, transport, and industrial processes and sets 2015 as its base year.

The establishment of an air emissions inventory for the UAE was made possible through the valuable contribution of various stakeholders from the public and private sectors. We mobilized air quality experts both locally and internationally, with the support of the Global Green Growth Institute (GGGI), and completed a series of stakeholder workshops to validate the data, methodology, and results. The active participation of our institutional partners only proves the paramount importance of this endeavour. On that note, I extend to them my sincerest appreciation for their continued support and hope that these partnerships will lay the groundwork for a stronger collaboration on air quality in the future.

H.E. Dr. Thani Bin Ahmed Al Zeyoudi
Minister of Climate Change
& Environment

Acknowledgements

A multidisciplinary team was involved in developing the UAE National Air Emissions Inventory. MOCCAE would like to thank all individuals and organisations for their active participation and contribution to the first UAE National Air Emissions Inventory.

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Federal Electricity and Water Authority
Federal Transport Authority- Land and Maritime
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Ajman Municipality
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Aegean Oil Terminal
Aggregates for Trading
Al A'ali Crushers
Al Azzani Ready Mix
Al Odaid Quarry
Al Shamsi Fibre Glass Co.
Alkaabi Rock
Allied Trading & Industry LLC
AMP Crushers
Arc Middle East LLC
Ashok Leyland UAE LLC
Aswan Trading
Atlantic Grease & Lubricants Manufacture LLC
Berg Industries
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Central Quarry & Mining LLC
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Coastal Energy LLC
DANEM Energy LLC
DP World (Dubai)
Dubai Airports
Dubai Blocs LLC
Emirates Airlines
Emirates Gas LLC
ENOC Lubricants & Grease Manufacturing Plant
EPPCO Aviation
EPPCO International Limited
Etihad Airways
Excellent Pipes Company LLC
Falcon Oil LLC
Fly Dubai
Fujairah Cement Industries PJSC
Fujairah Gold FZC
Fujairah National Quarry
Fujairah Oil Terminal
Fujairah Tank Terminals Ltd
GPS Chemoil LLC FZC
Guardian Zoujaj International Float Glass Co. LLC
Gulf Petrochem Oil Terminal
Horizon Emirates Terminal LLC
Hutchinson Ports (UAQ)
IL & FS Prime Terminals FZC
JF & I Packaging (Pvt) Ltd
JK Cement Works
Lafarge Emirates Cement
MAC Metal Foundry & Eng Co.
Naseem Al Hadaeq Perfumes
Port of Ajman
Port of Fujairah
Quality Castings Ltd FZE
Quick Mix Beton LLC
RAK Ceramics PJSC
RAK Rock LLC (Q1, Silica Quarry)
Ras Al-Khaimah Cement Company
Raknor LLC
Ras Al-Khaimah Ports
Readymix Gulf Ltd.
Rifco International FZ LLC
Salbookh Trading Crushers LLC
Saverglass LLC
Sharjah Airport
Silver Metals Industries LLC
Socar Aurora Fujairah Terminal FZC
Sodamco Emirates Factory for Building Materials LLC
Solar Lubricants Refinery LLC
Star Cement Co. LLC
Stevin Rock LLC
Suvire Electric FZC
Swiss International Chocolates LLC
Turkish Gulf Quarry LLC
UTICO
Vopak Horizon Fujairah Limited
Welmix Concrete
WRT Middle East FZE

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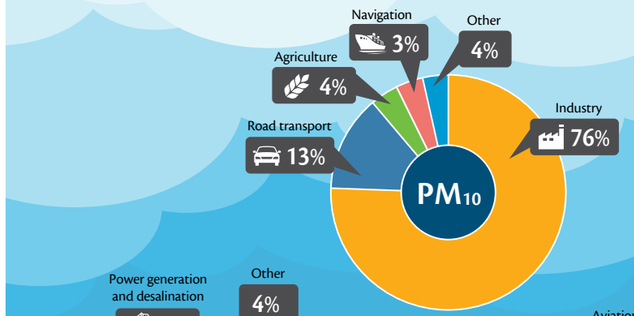
List of figures and tables

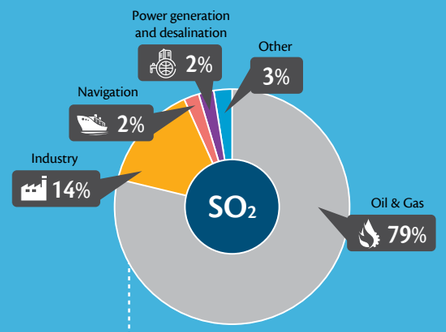
List of acronyms and abbreviations

ADNOC	Abu Dhabi National Oil Company
CO	Carbon monoxide
EAD	Environment Agency – Abu Dhabi
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
FSCA	Federal Statistics and Competitiveness Authority
GHG	Greenhouse gas
IPPU	Industrial processes and product use
LPG	Liquid petroleum gas
LTO	Landing and take-off (aviation)
MOCCAE	UAE Ministry of Climate Change and Environment
MOEI	UAE Ministry of Energy and Industry
MSW	Municipal solid waste
N	Nitrogen
NFR	Nomenclature for Reporting
NH_3	Ammonia
NMVOC	Non-methane volatile organic compounds
NO_X	Nitrogen oxides
PM_{10}	Particulate matter less than 10 micrometres in diameter
$PM_{2.5}$	Particulate matter less than 2.5 micrometres in diameter
POPs	Persistent organic pollutants
RAK	Ras Al-Khaimah
SO_X	Sulphur oxides
SO_2	Sulphur dioxide
t	Tonne
TSP	Total suspended particles
UAE	United Arab Emirates
UAQ	Umm Al-Quwain

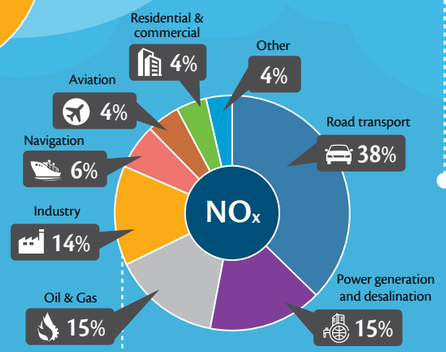
Main sources of air pollution in the UAE



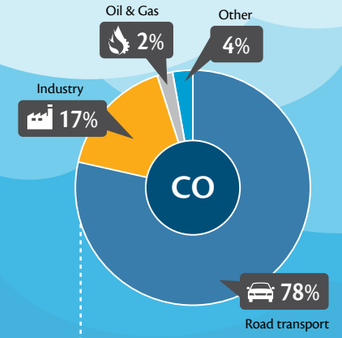
$PM_{2.5}$ & PM_{10}
Particulate matter of maximum 2.5 & 10 micrometers: tiny particles that can get deep into lungs and embedded in the organs shortening lifespan.



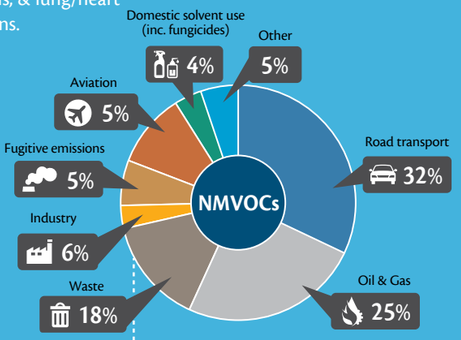
Sulfur Dioxide
Triggers asthma, respiratory problems, & breathing difficulties. It is also very damaging of the ecosystems.



Nitrogen Oxides
Worsens allergies, respiratory infections, & lung/heart conditions.



Carbon Monoxide
Reduces oxygen supply in the blood; harms the heart & brain.



Non-methane volatile organic compounds:
Causes respiratory inflammation & cancer.

Ozone
NOx reacts with NMVOCs and other air pollutants in the presence of sun light to produce ground level ozone.

Ozone affects the respiratory tract & triggers respiratory illnesses

Executive Summary

Improving air quality is a priority for the United Arab Emirates (UAE). It is part of the country's Green Agenda and one of the key performance indicators in the National Agenda of the UAE Vision 2021. In July 2017, the Ministry of Climate Change and Environment (MOCCAE) launched the Air Emissions Inventory Project to develop the first national-level inventory for air pollutant emissions in the UAE. The objective of the project was to identify the key sources of air pollutants in the country with the view of formulating strategies that can be put in place to improve air quality.

The Air Emissions Inventory Project was carried out in two phases. Phase I involved the development of the inventory methodology, which was successfully completed in 2018, and training for stakeholders on data collection. Phase II comprised the data collection and compilation of the national air pollutants inventory. This report presents the results from Phase II.

Although the emirates of Abu Dhabi, Dubai, and Ajman had separately undertaken efforts to quantify emission for some or all of their sectors, this is the first national air pollutant emission inventory carried out for the whole country. Using 2015 as the base year, the inventory undertaken included the following pollutants:

- Carbon monoxide (CO)
- Nitrogen oxides (NO_x)
- Sulphur dioxide (SO_2)
- Particulate matter of 10 micrometres or less (PM_{10})
- Particulate matter of 2.5 micrometres or less ($PM_{2.5}$)
- Non-methane volatile organic compounds (NMVOCs)

The pollutant $PM_{2.5}$ was not incorporated during Phase I of the inventory and was added in Phase II to ensure the completeness[1] of the report.

