هـيـئـة الـبـيـئـة - أبـوظـبـي
Environment Agency - ABU DHABI

GREENHOUSE GAS INVENTORY

And Projections For Abu Dhabi Emirate

Executive Summary of the Third Cycle

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TABLE OF CONTENTS

عـام التـسـامـح
YEAR OF TOLERANCE

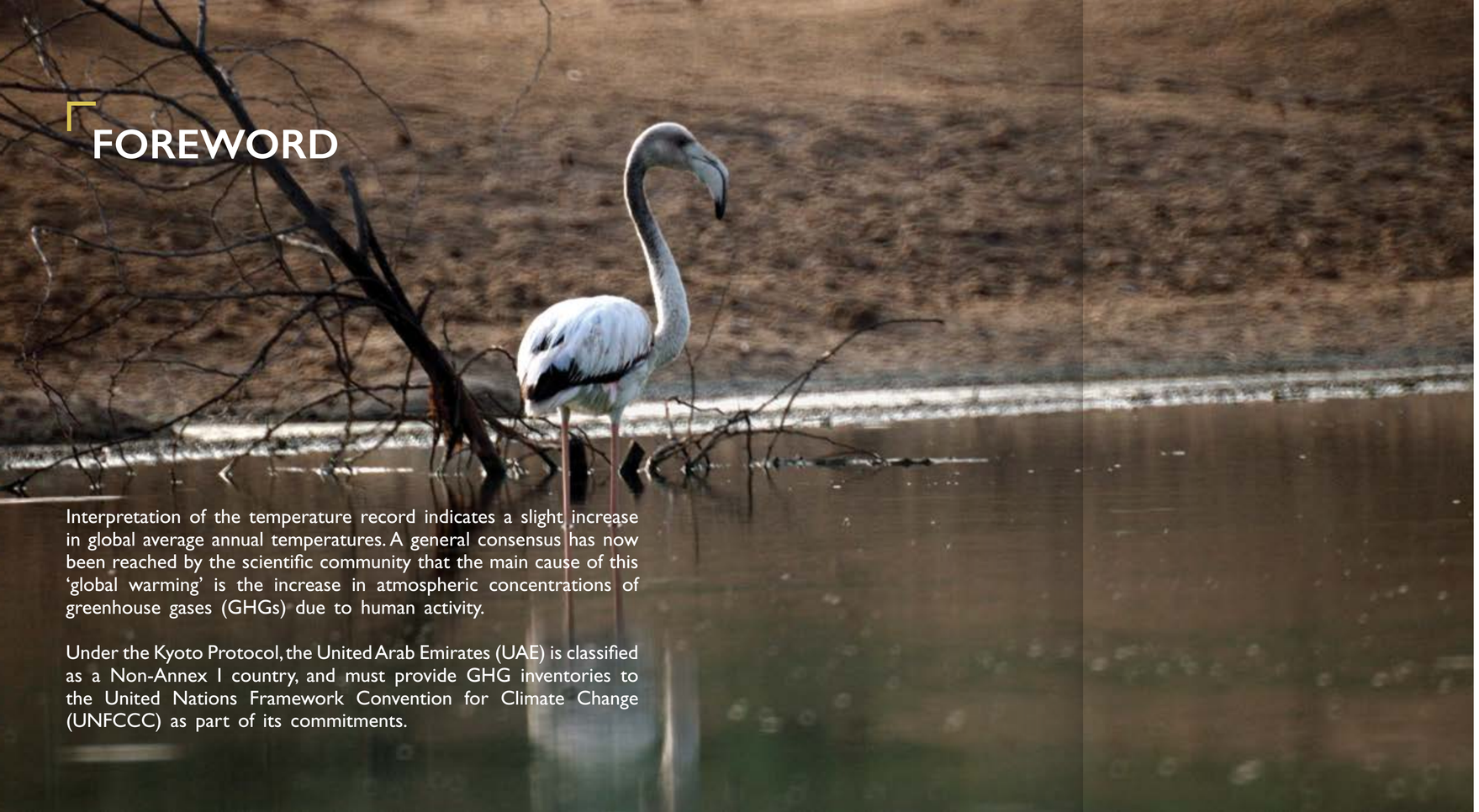
“Future generations will be living in a world that is very different from that to which we are accustomed. It is essential that we prepare ourselves and our children for that new world.”

Late Sheikh Zayed bin Sultan Al Nahyan

“Greenhouse gas inventory information is a key component of the Convention and the Paris Agreement to facilitate climate actions and assess their impacts, and I therefore commend the Environment Agency - Abu Dhabi efforts which will further strengthen the knowledge basis to address climate change in the context of Abu Dhabi’s diverse and rapidly growing economy.”

Patricia Espinosa, Executive Secretary of the UN Climate Change Secretariat

FOREWORD



Interpretation of the temperature record indicates a slight increase in global average annual temperatures. A general consensus has now been reached by the scientific community that the main cause of this 'global warming' is the increase in atmospheric concentrations of greenhouse gases (GHGs) due to human activity.

Under the Kyoto Protocol, the United Arab Emirates (UAE) is classified as a Non-Annex I country, and must provide GHG inventories to the United Nations Framework Convention for Climate Change (UNFCCC) as part of its commitments.

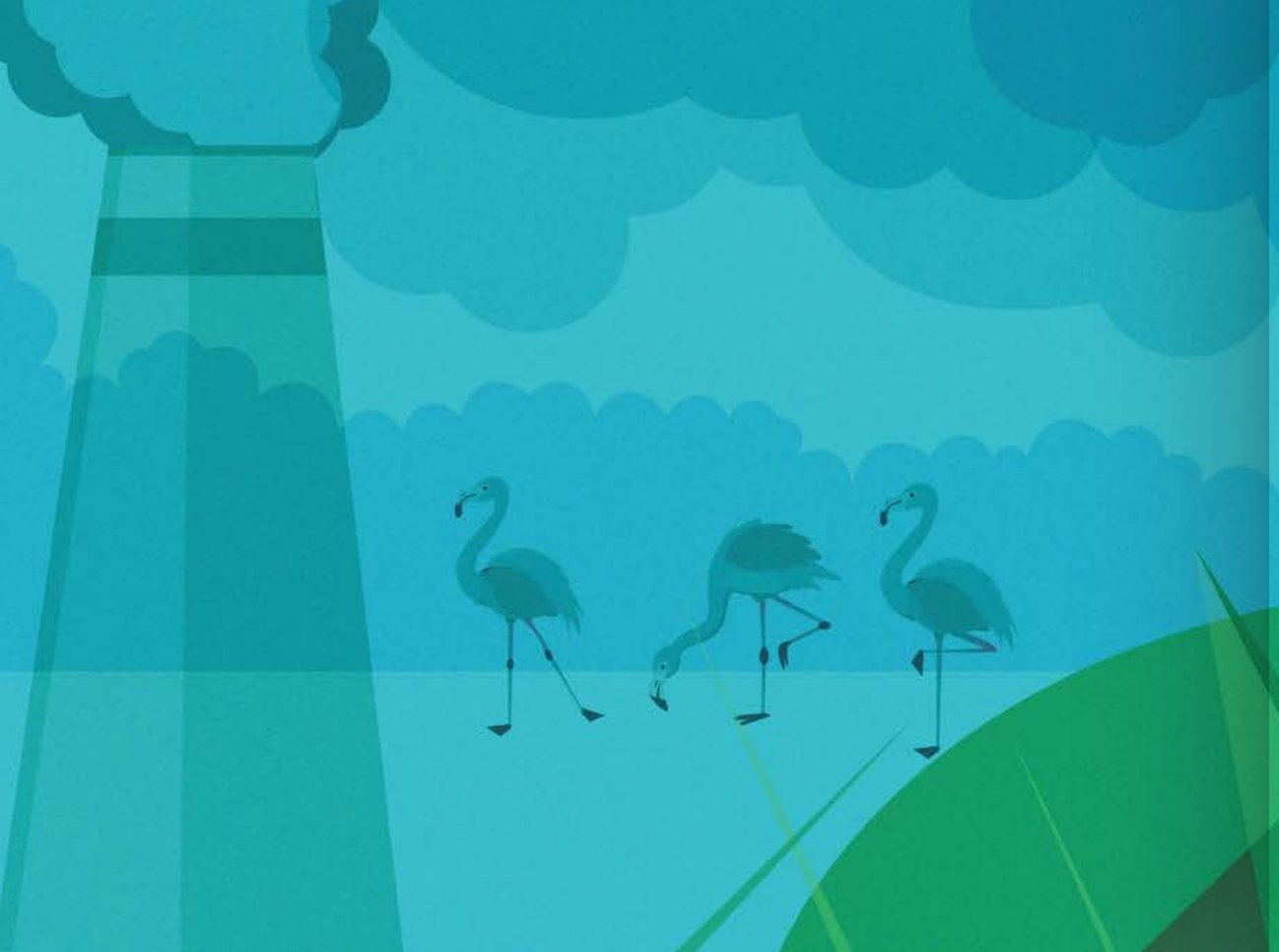
Air quality and climate change in the Emirate of Abu Dhabi have been the focus of the authorities for decades.