The methodology for compilation of the national inventory follows the EMEP[2]/European Environment Agency (EMEP/EEA) 2016 guidebook, internationally recognised for compiling air pollutant emission inventories (EEA, 2016). In this inventory, emissions are classified into the following sectors:

- Energy
- Transport[3]
- Industrial processes and product use (IPPU)
- Agriculture
- Waste

Similar to the pollutant $PM_{2.5}$, the agriculture and waste sectors were added later in Phase II.

For each sector, the guidebook provides three methodologies with varying levels of complexity. In most cases, due to data availability, the simplest methodology has been used. Where possible, however, more detailed methods have been used, resulting in higher levels of accuracy.

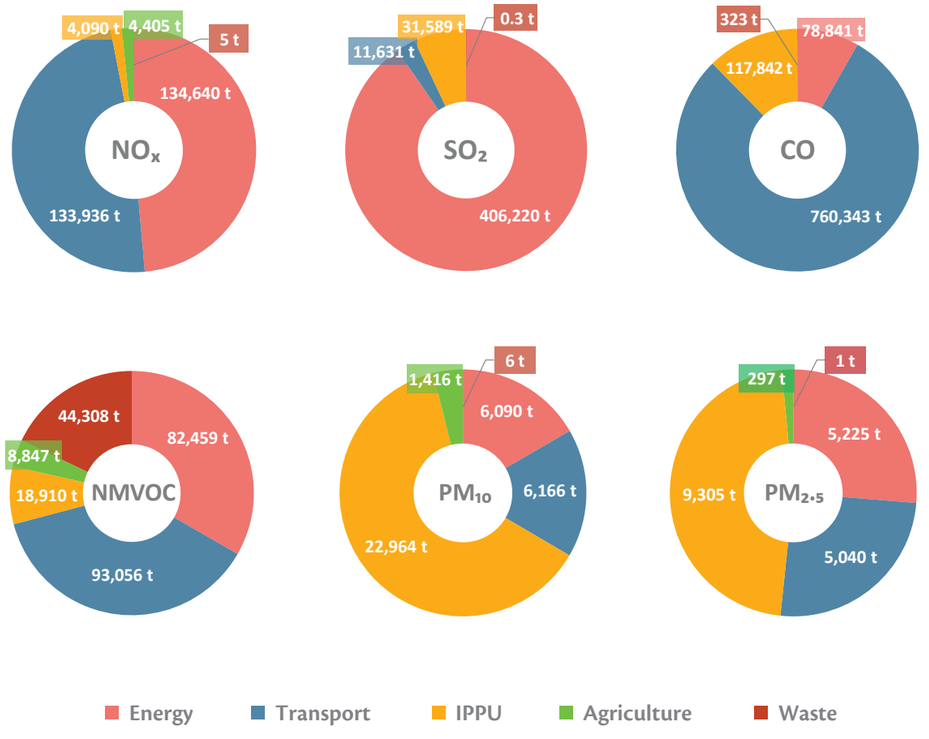
Priority was given to local and national official data sources. Where data was not available, estimates or assumptions were incorporated. Recommendations have therefore been made to improve the completeness and accuracy of the emission estimates in the next inventory compilation cycle. Of note is the lack of completeness for the industry sector, both in terms of combustion and process emissions. Therefore, collecting activity data to enhance this sector will be a key priority going forward.

Figure i, which presents a summary of the results of Phase II, shows that, as expected and in line with most other countries' inventories, emissions from the stationary energy and transport sectors dominate the emission sources.

Power generation and road transport comprise a large proportion of the NO_X emissions, with oil and gas operations also contributing a significant amount. For SO_2 emissions, oil and gas operations are the dominant source, while petrol-fuelled passenger cars and light duty vehicles comprise the majority of CO emissions, with the IPPU sector also being an important source. For particulate matter (both PM_{10} and $PM_{2.5}$), the dominant source is IPPU with smaller amounts arising from fuel combustion in industry and transport, from brake and tyre wear.

Although the agriculture and waste sectors have a minor contribution to the country's overall emissions, their role is more significant in terms of greenhouse gas emissions (GHG). However, of particular note are the estimated high NMVOC emissions from municipal solid waste (MSW) disposal on land.

Figure i Overview of UAE emissions by pollutant and sector, 2015 (in tonnes)



[1] 'Completeness' means that an annual inventory covers at least all sources, as well as all pollutants, for which methodologies are provided or for which supplementary methodologies have been agreed" (EEA, 2016, p. 14).
[2] Co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe, more commonly known as European Monitoring and Evaluation Programme, or EMEP.
[3] For ease of reference, this report uses 'Energy' and 'Transport', instead of 'Energy (Stationary)' and 'Energy (Mobile)'.

1. Introduction

1.1 Background

According to the World Health Organization (WHO), exposure to ambient air pollution accounts for an estimated 4.2 million deaths per year due to stroke, heart disease, lung cancer, and chronic respiratory diseases. It is thought that approximately 91% of the world's population live in places where air quality levels exceed WHO limits (WHO, 2016).

Studies show that exposure to air quality, alongside behavioural factors, serves as a significant determinant of respiratory health among UAE's adolescents (Barakat-Haddad et al). Specifically, risk assessment results for the UAE revealed that around 290 deaths and 89,000 hospital visits per year may be linked to air quality (Funk et al, 2014). Outdoor air pollution is also a major contributor to premature deaths (Gibson and Farah, 2012).

Against this background, improving air quality is a priority for the UAE. It is part of the country's Green Agenda (Ministry of Climate Change and Environment, 2016) and one of the Key Performance Indicators in the National Agenda (United Arab Emirates Cabinet, n.d.) of the UAE Vision 2021 (United Arab Emirates, n.d.). One of the first steps to improving air quality is to understand the sources by compiling an emissions inventory, and then actions can be put in place to improve air quality. A national air emissions inventory provides a detailed estimate of selected pollutants and their sources, which can serve to guide policy decisions on air pollution reduction measures.

Developing an air emission inventory in the United Arab Emirates arose from the need to improve air quality across the country and prevent adverse effects of air pollution on the health of humans and ecosystems. Inventories help to identify sources and quantities of air pollutants, which in turn provide policy-makers with reliable data to address the matter and formulate policies to limit those emissions.

With this in view, in July 2017, the Ministry of Climate Change and Environment (MOCCAE) launched the Air Emissions Inventory Project to develop the first national-level inventory for air pollutant emissions in the UAE. It covers all seven emirates, namely Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al-Quwain (UAQ), Ras Al-Khaimah (RAK) and Fujairah.

The Air Emissions Inventory Project was carried out in two phases. Phase I involved the development of the inventory methodology, which was successfully completed in 2018, and training for stakeholders on data collection. Phase II comprised the data collection and compilation of the national air pollutants inventory. This report presents the results from Phase II.

1.2 Scope of the inventory of emissions

Emission inventories have been compiled for 2015 for the following pollutants:

- Carbon monoxide (CO)
- Nitrogen oxides (NO_x)
- Sulphur dioxide (SO_2)
- Particulate matter of 10 micrometres or less (PM_{10})
- Particulate matter of 2.5 micrometres or less ($PM_{2.5}$)
- Non-methane volatile organic compounds (NMVOCs).

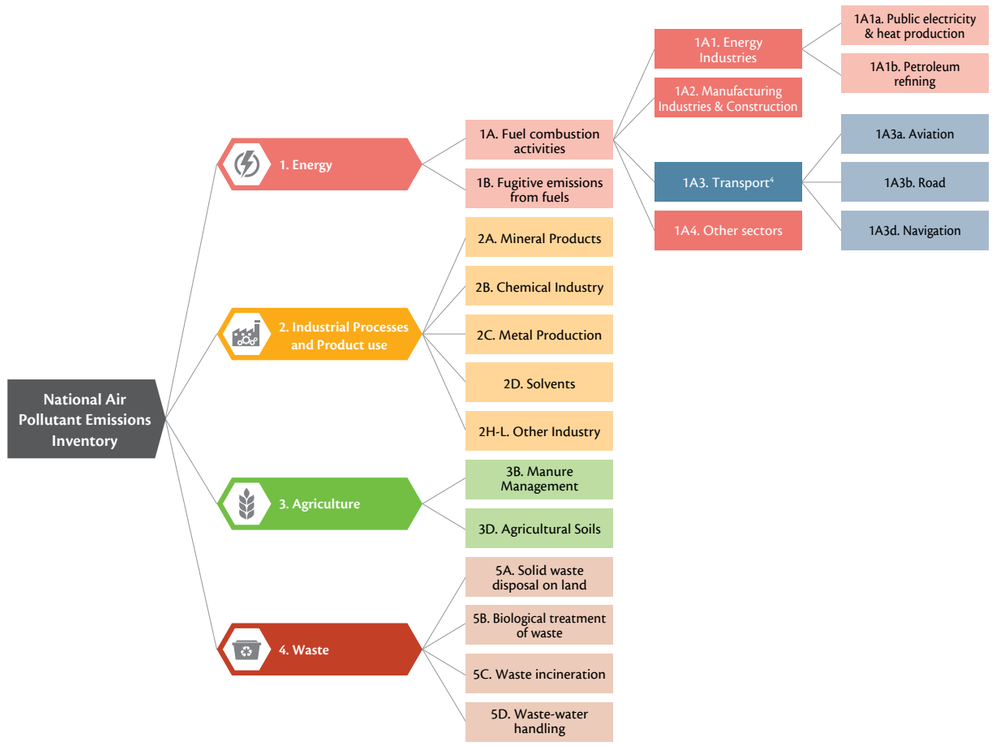
Emission estimates are divided into sectors as follows:

- Energy
- Transport
- Industrial processes and product use (this covers the emissions resulting from various industrial activities that produce emissions not directly as a result of energy consumed).
- Agriculture
- Waste

Each sector is later split into individual categories (e.g. Energy – transport) and sub-categories (e.g. road transport) and then further sub-divided into further categories where necessary (e.g. passenger vehicles)[4]. Each of these categories is assigned with a Nomenclature for Reporting (NFR) code (see Figure 1) (EEA, 2016). The nomenclature is consistent with the format used for reporting of GHG emission inventories under the United Nations Framework Convention on Climate Change (UNFCCC), but expanded for particular sources of air pollution. An abridged version of NFR codes is provided in Table 1.

[4] For ease of reference, in this report, the category 'Transport' was moved to the sector level.

Figure 1 Synopsis of Nomenclature for Reporting (NFR) code



Source: Adapted from European Environment Agency (2016).

Table 1 An abridged guide to the Nomenclature for Reporting (NFR) code[5]

NFR Code	Source description
1	**Energy**
1A	**Fuel Combustion Activities**
1A1	*Energy Industries*
1A1a	Public electricity and heat production[6]
1A1b	Petroleum refining (referred to in this report as oil and gas operation)
1A1c	Manufacture of solid fuels and other energy industries
1A2	*Manufacturing Industries and Construction*
1A3	*Transport*
1A3a	Aviation
1A3b	Road Transport
1A3c	Railways
1A3d	Navigation (shipping)
1A3eii	Other
1A4	*Other sectors (stationary and mobile combustion)*
1A5	*Other (not elsewhere specified)*
1B	**Fugitive Emissions from Fuels**
1B1	*Fugitive Emissions from Solid Fuels*
1B2	*Fugitive Emissions from Oil and Natural Gas*
2	**Industrial Processes and Product Use**
2A	*Mineral Products*
2B	*Chemical Industry*
2C	*Metal production*
2D	*Solvents*
2H	*Pulp and paper industry, food and beverages industry*
2I	*Wood Processing*
2K	*Consumption of POPs and heavy metals*
3	**Agriculture**
3B	*Manure Management*
3D	*Agricultural soils*
5	**Waste**
5A	*Solid Waste disposal on land (referred to in this report as MSW)*
5B	*Biological treatment of waste*
5C	*Waste Incineration*
5D	*Waste-water handling*
5E	*Other Waste*
6	**Other**

[5] NFR code 4, which does not appear on this list, relates to 'Land Use, Land Use Change and Forestry'. This category is only applicable to greenhouse gas inventories.
[6] Referred to as 'Power generation' in this report.

2. Methodology

2.1 Process of compilation

The air quality pollutant inventory was compiled by international inventory experts from Aether who undertook the task of quantifying the national estimates. The 2016 EMEP/EEA guidebook was followed throughout, abiding by the methodologies and quality assurance/quality control practices. The guidebook, widely used by many countries, was adapted – ensuring that the UAE inventory is comparable with many other inventories. In addition, the guidebook provides a transparent methodology across all relevant sectors for the UAE.

2.1.1 Emissions estimation and 'Tier' methodology

Given the complexities and impracticalities of undertaking direct measurements of the emissions from each source identified in the UAE, it is necessary to estimate emissions through an indicator that describes the source activity and an emission factor that is specific for the typology of the source. In general, anthropogenic (human-produced) emissions of air pollutants are estimated by multiplying emission factors with activity data for each source:

$$Estimated\ emissions_{pollutant} = Emission\ factor_{pollutant} \times Activity\ data$$

where the emission factor is the average emission rate of a given pollutant from a given source, relative to the intensity of a specific activity, and the activity data is a measure of the scale of activity providing the emissions.

Emissions can be estimated at different levels expressed in three tiers of increasing complexity. The 'Tier 1' is a simple method using already available default emission factors only. The 'Tier 2' method uses either country-specific emission factors, or default emission factors over a range of different technologies. The 'Tier 3' method uses emission factors that are not only country-specific but also differentiated by technology and operating conditions. Tier 3 is the most accurate and complex methodology, while it is easiest to obtain data for Tier 1.

The methodological choice for a particular source and in a particular country depends on the importance of that source to the level and trend of emissions in that country, as well as on the resources available to prepare the emissions inventory.

2.1.2 Data management

During Phase I of the inventory, after assessing the data availability and gaps, it was decided that a combination of top-down and bottom-up approaches was appropriate for the data collection by sector. This approach yielded more accurate findings than simply a top-down approach, and was more traceable and efficient than a bottom-up approach only. In other words, a bottom-up approach was followed wherever data exists and in the case that data were insufficient or did not exist, a top-down approach was applied.

The data and information required for compiling air quality emission inventories includes activity data provided directly from Ministries, environmental authorities, transport operators and industrial sites through especially designed questionnaires, as well as experts' judgement from discussions with local and national experts. Information was primarily collected during the project's latter stages of Phase I and early stages of Phase II during which a wealth of material was gathered.

Throughout the inventory compilation process, the sector experts applied the 2016 EMEP/EEA guidebook precepts on good practice to review and incorporate data gathered in a consistent and accurate manner. As far as possible, local or national datasets have been used in the inventory. In cases where local or national datasets were not available, information was taken from international datasets (see Figure 2).

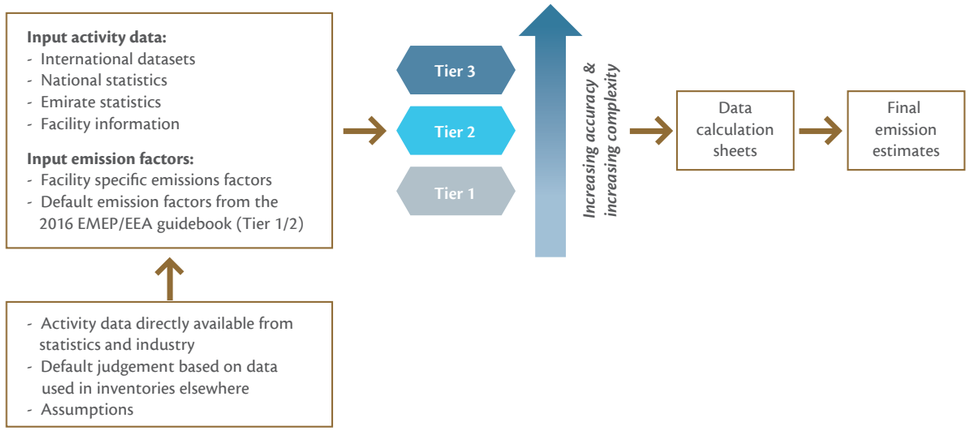
2.1.3 Compilation spreadsheets

The inventories were compiled in Excel spreadsheets. In general, there is a spreadsheet for each sector and within this file each tab contains the calculations for one or more than one NFR category, depending on the complexity of the calculation and method used. For the simpler calculations (Tier 1 and 2), default emission factors were obtained from the 2016 EMEP/EEA guidebook and combined with an activity statistic to estimate the annual emissions.

2.2 Stakeholder consultation

Preliminary results of the Air Quality National Emissions Inventory were presented to relevant stakeholders at an event in August 2019. This enabled any additional information to be collected and ensured that organisations were satisfied with the approach being used. Attendees included UAE Ministries, Emirate Municipalities, and transport and industrial organisations. Useful inputs were obtained, and these have been taken on-board for the final version of this report.

Figure 2 Overview of methodology



3. Summary of results

3.1 Estimates of emissions

A summary of the total emission estimates by pollutant and sector is shown in Figure 3, Figure 4, and Table 2. The data shows that, as expected, the stationary energy and transport sectors are the dominant sources of air pollutants.