In line with its strategic priority to protect the air and mitigate climate change in Abu Dhabi Emirate, the Environment Agency - Abu Dhabi (EAD) was pro-active in commencing biennial GHG inventories as part of its comprehensive plan for monitoring atmospheric emissions in the Emirate. Abu Dhabi's diverse and rapidly growing economy calls for conducting a comprehensive GHG inventory to ensure a proper basis upon which to form policy and make decisions.

Abu Dhabi Emirate's first GHG inventory was established for the base year 2010. The second GHG inventory targeted data from the year 2012 and established emission projections for 2030. This third cycle of Abu Dhabi GHG inventory involved updates of GHG data for the years 2014 and 2016, and refinement of projections of emissions for up to 2030.

Those inventories were instrumental in laying a foundation of knowledge regarding the baseline emissions and projections in the Emirate, and also in strengthening the capacity of local entities for efficiently tracking and reporting their sectors' emissions. The emirate-level GHG inventories enable development of local climate policies as well as support the federal government in fulfilling its commitments to the United Nations Framework Convention on Climate Change (UNFCCC) by enhancing the robustness of the UAE's National GHG Inventory and the National Communication Report.

This report provides an executive summary of the achievements and key findings of the GHG inventory and emission projections compiled using the best available data, standard methods and best practices in compliance with the Intergovernmental Panel on Climate Change (IPCC) guidelines.



CHAPTER 1

CLIMATE CHANGE AND GREENHOUSE GASES

1.1 DPSIR Analysis

1.1.1 State of Climate Change

Climate change is already being felt globally. Effects include: higher air and water temperatures; lower precipitation levels; and a rise in sea level, seawater acidity and salinity. Acidity levels in the Arabian Gulf are increasing at a faster rate than most other oceanic waters around the world. Abu Dhabi Emirate's marine biodiversity is impacted by a variety of stressors, including: coastal development, over-exploitation, habitat fragmentation and pollution.

1.1.2 Drivers & Pressures

The main drivers for the increasing pressure exerted by greenhouse gas (GHG) emissions in Abu Dhabi Emirate are rapid growth in population as well as economic development, coupled with an ever-increasing demand for water and energy. The main source of GHG emissions is the combustion of fossil fuels for electricity and water, oil and gas, and transportation.

1.1.3 Impacts

Abu Dhabi Emirate is particularly vulnerable to the impact of climate change due to its extreme arid climate and low-lying coastal areas. The emirate's exposure to storm-induced erosion and flooding could be affected, with concomitant impacts on coastal infrastructure and habitats. The Arabian Gulf is already one of the most stressed marine environments on earth. Changes in habitat quality and primary production may also affect productivity for fisheries. Increased salinity, temperature and acidity levels are all expected to take their toll on the marine environment as a result of climate change. Increased aridity and recent climate-driven changes in vegetation are also likely to impact local agriculture, bird species and a wide range of desert animals. Climate change may also have significant impacts on public health, the specificities of which are the subject of ongoing research.

1.1.4 Response

The Government of the UAE is fully committed to the United Nations Framework Convention on Climate Change negotiating process. The UAE National Agenda has set a target for clean energy to contribute 27% of the country's total energy mix by 2021. The UAE Energy Strategy aims to increase the contribution of clean energy to 50% by 2050. In recent years, new policies have been introduced in the electricity and water sector in Abu Dhabi, which aim to curb consumption through a reduction of subsidies and the introduction of incentives to increase end-user efficiency. New policies have also been introduced in the transportation sector to reduce emissions through a comprehensive surface masterplan, low emission zones and vehicle efficiency standards.

1.1.5 Outlook

Existing plans and proposed strategies for sustainable development ensure that Abu Dhabi Emirate will achieve significant GHG reductions in the mid-term. The emirate has undertaken a number of measures to tackle this issue, including: tariff reform; green building regulations and efficiency standards; district cooling; a new fuel pricing economy; and a federal freight network. However, the potential for change should not be under-estimated and adaptation to the impacts of climate change should be emphasised in future development plans.

CHAPTER 2

SCOPE AND METHOD

2.1 GHG Inventory

Following the IPCC guidelines for GHG national inventories, the inventory targeted both direct emissions (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6)) and indirect emissions (carbon monoxide (CO), nitrogen oxides (NOx), sulphur dioxides (SO_2) and non-methane volatile organic compounds (NMVOCs)) from the economic activities in the energy, industrial processes, agriculture, waste as well as land-use change and forestry sectors. Carbon sequestration and storage by the Abu Dhabi wetlands, particularly mangroves and seagrass, was estimated using the 2013 IPCC Wetlands Supplement.

Sectors' activity data were collected in close collaboration with the relevant local authorities and data sources. Several face-to-face meetings were held with stakeholders. Significant data were collected, crossed-checked and validated from different data sources using sectoral questionnaires. The encountered data gaps were resolved by the justified assumptions.

Three iterations were performed in total. For the inventory years 2014 and 2016, two iterations were done using the IPCC Revised 1996 Guidelines coupled with the Good Practice Guidance. For the inventory year 2016, a complementary iteration was done using the 2006 IPCC Guidelines coupled with the 2013 Wetlands Supplement. The complementary iteration allowed verification of the inventory results by comparable standard methodology, and provided analysis on the effect of the methodology and emission factors updates. It also allowed calculation of the CO_2 removals and storage by the mangroves and seagrass sinks. Abu Dhabi Emirate was among the first worldwide to conduct an inventory incorporating the 2013 IPCC Wetlands Supplement to the 2006 IPCC Guidelines.

The sectoral bottom-up approach was adopted for estimation of the GHG emissions, while the reference top-down approach was used for verification of the CO_2 emissions from fuel combustion. GHG emissions were calculated and analysed by sector, subsector and gas using the UNFCCC non-Annex I GHG inventory spreadsheets and the IPCC 2006 inventory software combined with the IPCC emission factor database. A key category analysis was performed to identify the main sources that are responsible for 95% of total direct GHG emissions in the Emirate.

For the inventory benchmark, three emission indicators were developed for Abu Dhabi Emirate following international best practices: CO_2 per capita, CO_2 per GDP and CO_2 per kWh electricity produced. Comparison of emission indicators with some selected countries and regions was performed using the emissions and economic data from international data sources such as the World Bank, International Monetary Fund and World Resource Institute.

Details of the input data and inventory calculations are presented in the technical report "Greenhouse Gas Inventory and Projections for Abu Dhabi Emirate - Technical Basis & Results of the Third Cycle".

2.2 GHG Projections

In addition to emission inventory updates for 2016, the future GHG emissions up to the year 2030 were studied. Three emission scenarios were projected and analysed by sector and subsector: a Historical Trajectory reference scenario as per the baseline emissions in the base year 2010; a Business-As-Usual scenario as per the state of emissions and implemented mitigation measures in the year 2016 (BAU2016); and a state of emissions with extended emission control (or Mitigation Path).

The GHG emission projections were developed using the best available demographic, economic and activity growth data. The potentials of emission reductions by the Mitigation Path scenario were assessed and analysed against both the Historical Trajectory and BAU2016 scenarios.