Figure 3 Overview of UAE emissions by pollutant and sector, 2015 (in tonnes)

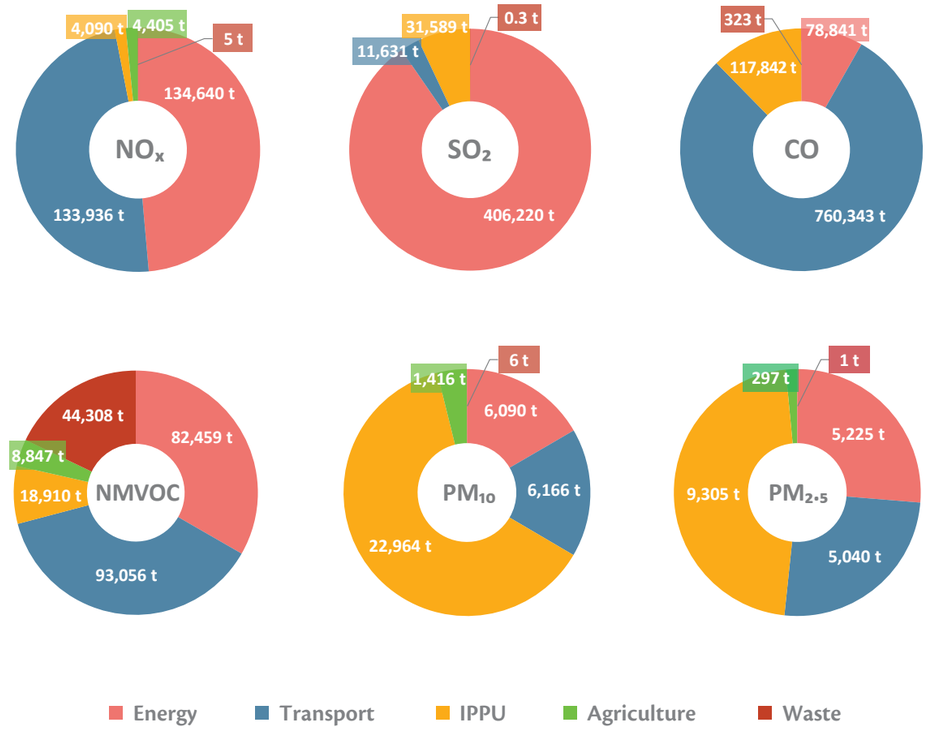


Figure 4 Estimated emissions by pollutant per sector, 2015 (in tonnes)

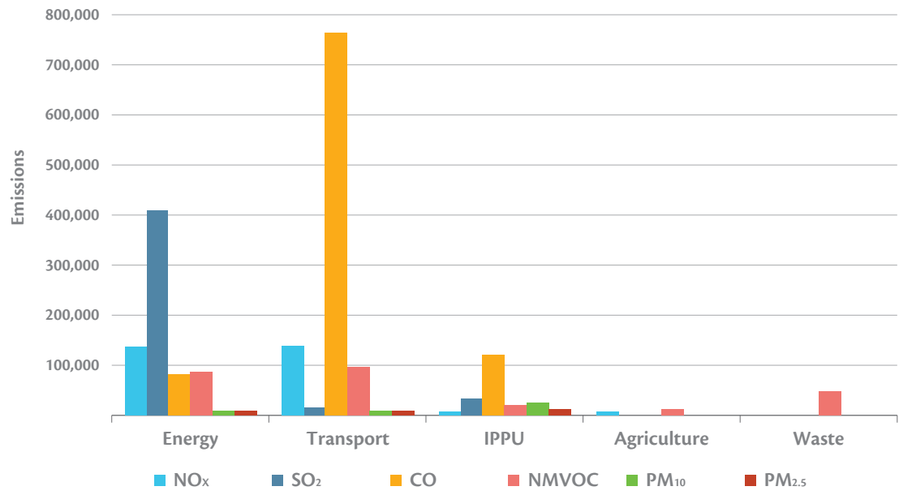


Table 2 Summary of total UAE air pollutant emissions per pollutant by sector, 2015 (in tonnes)

Sector	Emissions					
	NOx	SO_2	CO	NMVOC	PM_{10}	$PM_{2.5}$
Energy	134 640	406 220	78 841	82 459	6 090	5 225
Transport	133 936	11 631	760 343	93 056	6 166	5 040
Industrial processes and product use (IPPU)	4 090	31 589	117 842	18 910	22 964	9 305
Agriculture	4 405	NA[1]	NA	8 847	1 416	297
Waste	5	0.27	323	44 308	6.3	0.96
Total[2]	**277 076**	**449 439**	**957 349**	**247 581**	**36 642**	**19 868**

[1] NA – Not applicable (emissions of this pollutant do not arise from this source).
[2] The sum of the component parts may not exactly equal the total shown as a result of rounded off figures.

3.2 Key category analysis

A source of emissions is denoted as a key category if it has a significant influence on the country's total emissions in terms of the absolute level of emissions of a given pollutant. By highlighting these categories, the inventory compilation team were able to better assess the prioritisation for the improvement of data gathering and methodologies. Other users of the inventory can also clearly identify those categories that may be more applicable for other purposes such as mitigation to reduce air quality pollutant emissions.

In accordance with the 2016 EMEP/EEA guidelines, a key category analysis was carried out highlighting the more significant categories for each pollutant. This was performed using a simple Excel spreadsheet tool. Only an absolute level assessment has been undertaken,[7] wherefore the inventory categories are sorted from large to small in terms of emissions for a single year and all categories that contribute to 80% of the total emissions are highlighted to identify the vital few from the trivial many. Table 3 summarises the key categories in the inventory.

[7] In this case, only the absolute level is relevant as the inventories are only being compiled for 2015 and no trend in emissions is available. In addition, no uncertainty assessment has been undertaken at this stage.

Table 3 Sectors identified by the key category analysis, 2015

NFR category		Pollutant	Percentage of emissions (%)
1A3bi	Road transport: passenger cars	CO	38
1A3bii	Road transport: light duty vehicles	CO	37
2C3	Aluminium production	CO	10
1A1b	Oil and gas operations*	NMVOC	25
5A	Municipal solid waste disposal on land	NMVOC	18
1A3bii	Road transport: light duty vehicles	NMVOC	17
1A3bi	Road transport: passenger cars	NMVOC	14
1A3ai(i)	International aviation landing and take-off (LTO) (civil)	NMVOC	5
1B2av	Fugitive emissions from distribution of oil products	NMVOC	4
1A3bi	Road transport: passenger cars	NOx	18
1A3biii	Road transport: heavy duty vehicles and buses	NOx	16
1A1a	Power generation	NOx	15
1A1b	Oil and gas operations	NOx	14
1A3dii	National navigation (shipping)	NOx	5
1A2b	Non-ferrous metals	NOx	5
1A2f	Non-metallic minerals	NOx	4
2A1	Cement production	PM_{10}	18
1A2f	Non-metallic minerals	PM_{10}	11
2D3b	Road paving with asphalt	PM_{10}	10
2A5	Quarrying and mining of minerals other than coal	PM_{10}	10
2B	Chemical industries	PM_{10}	10
2A2	Lime production	PM_{10}	4
2C1	Iron and steel production	PM_{10}	4
1A3bvi	Road transport: automobile tyre and brake wear	PM_{10}	4
1A3bii	Road transport: light duty vehicles	PM_{10}	4
1A3dii	National navigation (shipping)	PM_{10}	3
1A3biii	Road transport: heavy duty vehicles and buses	PM_{10}	3
2A1	Cement production	$PM_{2.5}$	18
1A2f	Non-metallic minerals	$PM_{2.5}$	18
2B	Chemical Industries	$PM_{2.5}$	14
1A3bii	Road transport: light duty vehicles	$PM_{2.5}$	7
1A3dii	National navigation (shipping)	$PM_{2.5}$	5
2C1	Iron and steel production	$PM_{2.5}$	5
1A3biii	Road transport: heavy duty vehicles and buses	$PM_{2.5}$	5
2C3	Aluminium production	$PM_{2.5}$	4

NFR category		Pollutant	Percentage of emissions (%)
1A3bvi	Road transport: automobile tyre and brake wear	$PM_{2.5}$	3
1A1a	Power generation	$PM_{2.5}$	3
1A1b	Oil and gas operations	SO_2	79
1A2f	Non-metallic minerals	SO_2	7

* Although the term 'oil and gas operations' has been used here, NFR code 1A1b technically refers only to petroleum refineries. See sections 4.2.2 and 4.2.5 for further information.

The results show that road transport comprises a large proportion of the NO_x emissions, with power generation and oil and gas operations also contributing significant amounts. For SO_2, oil and gas operations are the dominant source, while passenger cars and light duty vehicles comprise the majority of CO emissions, with the IPPU sector also being an important source. For particulate matter (both PM_{10} and $PM_{2.5}$), the dominant sources are IPPU with smaller amounts arising from fuel combustion in industry and transport, from brake and tyre wear.

The agriculture and waste sectors play a minor role, and as discussed in the report, these are more significant sectors in terms of GHG emissions, with particular attention to the estimated high NMVOC emissions from MSW disposal on land.

4. Energy

4.1 Overview of emissions

Stationary combustion comprises burning of fuels to provide energy in power stations to generate electricity and desalinate water in oil and gas operations, and in other industries. This sector also includes fugitive emissions from extraction, processing, and delivery of fossil fuels. These activities result in emissions of all the pollutants considered within the scope of this inventory, and include some of the most significant sources of the air pollutants covered in the inventory.

The emission estimates for stationary combustion show that different sectors are responsible for the largest share of emissions for different pollutants (see Figure 5 and Table 4).

Figure 5 Estimated emissions from the energy sector by pollutant, 2015 (in tonnes)

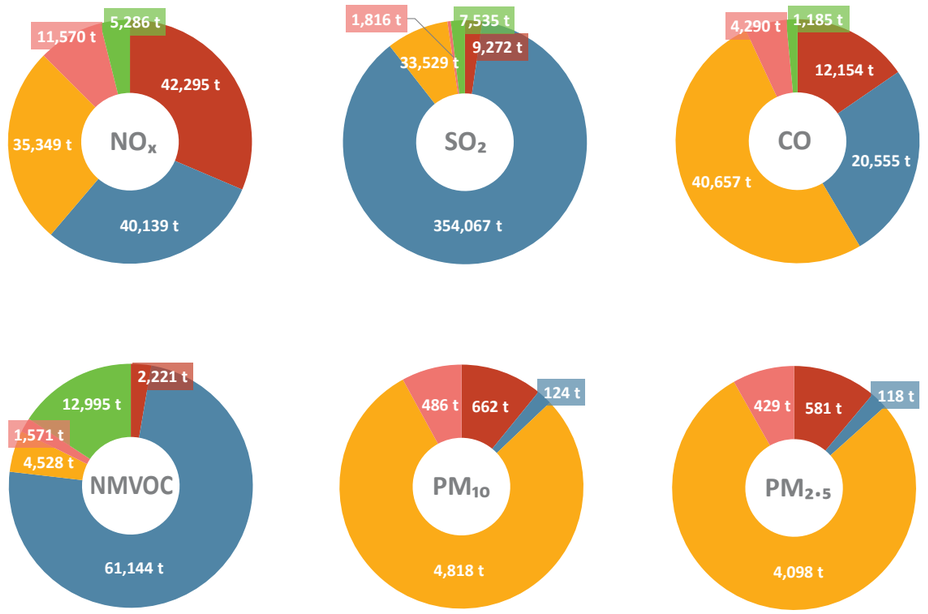


Table 4 Estimated emissions from the energy stationary sector by pollutant, 2015 (in tonnes)

Sector/category		Emissions					
		NOx	SO_2	CO	NMVOC	PM_{10}	$PM_{2.5}$
1A1a	Power generation	42 295	9 272	12 154	2 221	662	581
1A1b	Oil and gas operations	40 139	354 067	20 555	61 144	124	118
1A2	Stationary combustion in manufacturing industries and construction	35 349	33 529	40 657	4 528	4 818	4 098
1A4	Small-scale combustion[1]	11 570	1 816	4 290	1 571	486	429
1B	Fugitive emissions	5 286	7 535	1 185	12 995	IE[2]	IE
Total[2]		**134 640**	**406 220**	**78 841**	**82 459**	**6 090**	**5 225**

[1] Refers to commercial and residential sectors.
[2] IE – Included elsewhere. For Abu Dhabi, fugitive emissions are reported in the oil and gas operations sector (1A1b).
[3] The sum of the component parts may not exactly equal the total shown as a result of rounded off figures.

NO_X emissions are produced from all combustion processes and all fuels, and the public electricity and desalination[8] category is the largest single source of NO_X emissions, closely followed by oil and gas operations. Emissions arising from sub-sectors within the stationary combustion in manufacturing industries and construction are also key categories for NO_X emissions.

For SO_2 emissions, the oil and gas sector make by far the largest contribution, followed by stationary combustion in manufacturing industries and construction.

CO emissions arise mostly from stationary combustion in manufacturing industries and construction, with solid fuel combustion in cement manufacture (reported in RAK and Fujairah) being the largest contributors.

NMVOC emissions arising from the oil and gas sector were the most significant sources and a key category in the inventory.

For PM emissions, the only major source and key category amongst stationary combustion activities was combustion of solid fuels in cement manufacture.

4.2 Overview of methodology

4.2.1 1A1a – Power generation and desalination

In the UAE, electricity production and water desalination are fuelled by the burning of natural gas in normal conditions, and diesel and residual fuel oil as backup. In 2015, the most common technology in operation was gas turbine generation, although some generation in steam turbines also occurred.

Estimations of emissions from power generation and desalination are a Tier 2 standard for the generation facilities in Sharjah, Ajman, RAK, and Fujairah, as those use data on fuel consumption by fuel type and type of generation technology in 2015. This information was gathered from the electricity and water authorities in UAE. A Tier 3 standard was available for the generation facilities in Abu Dhabi and Dubai, and therefore used. There are no power generation facilities in the emirate of UAQ.

[8] Desalination tends to occur at the same sites as electricity generation, and as one fuel consumption figure is often reported for the two activities combined, they are treated as a single activity in this inventory.

4.2.2 1A1b[9] – Oil and gas operations

This sub-sector includes emissions arising from exploration and production, oil refineries and gas processing. In 2015, there were four oil refineries in the UAE and multiple gas processing plants. These operations take place in the emirates of Abu Dhabi, Dubai and Fujairah.

With respect to Abu Dhabi, emission estimates for NO_X, SO_2, CO and NMVOCs were provided directly by the Abu Dhabi National Oil Company (ADNOC) and they were considered to be a combination of Tier 2 and Tier 3 methods. For particulate matter, a Tier 1 approach was applied, using activity data provided by ADNOC and emission factors from the 2016 EMEP/EEA guidebook.

In the case of the Dubai refineries, emission estimates for all pollutants reported have been provided directly by Dubai Municipality and are thought to be based on stack monitoring and thus also considered to be a Tier 3 method. In accordance with the 2016 EMEP/EEA guidebook, it has been assumed that for this sector:

Total suspended particles (TSP) = PM_{10} = $PM_{2.5}$

For Fujairah, the amount of fuel combusted in 2015 was provided by the refinery directly. Since no further information was provided, the simplest method – Tier 1 – utilising emission factors from the 2016 EMEP/EEA guidebook was applied.

4.2.3 1A2 – Stationary combustion in manufacturing and construction

The emissions included in this category result from fuel consumption in combustion to provide heat, electricity and mechanical work for manufacturing and construction. **This is distinct from emissions resulting from industrial processes and product use (IPPU), which are covered in section 6.** In the NFR framework, this category is subdivided into a number of different subcategories, including:

- 1A2a Iron and steel
- 1A2b Non-ferrous metals
- 1A2c Chemicals
- 1A2d Pulp, paper and print
- 1A2e Food processing, beverages and tobacco
- 1A2f Non-metallic minerals
- 1A2gviii Other stationary combustion in industry

In the UAE, key activities grouped under subcategory 1A2f (Non-metallic minerals) include manufacture of cement, asphalt, glass, plaster, ceramics and mineral wool, among others. The subcategory 1A2gviii (Other stationary combustion in industry) includes quarrying and crushing of stone, and concrete production.

Several types of fuel combustion data were available, depending on the emirate and subcategory, which necessitated a varied approach to emissions estimation. For Dubai and Abu Dhabi, emissions data were taken directly from their emissions inventories.

Assessment of completeness

The emissions estimates presented for 1A2 'Stationary combustion' in 'Manufacturing and Construction' (as well as for industrial processes and product use – see section 6) for Ajman, RAK, and Fujairah are based only on the data provided in the returned questionnaires. Responses have not been received from all industrial facilities in these emirates, and of those received, not all provided fuel consumption or production data. Therefore, for some subsectors, emissions could not be estimated, or they are likely to be underestimated. No gap-filling based on assumptions or proxy data has been attempted.

For Sharjah and UAQ, no data was available from questionnaires. Total liquid petroleum product consumption (for both emirates) and total natural gas consumption (Sharjah only) was combined with Tier 1 emissions factors to give a 'Total industry' emissions estimate not split by subsector.

For Abu Dhabi and Dubai, emissions estimates are likely to cover most of the emitting facilities, as they compiled directly by the local municipalities who undertake the tasks of licensing and monitoring the industries in their territory.

Due to the lack of completeness, estimates of emissions from industry (both combustion and IPPU) should be interpreted as 'reported' emissions, rather than a true total.

4.2.4 Small-scale combustion [1A4]

Small-scale combustion emissions correspond to the combustion of fuels in the commercial and residential sectors. Data on the total amount of fuel consumed in the commercial and residential sectors at the national level were available from the 2016 Annual Statistical

[9] In the NFR reporting structure, 1A1b is referred to as petroleum refineries. Exploration and production emissions would normally be accounted for in the industrial combustion sector (1A2), but have been included here so that all emissions arising from oil and gas operations are included in one sector.

Report (Ministry of Energy and Industry of United Arab Emirates, 2016). However, although the report presented the total amount of fuel, the data was not disaggregated by type of fuel. Assumptions were therefore made on the types of fuel being combusted and the split between different emirates. It was assumed that all of the fuel combusted in the residential sector was liquefied petroleum gas (LPG) and for the commercial sector it was assumed that 70% was LPG and 30% diesel. Due to lack of emirate-specific GDP data available, the amount of fuel combusted has been split across the emirates based on the population residing in each. Default emission factors from the 2016 EMEP/EEA guidebook were applied.