The mitigation policies and plans that were analysed include:

- Nuclear energy programme
- Renewable energy programme
- Electricity and water Demand Side Management (DSM) programme (Tarsheed energy and water saving)
- Surface transport master plan (demand strategies and high-efficiency vehicles)
- Oil and gas environment, health and safety (EHS) programme
- Waste sustainable management programme
- Carbon capture and storage project
- Energy efficiency programme for the production of aluminium, oil and gas

Details of the input data, scenario assumptions, mitigation practices and projection calculations are presented in the technical report "Greenhouse Gas Inventory and Projections for Abu Dhabi Emirate- Technical Basis & Results of the Third Cycle".

TOTAL EMISSIONS

3.1 Trend of GHG Emissions

Anthropogenic GHG emissions in Abu Dhabi Emirate have been driven largely by economic and population growth and the increasing demand for water and energy. The emirate's GHG baseline (2010) and update inventories (2012, 2014, 2016) have shown that total direct GHG emissions increased from 99,101 Gg CO_2-eq in the year 2010 to 135,364 Gg CO_2-eq in 2016 (Figure 3.1). This increase of 36.6% over the six years was in line with the increased trend of the emirate's population (38.9%) and GDP (34.5%, constant 2007 prices).

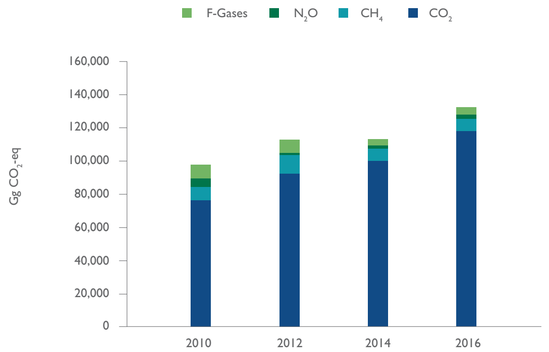


Figure 3.1: Trend of Total GHG Emissions in Abu Dhabi Emirate during 2010-2016

3.2 Sources of Emissions

Across the different activities in energy, industrial processes, agriculture, land-use change and forestry (LUCF) and waste, the energy sector was the dominant contributor (78.2%) of the emirate's GHG emissions in 2016 (Table 3.1, Figure 3.2).

Table 3.1: GHG Emissions in Abu Dhabi Emirate, 2016

	CO_2	CH_4	N_2O	PFCs[1]	HFCs	SF_6
Gas quantity (Gg)	120,508.87	370.95	7.35	0.5606 (CF_4) 0.0560 (C_2F_6)	0.01	0.02
Global Warming potential (IPCC-SAR)	1	21	310	6500 (CF_4) 9200 (C_2F_6)	4750	23900
Gas quantity (Gg CO_2-eq)	120,508.8	7,790.0	2,277.2	4,160.2	46.6	580.7
Gas contribution (%)	89.0	5.8	1.7	3.5		

[1] EAD estimation of PFCs was based on the updated IPCC 2006 emission factors. Emirates Global Aluminium (EGA) estimation (based on lower emission factors for their production lines) showed much lower PFC emissions (214 Gg CO_2-eq in 2014 and 87 CO_2-eq in 2016).

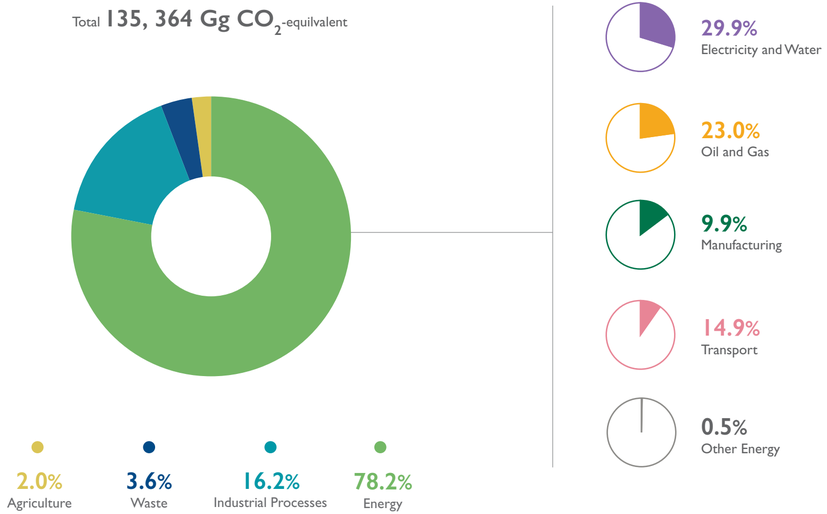


Figure 3.2: Sources of GHG Emissions in Abu Dhabi Emirate in 2016

The key category analysis of GHG emissions in the emirate showed that the CO_2 emissions attributed to stationary fuel combustion for energy industries (oil, gas and power, combined with water desalination) and mobile fuel combustion in road vehicles require particular attention in mitigation plans (Figure 3.3).

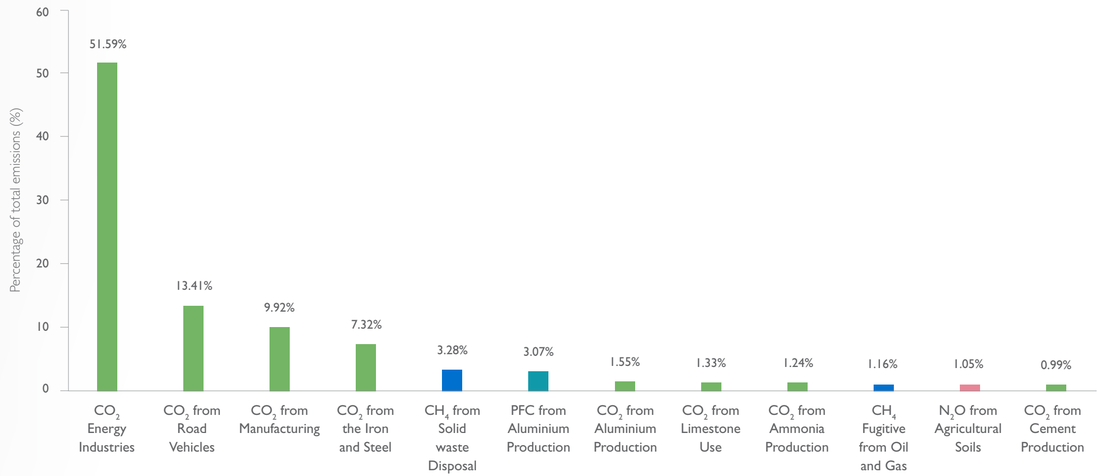


Figure 3.3: Key Category Analysis of GHG Emissions in Abu Dhabi Emirate in 2016

Considering the amount of emitted GHG gases in the emirate and their global warming potential (according to IPCC Second Assessment Report), CO_2 was the major gas emitted from fuel combustion, constituting 89% of the total GHG emissions. Other GHG gases such as methane (CH_4), nitrous oxide (N_2O) and the F-gases (PFCs, HFCs, SF_6) contributed less: 5.8%, 1.7%, and 3.5%, respectively (Figure 3.4).