4.2.5 1B – Fugitive emissions from fuels

Intentional or unintentional releases of air pollutants may occur during the extraction, processing and delivery of fossil fuels to the point of final use. These are known as fugitive emissions for which estimates are subject to a high level of uncertainty.

Emissions arising from the following categories have been estimated:

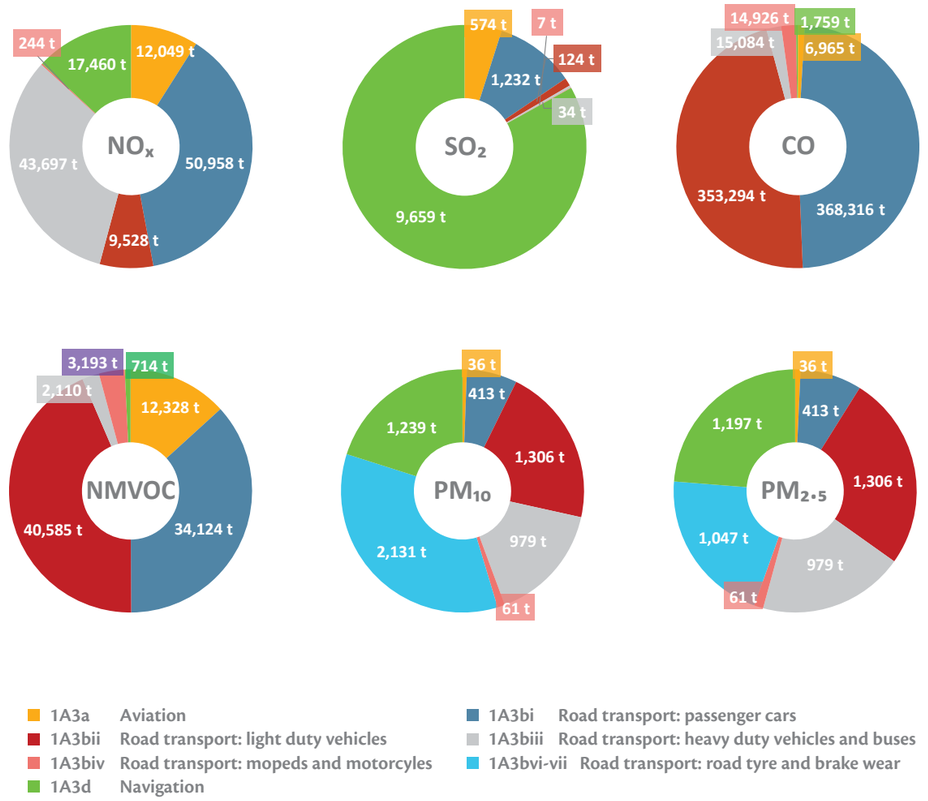
- **1B2ai – Fugitive emissions oil: exploration, production and transport.** This includes fugitive emissions from production platforms, storage tanks, tanker loading, and losses during transport in marine tankers and pipelines. The estimates for this category have been compiled for Dubai and Fujairah. The emissions data provided by ADNOC included estimates for fugitive sources and therefore emissions for the Abu Dhabi emirate are reported in 1A1b (oil and gas operations). This activity is not thought to occur in other emirates.
- **1B2aiv – Fugitive emissions oil: refining and storage.** Fugitive emissions arising from this category are assumed to be included in those emirates with refineries in the 1A1b (oil and gas operations) sector.
- **1B2av – Distribution of oil products.** This covers emissions arising from gasoline distribution in each of the emirates for which estimates are based on the amounts of fuel sold.
- **1B2c – Venting and flaring.** The UAE has a zero routine flaring policy in all of its oil and gas operations and compared to the year 1995, some of the largest oil and gas companies have managed to achieve a 76% reduction of hydrocarbon flaring. However, flaring sometimes does occur for safety and operational reasons. The emissions data provided by ADNOC included estimates for fugitive sources and therefore emissions for the emirate of Abu Dhabi are reported in 1A1b (oil and gas operations). The amount of fuel flared in the Fujairah refinery was provided. For Dubai, no information was available; however, it was assumed that the same proportion of fuel flared to that combusted in the refineries in Abu Dhabi also applied to Dubai. Default emission factors were then applied in accordance with the 2016 EMEP/EEA guidebook.

5. Transport

5.1 Overview of emissions

This sector covers aviation, road transport, railways, and shipping. Railway emissions are not covered in the inventory because Etihad Rail only began its operation in 2016 and there was no activity in this sector prior to this date in the UAE. Emission estimates for non-road mobile machinery are not explicitly included as a separate source, due to a lack of activity data (which is also common across many other countries).

Figure 6 Estimated emissions from the energy mobile sector by pollutant, 2015 (in tonnes)



The emission estimates show that both passenger cars and heavy-duty vehicles dominate the NO_X emissions for this sector (see Figure 6 and Table 5). The aviation and navigation sectors also contribute to the total transport emissions across all pollutants.

Table 5 Estimated emissions from the energy mobile sector by pollutant, 2015 (in tonnes)

Sector/category		Emissions					
		NOx	SO_2	CO	NMVOC	PM_{10}	$PM_{2.5}$
1A3a	Aviation	12 049	574	6 965	12 328	36	36
1A3bi	Road transport: passenger cars	50 958	1 232	368 316	34 124	413	413
1A3bii	Road transport: light duty vehicles	9 528	124	353 294	40 585	1,306	1 306
1A3biii	Road transport: heavy duty vehicles and buses	43 697	34	15 084	2 110	979	979
1A3biv	Road transport: mopeds and motorcycles	244	7.5	14 926	3 193	61	61
1A3bv	Road transport: gasoline evaporation	NA[1]	NA	NA	NE[2]	NA	NA
1A3bvi-vii	Road transport: road tyre and brake wear	NA	NA	NA	NA	2 131	1 047
1A3d:	Navigation	17 460	9 659	1 759	714	1 239	1 197
Total[3]		**133 936**	**11 631**	**760 343**	**93 056**	**6 166**	**5 040**

[1] NA – Not applicable (emissions of this pollutant do not occur from this source).
[2] NE – Not estimated (emissions from gasoline evaporation from road vehicles have not been estimated as the simplest approach (Tier 1) requires information on the annual distance travelled by each vehicle type, which was not available).
[3] The sum of the component parts may not exactly equal the total shown as a result of rounded off figures.

5.2 Methodology

Aviation:[10] Emission estimates were compiled for the Landing and Take-off (LTO) element only and no emission estimates were derived for the cruise element due to a lack of available information. It has been assumed that the following emirates primarily have international flights and all emissions arising are reported under 'international': Abu Dhabi, Dubai, and Sharjah. Domestic flights are assumed to occur from airports in RAK and Fujairah. There are no airports in Ajman or UAQ, thus emissions from these sources have been reported as 'not occurring'.

Differing levels of complexity have been used to derive the emission estimates depending on whether the emirate provided landings and take-offs by aircraft type. Dubai and Sharjah provided this information allowing the more detailed method (Tier 3) to be used. It was then assumed that the aviation fleet profile in Abu Dhabi was similar to that of Dubai. For other emirates, it was assumed that aircraft were on average akin to a C560 plane and thus a Tier 1 approach was used.

Road transport: The estimated amount of total fuel consumed in the road transport sector for each emirate was provided by the Ministry of Energy and Industry (MOEI). In order for a Tier 1 method to be followed, information on the amount of fuel consumed by each vehicle type (such as cars, light duty vehicles, heavy goods vehicles, buses, and motorcycles) is required. Data was estimated using a bottom-up approach by combining an estimate of the mileage driven by the number of vehicles. The latter was obtained from Dubai's road transport statistics between 2014 and 2016, and it was assumed that a similar fleet profile existed in other emirates.

In terms of mileage driven, as no data was available, it was based on experts' judgement and on the amount of fuel consumed. However, there are two exceptions. The first is Abu Dhabi, where some information on the age of the fleet was available from the Air Emissions Inventory published by the Environment Agency of Abu Dhabi (EAD). This allowed a more complex Tier 2 method to be used for the emirate. For Dubai, 2017 emission estimates for the transport sector were directly provided by the Dubai Municipality. In the absence of any other information, the data was scaled by the estimated difference in vehicle registrations between 2015 and 2017 in order to derive a 2015 estimate.

Passenger cars have been assumed to be 99% gasoline fuelled and, along with gasoline fuelled light duty vehicles, contribute the largest amount of CO emissions. This is expected as CO emissions are substantially higher from gasoline fuelled vehicles and in particular older vehicles. As the age profile of the UAE fleet is unknown for most of the emirates, the simplest methodology from the 2016 EMEP/EEA guidebook has been used.

The emissions factors utilised assume a typical EU-15 fleet and activity data for 1995, and apply to countries with older vehicle fleets. It is therefore likely that air pollutant emissions are in fact over-estimated for the UAE.

Shipping:[11] For Abu Dhabi and Dubai, emission estimates were obtained directly from the emirate concerned. Where information for particular pollutants was not provided, it was supplemented with information from the 2016 EMEP/EEA guidebook. The inventories only covered in-port emissions and therefore it was decided that a similar approach should be adopted for other emirates. Estimates were derived for UAQ, RAK, and Fujairah based on ships arriving at the ports and the ship profile information provided.

For Sharjah and Ajman, in the absence of any other information, the emission estimates were based on the amount of fuel sold for navigation purposes, which was provided by the MOEI. Unfortunately, it led to inconsistencies in the methodology used between the emirates. A Tier 1 approach has been used for the above mentioned emirates, which has combined the estimated fuel consumed in this sub-sector with default emission factors from the EMEP/EEA guidebook.

Non-road mobile machinery: It is assumed that the emissions arising from the combustion of fuel in mobile machinery is included in the road transport emission estimates, as the fuel data provided did not allow emission estimates to be made for these specific sources.

[10] Emissions arising from ground support equipment at airports and ports are not reported in these categories and would be reported under "Other" (1A5). However, no information was available to allow direct estimates made for these sources and it has been assumed that they are accounted for in the road transport sector.

[11] Emissions arising from ground support equipment at airports and ports are not reported in these categories and would be reported under 'Other' (1A5). However, no information was available to allow direct estimates made for these sources. It was assumed that they are accounted for in the road transport sector.

6. Industrial processes and product use (IPPU)

6.1 Overview of emissions

Emissions accounted for in this category are those associated with industrial processes and product use (see Figure 7 and Table 6), and exclude combustion related emissions.

Emissions from industrial processes in the UAE most significantly arise from metal and mineral industries, while those from metal industries are predominantly from primary and secondary aluminium production, and iron and steel production. Emissions from mineral industries are predominantly from cement production.

Across the country, emissions from product use are generally not estimated due to data limitations. Domestic solvent use (which includes cosmetics and toiletries, car care products, and household products), the largest estimated category for product use, has been estimated using a default per capita value.

Figure 7 Estimated emissions from the IPPU sector by pollutant, 2015 (in tonnes)

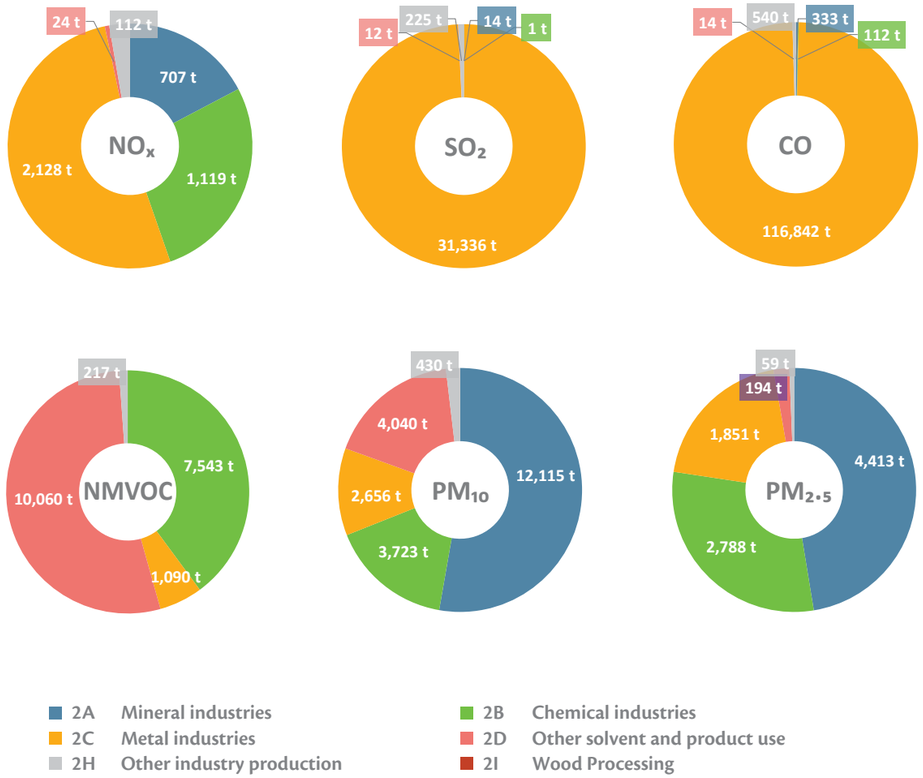


Table 6 Estimated emissions from the IPPU sector by pollutant, 2015 (in tonnes)

Sector/category		Emissions (tonnes)					
		NOx	SO_2	CO	NMVOC	PM_{10}	$PM_{2.5}$
2A	Mineral industries	707	14	333	NA	12,115	4,413
2B	Chemical industries	1 119	1.4	112	7 543	3 723	2 788
2C	Metal industries	2 128	31 336	116 842	1 090	2 656	1 851
2D	Other solvent and product use	24	12	14	10 060	4 040	194
2H	Other industry production	112	225	540	217	430	59
2I	Wood processing	0.0000047	0.000047	0.000047	0.000024	0.0013	NA
2J	Production of persistent organic pollutants (POPs)	NA[1]	NA	NA	NA	NA	NA
2K	Consumption of POPs and heavy	NA	NA	NA	NA	NA	NA
2L	Other production	NA	NA	NA	NA	NA	NA
Total[2]		**4 090**	**31 589**	**117 842**	**18 910**	**22 964**	**9 305**

[1] NA – Not applicable (emissions of this pollutant do not occur from this source).
[2] The sum of the component parts may not exactly equal the total as a result of rounded off figures.

6.2 Methodology

In general, a bottom-up approach has been used in estimating emissions from industrial processes. Input data were largely acquired from questionnaires distributed to individual facilities throughout the UAE. An additional data base compiling all the received data was created. This approach means that emission estimates are only as complete as the data received, and therefore completeness remains an issue for the IPPU sector across the UAE. Where available, international data sets were used to complement facility data and improve the report's completeness.

Either the simplest (Tier 1) or a more detailed method (Tier 2 to 3), in accordance with the 2016 EMEP/EEA guidebook, was applied to estimate emissions from each facility and was dependent on the level of detail of the information provided. The exception to this was Abu Dhabi (Environmental Agency of Abu Dhabi, 2018) and Dubai (Dubai Municipality, n.d.), for which emission estimates were directly available from both emirates.

7. Agriculture

7.1 Overview of emissions

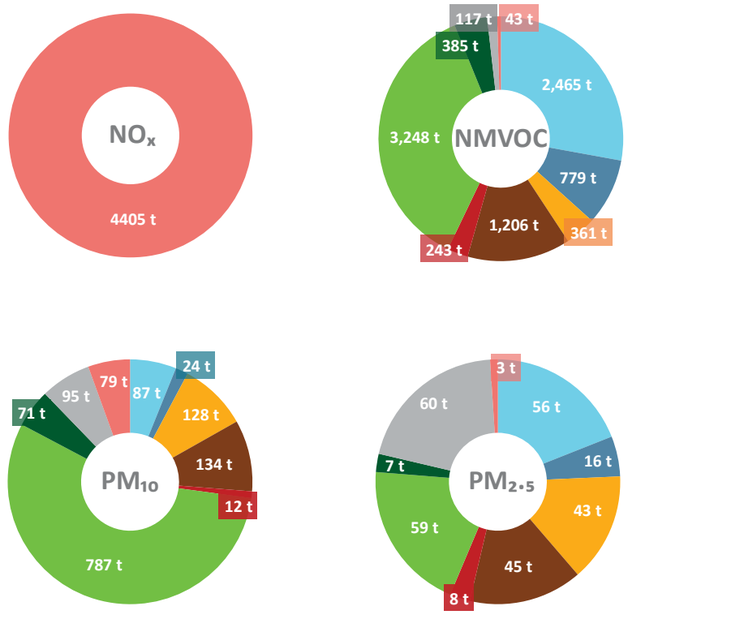
Emissions from the agriculture sector are of minor significance for all air quality pollutants included in this inventory. SO_2 and CO emissions are not applicable for the agriculture sector and are therefore not included in this section (see Figure 8 and Table 7). It should be noted that the primary air pollutant from the agriculture sector is NH_3, which is not yet included in the inventory.

The main activity that causes emissions is manure management. The term manure refers to excrement from agricultural livestock that is used as a fertiliser.

NO_X and NMVOC emissions arise from the excreta of agricultural livestock that are deposited in and around buildings, and collected as liquid slurry, solid manure or litter-based farmyard manure. Emissions of particulate matter (PM) are mainly from feed, bedding, and feathers which occur from buildings used to house livestock.

The majority of NMVOC and PM_{10} emissions from manure management are due to farmed cattle and poultry. A much larger proportion of $PM_{2.5}$ emissions are due to camels, which have approximately the same contribution as dairy and non-dairy cattle to $PM_{2.5}$ emissions from manure management.

Figure 8 Estimated emissions from the agriculture sector by pollutant, 2015 (in tonnes)



All NO_X emissions are accounted for under crop production and agriculture soils as manure is typically not stored before being applied to fields as a fertiliser. These NO_X emissions are the largest source of emissions from the agriculture sector. Negligible emissions of NMVOC, PM_{10} and $PM_{2.5}$ are estimated from crop production and agriculture soils (3D).