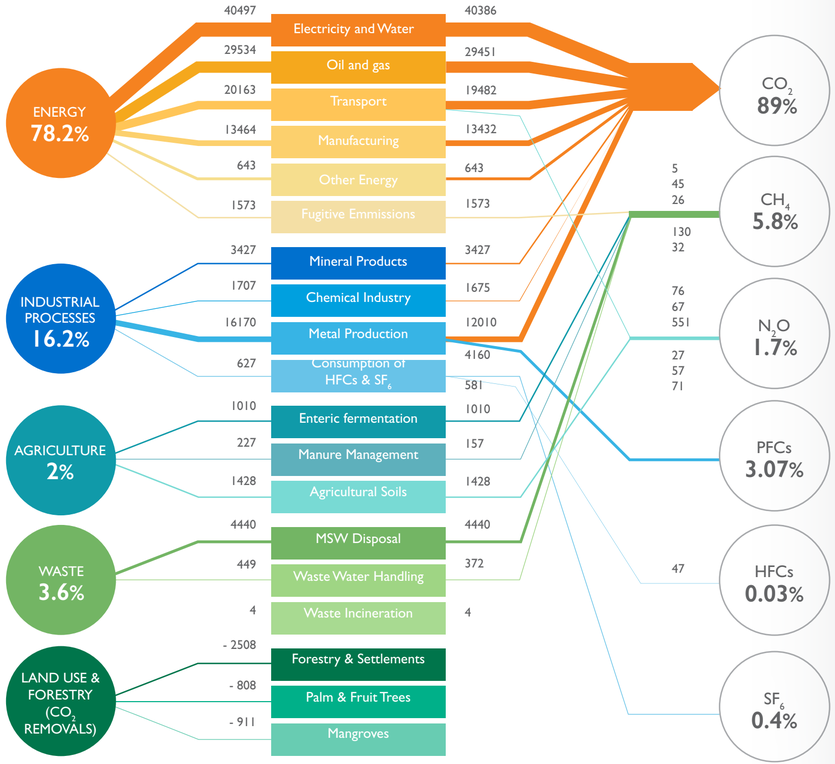


Figure 3.4: Abu Dhabi Emirate's GHG Sankey diagram for 2016 (total emissions 135,364 Gg CO_2-eq)

In 2016, between 4,277 to 6,469 Gg of CO_2 emissions (≤6% of the Emirate's total CO_2 emissions) were sequestered by the extensive system of forestry, perennial croplands and mangrove plantations throughout the emirate (Table 3.2).

Table 3.2: Carbon Sequestration by Vegetation, 2016

Plantation type	Carbon sequestration[2] (Gg CO_2)
Forest land	2,508 – 3,133
Wetlands (Mangroves)	911
Perennials cropland	808 – 2,425
Total	**4,227 - 6,469**

According to the IPCC supplement for wetlands, the added value of Abu Dhabi Emirate's wetlands (mangroves and seagrass meadows) is in holding about 61,324 Gg of CO_2, where carbon is stored in the soil and biomass of the plants. This quantity may be released if the wetlands are extracted or drained.

[2] IPCC 2006 Guidelines provided higher sequestration than IPCC Revised 1996 Guidelines.

3.3 Emission Indicators

Abu Dhabi's contribution to the world total GHG emissions is quite small and did not exceed 0.26% in 2014. Compared with the UAE total GHG emissions, Abu Dhabi Emirate's emissions accounted for about 55% of the national GHG emissions in the year 2014. At a local level, the UAE aims to ensure sustainable development while preserving the environment, and to achieve a perfect balance between economic and social development. However, the per capita CO_2 emissions were among the highest in the region, reaching 41.44 tonnes CO_2 per capita in 2016, an increase of 11% from 2010.

While the CO_2 emissions per GDP indicator increased to 0.217 Kg CO_2/AED (constant 2005 prices) in 2016 (an increase of 25% over 2010), the carbon intensity for electricity production decreased to 0.41 Kg CO_2/KWh (a reduction of 13% from 2010). This reflects the switch to a cleaner fossil fuel (natural gas) for electricity and water production in the last years.

However, the main player in emission indicators is CO_2, with levels increasing faster than both population and GDP between 2010 and 2016. The main activities contributing to 2016's CO_2 emissions were the production of public electricity and water desalination (33.5% of all CO_2 emissions); oil and gas extraction and processing (24.4%); manufacturing and industrial processes (25.3%) and transport (16.2%). The above categories are therefore key areas to target for future improvement in the emirate's emission indicators.

Compared with neighbouring countries in the Middle East, Abu Dhabi Emirate's emission indicators linked to the economy or electricity production were low (Figure 3.5 and Figure 3.6). This reflects the effective performance of economic development with low emission intensities and the use of efficient technology and clean fuel compared to other countries in the region. It should be noted that no single indicator can provide a complete picture of a country's CO_2 emissions performance or its relative capacity to reduce emissions.

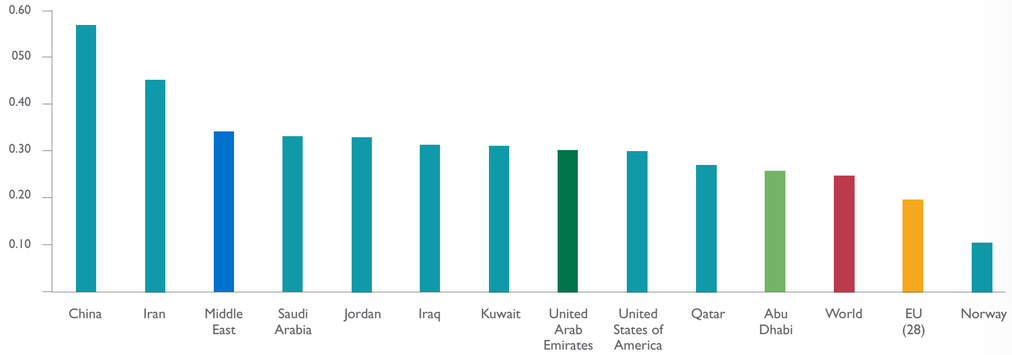


Figure 3.5: Emission Indicator CO_2 per GDP for Abu Dhabi Emirate and Other Countries and Regions (Kg/int.$ current), 2014

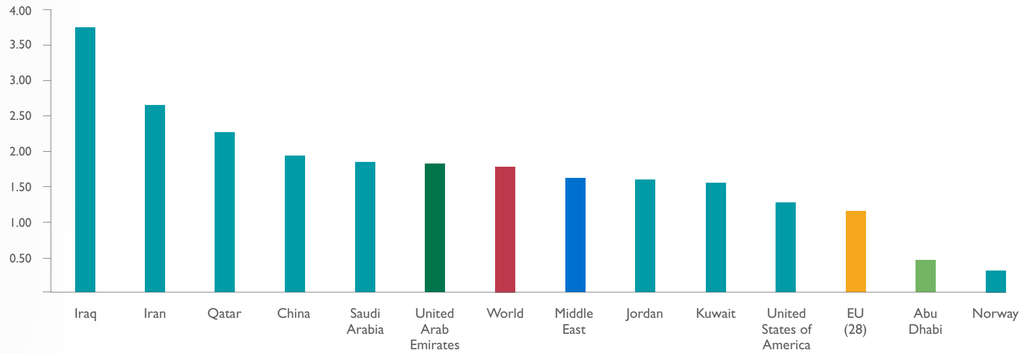


Figure 3.6: Emission Indicator CO_2 per KWh (Kg/KWh) for Abu Dhabi Emirate and Other Countries and Regions, 2014

3.4 Inventory Verification

Verification analysis showed that the emirate's total GHG emissions in the year 2016 were 2.7% lower by the improved IPCC 2006 guidelines (compared with the IPCC Revised 1996 Guidelines). This is due to the enhanced emission factors, avoided double counting of emissions and estimates of actual emissions rather than "potential" by the improved guidelines.

Verification of CO_2 emissions from fuel combustion (the major emission contributor) showed that the deviation between the reference top-down and the sectoral bottom-up approach of estimation was 1% and 6% for the inventory years 2014 and 2016, respectively. The achieved results are consistent with the IPCC expectation (5%).

3.5 Projection of GHG Emissions

Analysis of emission scenarios indicates that the GHG emissions can reach 340,254 Gg CO_2-eq by the year 2030 under the "Historical Trajectory" scenario (projected based on 2010 baseline emissions).

If development plans continue according to the Business-As-Usual scenario as in the year 2016 (BAU2016), future GHG emissions in Abu Dhabi Emirate are expected to increase by a factor of 2.7, from 99,101 Gg CO_2-eq in 2010 to 267,352 Gg CO_2-eq in the year 2030 (considering implemented policies as in the year 2016 and taking into account the expected changes in population, GDP and sectors' growth). In this scenario, by 2030 sectoral GHG emissions might be increased by 303%, 194%, 170% and 153% in energy, industrial processes, agriculture and waste, respectively (Figure 3.7).

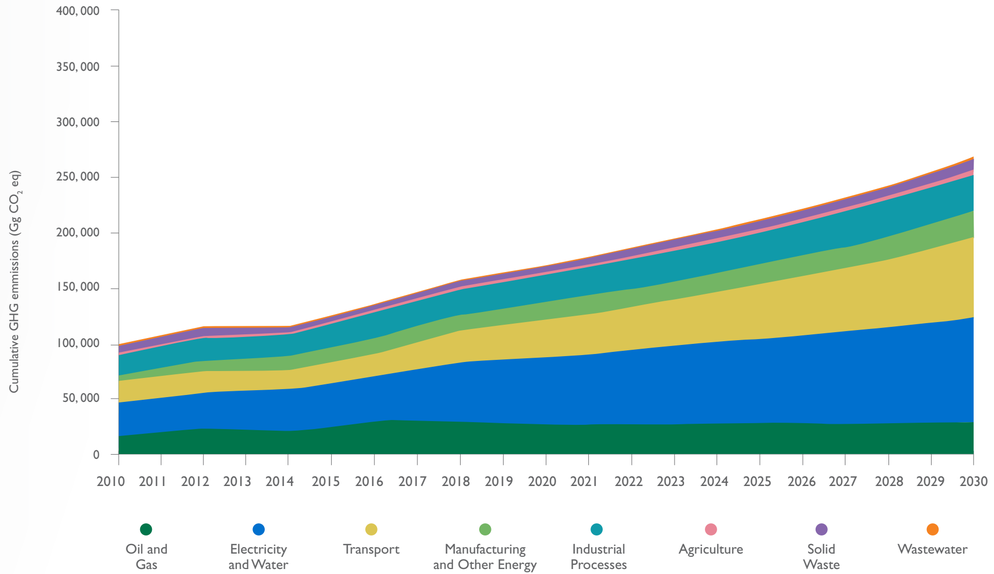


Figure 3.7: Projected Sectoral GHG Emissions According to Business-as-Usual as in 2016

Compared with the Historical Trajectory reference scenario, the BUA2016 has lower total emissions (19% lower in 2016) due to the mitigation measures implemented after the year 2010, especially in the power (such as MASDAR 10 MW PV and Shams 100 MW CSP power plants), industry and waste sectors (Figure 3.8).

Initial analysis of the future opportunities for GHG emission mitigation shows that the emirate has the potential to reduce around 42% (113,489 Gg CO_2-eq) of its "BAU2016" emissions by the year 2030. This will be achieved by considering additional emission control measures and policies (presented in Section 2.2 above), in a so-called "Mitigation Path" scenario (Figure 3.8).

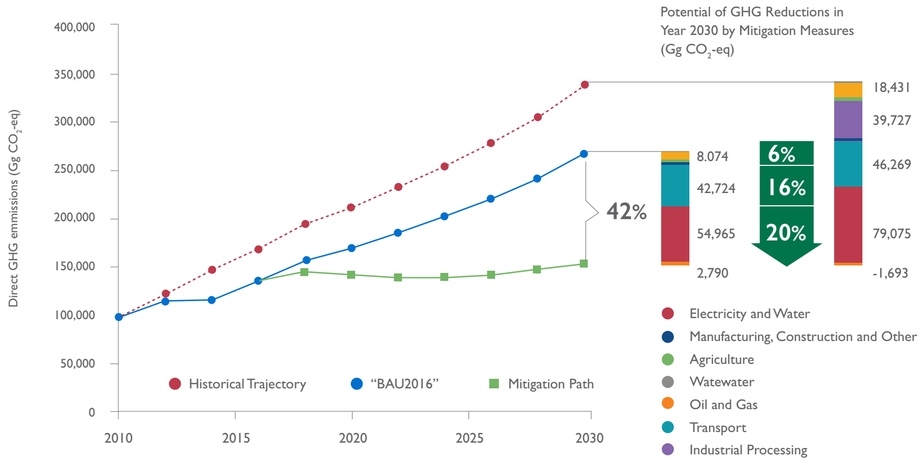
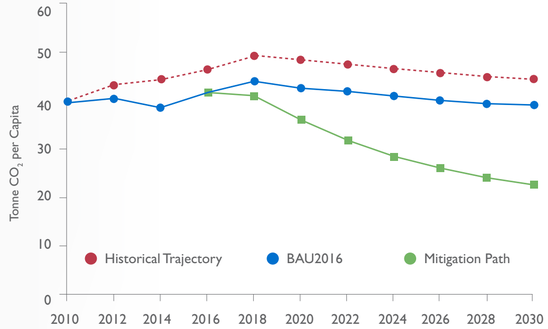


Figure 3.8: Projected GHG Emission Scenarios for Abu Dhabi Emirate

The largest potential for emission reductions in the year 2030 is expected to come from the power sector (combined electricity and water production with DSM, 20%), followed by transport (16%), solid waste (3%), and other sectors (3%). By the year 2030, with the support of Tarsheed DSM programme, nuclear and renewables are expected to cover around 46% of electricity demand and avoid 29,124 Gg of CO_2-eq.

After the year 2020, with the extended implementation of renewables, energy efficiency and operation of the nuclear plant (Mitigation Path scenario), it is expected that the emission indicators (CO_2 per capita and CO_2 per GDP) will drop to about 50% of the current value by the year 2030, whilst under the Business-As-Usual scenario (BAU2016), the trend of emission indicators might slightly decrease (Figure 3.9).



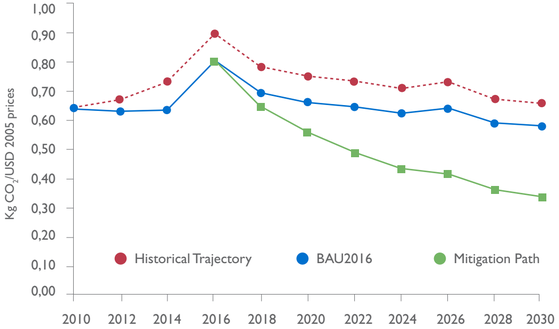


Figure 3.9: Projections of CO_2 emissions indicators for Abu Dhabi Emirate

Analysis also shows that the mitigation strategies will have public health co-benefits by improving the air quality through reducing the short-lived gases and anthropogenic particulate matter. It is estimated[3] that in the year 2030, around 731 premature deaths and 10,189 health facility visits can be avoided by the mitigation path, compared with the "BAU2016" scenario. However, these projections and analysis will need to be reviewed and updated where necessary in close collaboration with the relevant stakeholders.

[3]Estimates were based on local health co-benefit factors sourced from the public health co-benefits of GHG mitigation strategies in Abu Dhabi, AGEDI 2016.

CHAPTER 4

ENERGY SECTOR EMISSIONS

Emissions in the Energy sector derive from the combustion of fuel (main source) or from fugitive emission sources. Fugitive emissions include leaks, unintended and irregular gas releases, whilst fuel combustion includes the combustion of fuel for the specific generation of energy.

The Energy sector is split into the Energy Industries, Transport, Manufacturing and Construction and Other Energy subsectors. The Energy Industries subsector comprises of combined electricity and water, oil and gas industries.

4.1 Sources of GHG Emissions in the Energy Sector

The Energy sector was the source of 105,875 Gg CO_2-eq (78.2% of the emirate's total GHG emissions) in 2016. Fuel combustion accounted for 98.5% of these emissions, while fugitive emissions from oil and gas contributed only 1.5%. Public electricity and desalinated water production was the single largest source in the Energy sector, followed by oil and gas, transport and manufacturing (Figure 4.1). CO_2 was the primary direct GHG in the sector, and CH_4 was primarily generated from fugitive sources (Figure 4.2).