Table 7 Estimated UAE emissions from the agricultural sector by pollutant, 2015 (in tonnes)

Sector/category		Emissions					
		NOx	SO_2	CO	NMVOC	PM_{10}	$PM_{2.5}$
3B1a	Manure management – Dairy cattle	NO[1]	NA[2]	NA	2 465	87	56
3B1b	Manure management – Non-dairy cattle	NO	NA	NA	779	24	16
3B2	Manure management – Sheep	NO	NA	NA	361	128	43
3B4d	Manure management – Goats	NO	NA	NA	1 206	134	45
3B4e	Manure management – Horses	NO	NA	NA	243	12	7.9
3B4gi	Manure management – Laying hens	NO	NA	NA	3 248	787	59
3B4gii	Manure management – Broilers	NO	NA	NA	385	71	7.1
3B4h	Manure management – Camels	NO	NA	NA	117	95	60
3D	Crop production and agricultural soils	4,405	NA	NA	43	79	3
Total[3]		**4,405**	**NA**	**NA**	**8,847**	**1,416**	**297**

[1] NO – Not occurring
[2] NA – Not applicable (emissions of this pollutant do not occur from this source).
[3] The sum of the component parts may not exactly equal the total shown as a result of rounded off figures.

7.2 Methodology

All emission estimates for NO_X, NMVOCs, PM_{10} and $PM_{2.5}$ have been made using the Tier 1 method. No emissions of SO_2 or CO occur from the agriculture sector.

Data on livestock population, agricultural soils and crops was available from the Federal Statistics and Competitiveness Authority (FCSA). Other additional information, such as the rate of application of fertilisers, was sourced from FAO datasets and was allocated to UAE based on national crop area statistics. The simplest methodology from the 2016 EMEP/EEA guidebook has been utilised throughout the inventory. The assumption is that no manure is stored or used in anaerobic digesters, but all manure that it is produced within the UAE is applied directly to cropland.

8. Waste

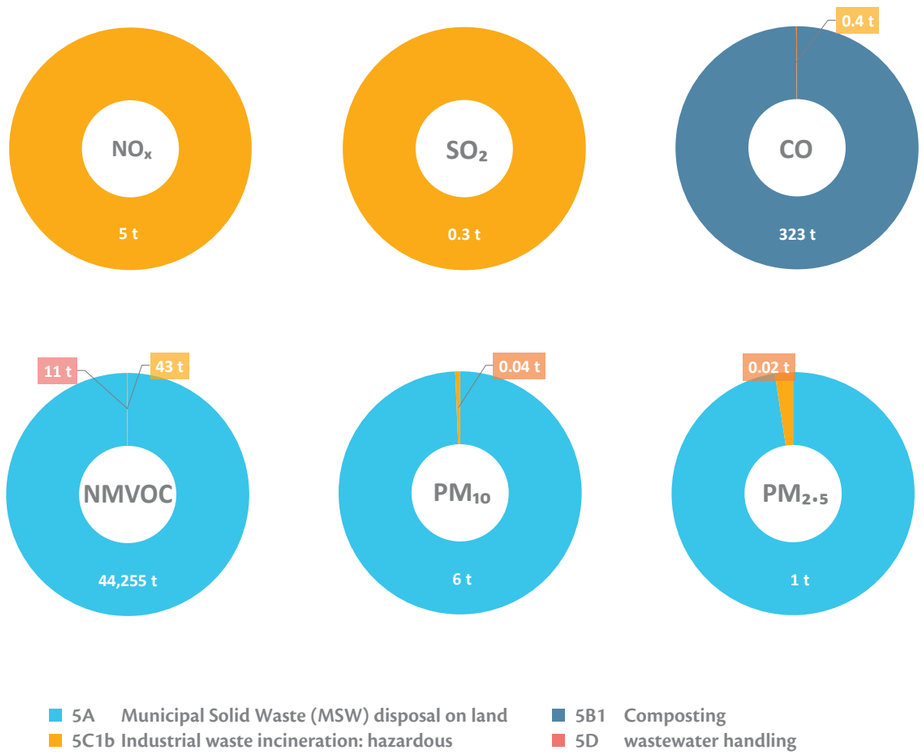
8.1 Overview of emissions

Emissions from the waste sector are of minor significance for all air quality pollutants included in this inventory, except for NMVOC emissions from MSW[12] disposal on land, which is identified as a key category (see Figure 9 and Table 8). It should be noted that some waste disposal activities can give rise to other pollutants, particularly heavy metals and persistent organic pollutants (POPs) that are not yet included in the inventory. Small amounts of carbon monoxide emissions from composting were estimated.

Negligible emissions of all pollutants are estimated from the incineration of hazardous waste in clinical waste incinerators. The incineration of hazardous waste is limited mostly to Abu Dhabi and Dubai.

Wastewater is treated and collected in all the emirates except UAQ. The practice gives rise to insignificant emissions of NMVOC.

Figure 9 Estimated emissions from the waste sector by pollutant, 2015 (in tonnes)



[12] The bulk of MSW originates from households, although similar wastes from sources, such as commerce, offices, public institutions, and selected municipal services are also included. MSW also includes bulky waste, but excludes waste from municipal sewage networks, and municipal construction and demolition waste.

Table 8 Estimated UAE emissions from the waste sector by pollutant, 2015 (in tonnes)

Sector/category		Emissions					
		NOx	SO_2	CO	NMVOC	PM_{10}	$PM_{2.5}$
5A	Municipal solid waste disposal on land	NA[1]	NA	NE	44 255	6.2	0.94
5B1	Composting	NE[2]	NA	323	NE	NE	NE
5C1b	Industrial waste incineration – Hazardous	5	0.27	0.41	43	0.041	0.023
5D	Wastewater handling	NA	NA	NA	11	NE	NE
Total[3]		**5**	**0.27**	**323**	**44 308**	**6.3**	**0.96**

[1] NA – Not applicable (emissions of this pollutant do not occur from this source).
[2] NE – Not estimated (emissions of this pollutant are likely to occur from this source, but there are no default emission factors available in the EMEP/EEA guidebook).
[3] The sum of the component parts may not exactly equal the total shown as a result of rounded off figures.

8.2 Methodology

The majority of activity data for the waste sector was obtained from waste data collected by MOCCAE, which provided national totals of MSW disposal routes, including waste disposal on land, composting, and hazardous waste incineration. For MSW disposal on land, a breakdown of activity data by emirate was available.

Data on the volume of collected and treated wastewater by emirate was available from the FCSA 2015 national data set.

The simplest methodology from the 2016 EMEP/EEA guidebook are utilised throughout, except for composting (Tier 2), where it was assumed that 'windrow' composting[13] is practiced.

Emission estimates for the waste sector can be treated as being highly uncertain due to the use of predominantly default emission factors on a limited evidence basis. Substandard completeness of the waste sector inventory is also a concern, where it is possible that uncollected MSW or wastewater not accounted for in national data may give rise to additional emissions.

[13] Windrow composting is the production of compost by piling organic matter or biodegradable waste, such as animal manure and crop residues, in long rows (windrows). This method is suited to producing large volumes of compost. For further reading, please see http://www.fao.org/3/a-y5104e.pdf

9. Conclusions and recommendations

This project has provided the results of a ground-breaking air pollutant inventory conducted for the UAE. Emission estimates have been compiled for the year 2015 for six criteria pollutants. The results of the inventory have allowed the main pollution sources to be identified, enabling appropriate action to be taken to improve air quality across the UAE.

The estimations showed that the stationary energy and transport sectors are the dominant sources of air pollutants. Power generation comprises a large proportion of the NO_X emissions, with road transport and oil and gas operations also contributing significant amounts. For SO_2 emissions, oil and gas operations are the dominant source. On the other hand, petrol fuelled passenger cars and light duty vehicles comprise the majority of CO emissions, with the IPPU sector also being an important source. For particulate matter (both PM_{10} and $PM_{2.5}$), the dominant sources are IPPU with smaller amounts arising from fuel combustion (in industry and transport) and road vehicle brake and tyre wear.

The agriculture and waste sectors play a minor role, as these are more significant sectors in terms of GHG emissions, in particular with regard to the estimated high NMVOC emissions from MSW disposal on land.

The process of collecting the activity data has been an enormous task and a substantial amount of useful information has been obtained, which has allowed detailed calculations to be undertaken in many cases. However, completeness remains a matter of concern, particularly in the industrial combustion and process sectors.

An update to the inventory is recommended every two to three years. Efforts should focus on completeness, on those key categories, and where improvements can be made with a low or medium level of effort. Inclusion of activities, such as construction, which are well known contributors to air pollution, should be addressed. Future editions of this document can include additional regulated criteria pollutants such as ammonia or lead. Significant improvements to the accuracy of the national inventories can be achieved with the development of country emission factors that reflect the local practices and technologies. In addition, the geographical allocation of these estimated emissions is utterly important for the identification of areas for priority intervention.

In the meantime, synergies between public entities and the private sector should be maintained and reinforced in order to undertake regular updates of this inventory, thus improving accuracy and completeness in every edition.

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