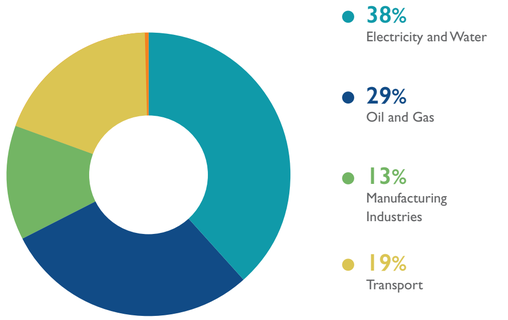


Figure 4.1: Contributions of energy subsectors towards total GHG emissions from the Energy sector in Abu Dhabi Emirate in 2016

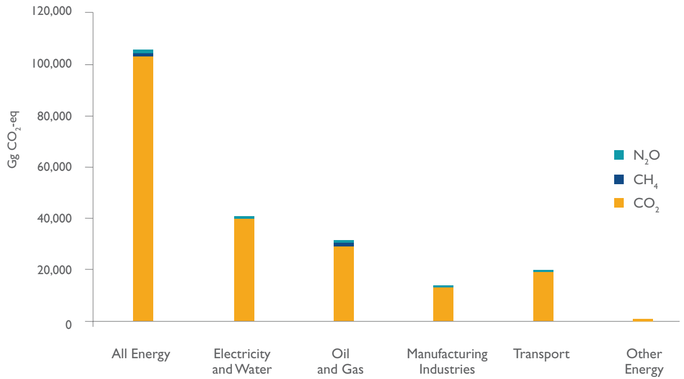


Figure 4.2: Breakdown of direct GHG emissions from the Energy sector in Abu Dhabi Emirate in 2016

4.2 Trend of GHG Emissions in the Energy Sector

Between the years 2010 and 2016, total GHG emissions from the Energy sector increased by 47.2% (Figure 4.3). In comparison, combined electricity and water production emissions increased by 31.3%, oil and gas emissions increased by 80.8%, manufacturing emissions increased by 179.3% and transport emissions increased by 8.7% (Figure 4.4). The trend of energy subsectors emissions varied during the previous years. This reflected the change in activity data or change in emission factors. The main driver for the decreased emissions in the oil and gas subsector in 2014 compared to 2012 was the decreased flaring and the improved oil production efficiency (lower fuel combusted). In the transport subsector, the drivers for the decreased emissions in 2014 compared to 2012 were the increased conversion to clean CNG fuel and the decreased gasoline and diesel oil fuel quantities used in road transport, although the total volume of vehicles in the emirate increased.

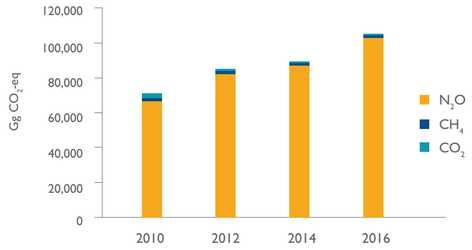


Figure 4.3: Trend of GHG emissions by gas from the Energy sector in Abu Dhabi Emirate during 2010-2016

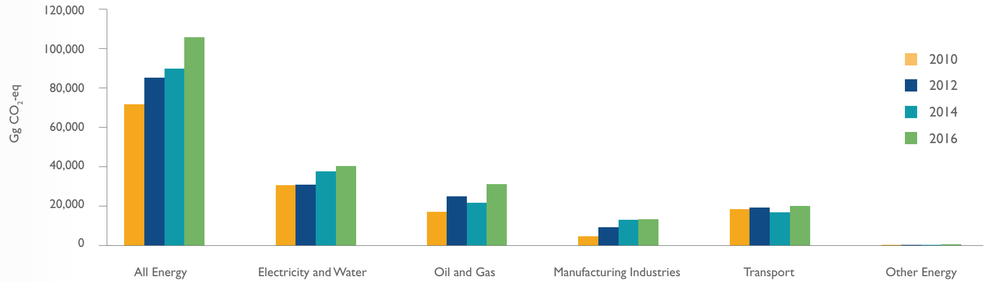


Figure 4.4: Trend of total GHG emissions by Energy subsector in Abu Dhabi Emirate during 2010-2016

4.3 GHG Emission Projections for the Energy Sector

Analysis of the Historical Trajectory emission scenario for the Energy sector indicates that the GHG emissions would reach 240,180 Gg CO_2-eq by the year 2030 without mitigation (increase factor 3.34 from 2010 level).

If development plans continue according to the Business-As-Usual scenario as in the year 2016 (BAU2016), future GHG emissions from the Energy sector are expected to reach 217,923 Gg CO_2-eq by the year 2030 (Figure 4.5).

The existing mitigation strategies and plans considered in the Mitigation Path scenario will reduce the Energy sector's emissions by 47.2% (102,946 Gg CO_2-eq) of its BAU2016 by 2030; the Mitigation Path emissions are expected to reach 114,977 Gg CO_2-eq.

The largest potential for emission reductions is expected to come from the combined electricity and water production and DSM (25.2%). These are then followed by transport (19.6%), oil and gas (1.3%), and manufacturing (1.1%). The DSM, nuclear, renewables and waste-to-energy programs are expected to reduce 54,965 Gg CO_2-eq (57.7% of the power sector's BAU emissions) by the year 2030.

In comparison with the emirate's total potential of emission reduction (113,489 Gg CO_2-eq in 2030), the contribution of the Energy sector in emission reduction is expected to be significant (90.71%).

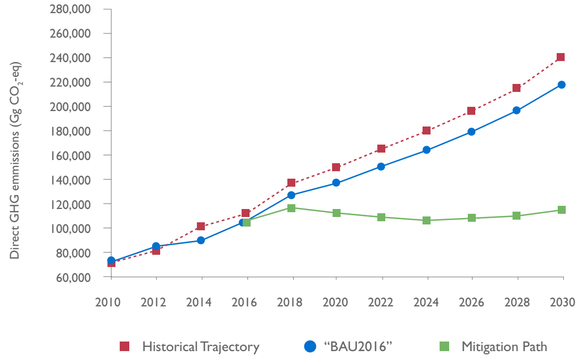


Figure 4.5: Projected GHG emission scenarios for the Energy sector in Abu Dhabi Emirate

CHAPTER 5

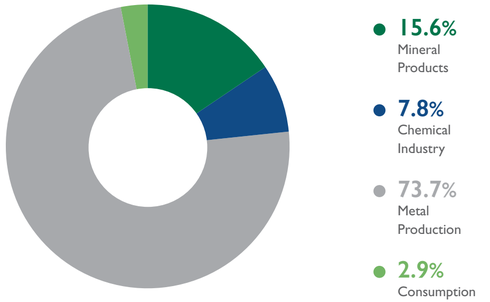
INDUSTRIAL PROCESSES SECTOR EMISSIONS

The Industrial Processes sector covers the use of halocarbons and SF_6 in products, and GHG emissions from non-energy uses of fossil fuel carbon. Only GHG emissions from physical and chemical transformation processes are considered here.

GHG emissions from the Industrial Processes sector may result from the production and consumption of mineral products (cement, asphalt, lime/ limestone and glass), the chemical industry (production of ammonia and ethylene), metal production (iron and steel and aluminium) and the production and consumption of halocarbons and SF_6 (used for refrigeration and circuit breaker purposes, respectively).

5.1 Sources of GHG Emissions in the Industrial Processes Sector

The Industrial Processes sector was the source of 21,931 Gg CO_2-eq (16.2% of the emirate's total GHG emissions) in the year 2016. Metal production (mainly iron and steel, and aluminium) was the single largest source in the Industrial Processes sector, followed by mineral products (mainly limestone and dolomite use, and cement production), and chemical production (mainly ammonia production), Figure 5.1. CO_2 was the main direct GHG in the sector, followed by PFCs (CF_4 and C_2F_6) in limited quantities, and the HFCs and SF_6 were minor (Figure 5.2).



- **15.6%** Mineral Products
- **7.8%** Chemical Industry
- **73.7%** Metal Production
- **2.9%** Consumption of Halocarbons and SF_6

Figure 5.1: Contributions of Industrial Processes Subsectors towards total GHG emissions from the Industrial Processes Sector in Abu Dhabi Emirate in 2016

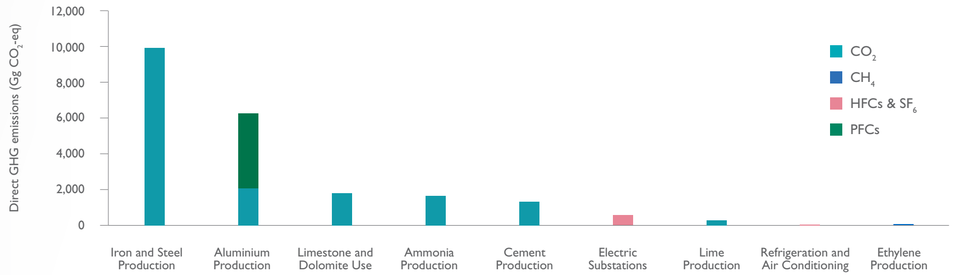


Figure 5.2: Breakdown of direct GHG emissions from the Industrial Processes Sector in Abu Dhabi Emirate in 2016

Note: EAD estimation of PFCs was based on the updated IPCC 2006 emission factors. EGA estimation (based on lower emission factors for their production lines) showed much lower PFC emissions (214 Gg CO_2-eq in 2014 and 87 CO_2-eq in 2016).

5.2 Trend of GHG Emissions in the Industrial Processes Sector

Between the years 2010 and 2016, total direct GHG emissions from the Industrial Processes sector increased by 22.5% (Figure 5.3). The trend of subsector emissions varied during the previous years. This reflected the change in activity data or change in emission factors. The main driver for the decreased emissions in 2014 was the PFCs from the aluminium industry; although the aluminium production volume increased in 2014, the PFCs emissions decreased due to enhancement in the emission factor (Figure 5.4).

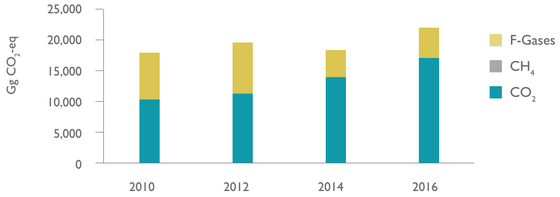


Figure 5.3: Trend of GHG emissions by gas[4] from the Industrial Processes sector in Abu Dhabi Emirate during 2010-2016

[4] F-Gases include PFCs, HFCs and SF_6

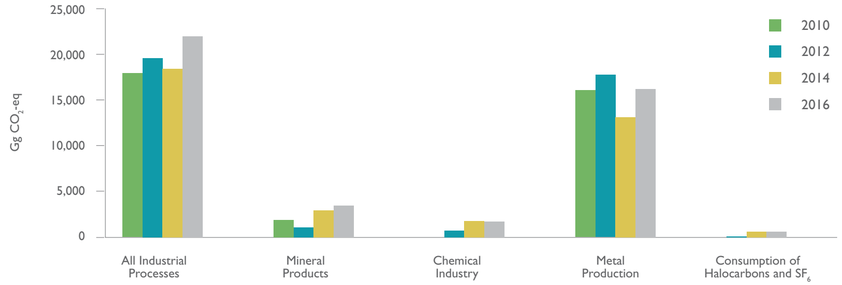


Figure 5.4: Trend of total GHG emissions by Industrial Processes subsector in Abu Dhabi Emirate during 2010-2016

5.3 GHG Emission Projections for the Industrial Processes Sector

Analysis of the Historical Trajectory emission scenario for Industrial Processes sector indicates that, without mitigation, the total GHG emissions would increase in the year 2030 by a factor of 4.16 from the 2010 levels.

If development plans continue according to the Business-As-Usual scenario as in the year 2016 (BAU2016), future GHG emissions from Industrial Processes are expected to increase by a factor of 1.94 from the 2010 levels to reach 34,823 Gg CO_2-eq in the year 2030. In this scenario, the main GHG emissions in 2030 will be from iron and steel industrial processes (38.5%) followed by aluminium industrial process (36%), other industrial processes 16%, and cement industrial process 9.5%.

Compared with the Historical Trajectory, the BAU2016 scenario can reduce about 39,727 Gg CO_2-eq (or 53 %) in 2030 (Figure 5.5). In the lack of mitigation policy targets or measures, the Mitigation Path was assumed similar to the BAU2016

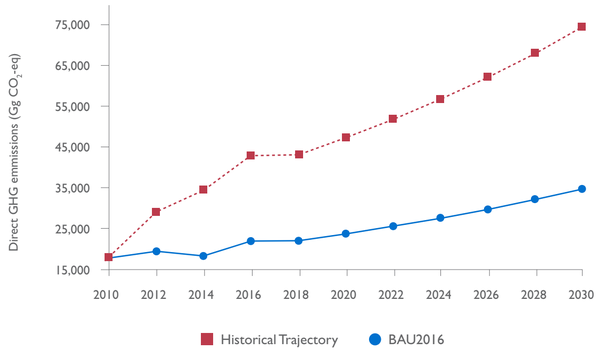


Figure 5.5: Projected GHG emission scenarios for the Industrial Processes Sector in Abu Dhabi Emirate

CHAPTER 6

AGRICULTURE SECTOR EMISSIONS

The Agriculture sector includes GHG emissions from enteric fermentation, manure management and agricultural soils.

Enteric fermentation is a digestive process by which carbohydrates are broken down in ruminant animals. Manure management refers to capture, storage, treatment, and utilization of animal manures. Agricultural soil GHG emissions are due to the application of soil nitrogen and the cultivation of organic soils.

6.1 Sources of GHG Emissions in the Agriculture Sector

The Agriculture sector was the source of 2,665 Gg CO_2-eq (1.97% of the emirate's total GHG emissions) in 2016, with Agricultural soil being the single largest source of the emissions (Figure 6.1). The direct GHGs were mainly N_2O, followed by CH_4 (Figure 6.2).

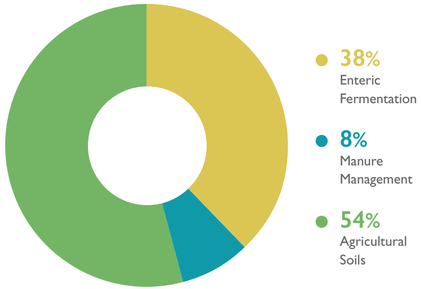


Figure 6.1: Contributions of agriculture subsectors towards total GHG emissions from Agriculture sector in Abu Dhabi Emirate in 2016

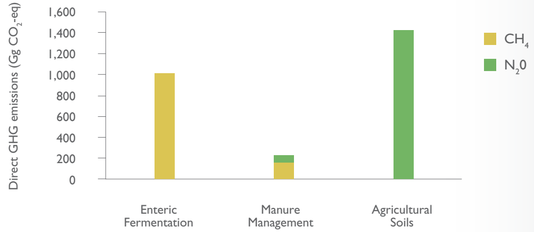


Figure 6.2: Breakdown of direct GHG emissions from the Agriculture sector in Abu Dhabi Emirate in 2016

6.2 Trend of GHG Emissions in the Agriculture Sector

Between the years 2010 and 2016, total direct GHG emissions from the Agriculture sector increased by 10.5% (Figure 6.3).

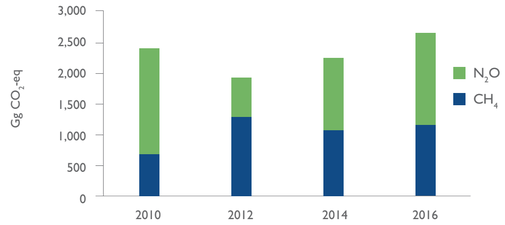


Figure 6.3: Trend of GHG emissions by gas from the Agriculture sector in Abu Dhabi Emirate during 2010-2016

Apart from 2010, where fertiliser and animal waste management data were a challenge with low certainty, the total annual emissions increased from 2012 to 2016. The main drivers for this increase were the increased agricultural cultivated areas (with more fertiliser quantities applied in the soil), and the increased number of livestock in the emirate (Figure 6.4).

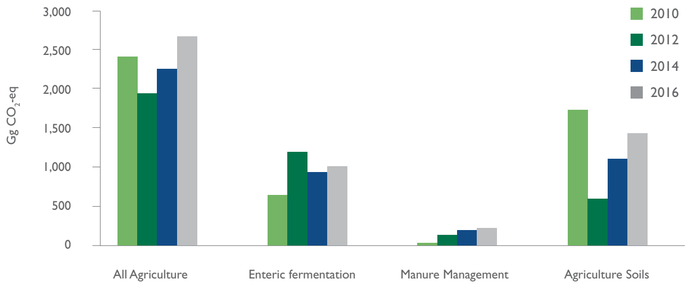


Figure 6.4: Trend of total GHG emissions by Agriculture subsector in Abu Dhabi Emirate during 2010-2016

6.3 GHG Emission Projections for the Agriculture Sector

Analysis of the Historical Trajectory emission scenario for the Agriculture sector indicates that, without mitigation, the total GHG emissions will increase in the year 2030 by a factor of 1.69 from the 2010 levels.

If development plans continue according to the Business-As-Usual scenario as in the year 2016 (BAU2016), future GHG emissions from Agriculture activities are expected to increase by a factor of 1.7 from the 2010 levels to reach 4,103 Gg CO_2-eq in the year 2030; almost the same level of future emissions in the Historical Trajectory scenario (Figure 6.5).

Considering that the livestock numbers reach the sustainable carrying capacity of the land by 2030 (Mitigation Path), future GHG emissions in Agriculture sector are expected to decrease by a factor of 0.68 from the 2010 levels to reach 1,634 Gg CO_2-eq in the year 2030.

Analysis shows that the Agriculture sector has the potential to reduce around 60.2% (2,469 Gg CO_2-eq) of its BAU2016 emissions in the year 2030. The large reduction (52.1%) will be in enteric fermentation emissions.
In comparison with the emirate's total potential of emission reduction (113,489 Gg CO_2-eq in 2030), the contribution of Agriculture sector in emission reduction is expected to be minor (2.18%).

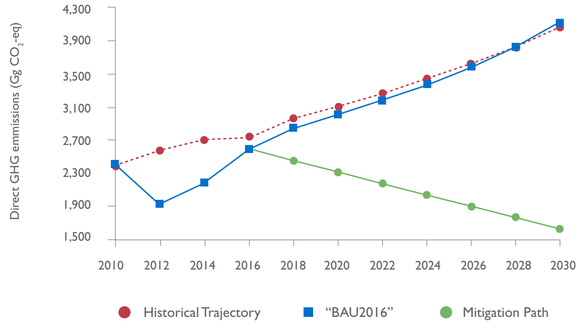


Figure 6.5: Projected total GHG emission scenarios for the Agriculture sector in Abu Dhabi Emirate

CHAPTER 7

LAND-USE CHANGE AND FORESTRY SECTOR EMISSIONS AND REMOVALS

The Land-Use Change and Forestry (LUCF) sector covers GHG emissions and removals from different land uses. Land types assessed include managed forestry, cropland, settlements (trees), and wetlands.

Only CO_2 removals from woody biomass growth were assessed due to the lack of data related to land conversion, abandonment of managed lands, and CO_2 emissions/removals from soils. In addition, no projections were made for this sector due to a lack of data.

7.1 Sinks of CO_2 Removals in the Land-Use Change and Forestry Sector

Carbon dioxide (CO_2) is removed from the atmosphere through photosynthesis as woody biomass grows. Inventory results showed that in the year 2016, the LUCF sector removed between 4,277 to 6,469 Gg of CO_2 emissions[5] (≤6% of the Emirate's total CO_2 emissions), most of which was removed by the Forestry areas (Figure 7.1).

The GHG emissions attributed to the desalinated water quantities used in forestry irrigation were estimated at 173 Gg CO_2-eq. Those emissions offset about 7% of the forest's annual carbon sequestration, leading to a net sequestration of 2,335 Gg CO_2 by the forest land.

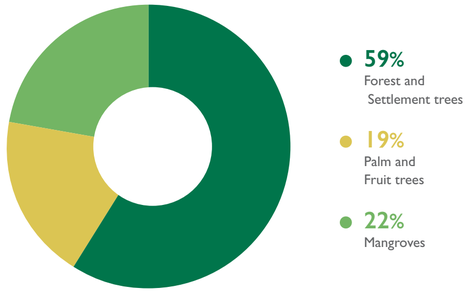


Figure 7.1: Contributions of woody biomass categories towards total CO_2 removals in Abu Dhabi carbon sinks in 2016

[5] IPCC 2006 Guidelines provided higher sequestration than IPCC Revised 1996 Guidelines due to the improved estimation methodology and improved emission factors in the updated guidelines.

7.2 Potential Emissions from Wetlands

Use of the updated IPCC 2006 methodology allowed for the assessment of mangrove and seagrass wetland areas. These are natural resources in the emirate that are not accounted for under the Revised IPCC 1996 methodology. Calculations showed that 911 Gg CO_2 is removed from the atmosphere annually by mangrove growth.

Calculations also showed that Abu Dhabi's wetlands (mangroves and seagrass meadows) hold 16,709 Gg carbon in the biomass and soil of these lands, which has accumulated over the years. If wetland areas are extracted[6], about 61,324 Gg CO_2 may be released to the atmosphere. This equates to half of the emirate's total CO_2 emissions in 2016. If the mangrove land area is drained, about 450 Gg CO_2 may be emitted (Figure 7.2).

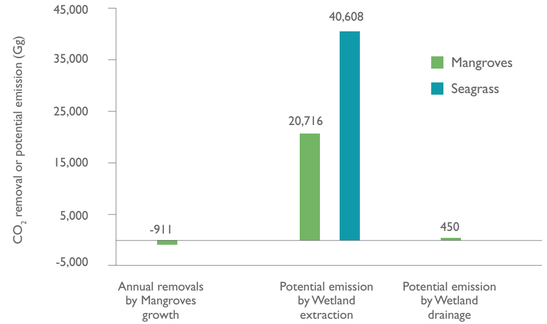


Figure 7.2: Annual CO_2 removals and potential CO_2 emissions from extraction and drainage of mangrove and seagrass areas in Abu Dhabi Emirate in 2016

[6] Extraction refers to the excavation of wetlands for port, harbour and marina construction, construction for aquaculture ponds and construction of salt production ponds, with soil dredging.

7.3 Trend of CO_2 Removals in the Land-Use Change and Forestry Sector

Analysis, based on the best available data, showed that the removals of CO_2 from woody biomass growth (excluding mangroves) slightly decreased after the year 2012. This might be due to the minor changes in the forestry areas that have taken place in the last few years (Figure 7.3).

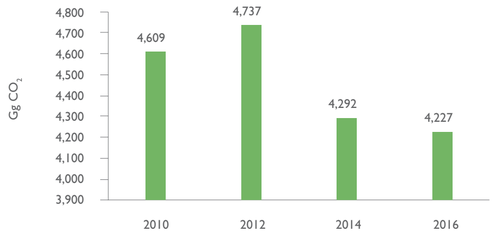


Figure 7.3: Trend of CO_2 annual removals in the LUCF sector (excluding mangroves) in Abu Dhabi Emirate during 2010-2016

[6] Extraction refers to the excavation of wetlands for port, harbour and marina construction, construction for aquaculture ponds and construction of salt production ponds, with soil dredging.

WASTE SECTOR EMISSIONS

The Waste sector includes emissions from municipal solid waste disposal to landfill, emissions from domestic or commercial wastewater treatment, and emissions from waste incineration.

8.1 Sources of GHG Emissions in the Waste Sector

The Waste sector was the source of 4,892 Gg CO_2-eq (3.61% of the emirate's total GHG emissions) in the year 2016. Solid waste disposal on land, wholly deriving from municipal solid waste (MSW) disposal to landfill[7], was the primary source of emissions (Figure 8.1). CH_4 was the primary direct GHG in the sector (Figure 8.2).

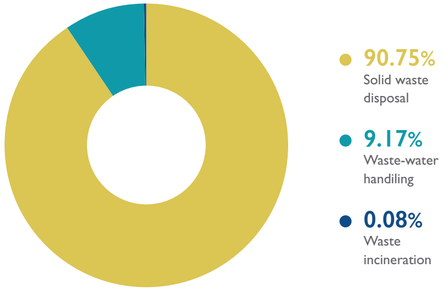


Figure 8.1: Contributions of Waste subsectors towards total GHG emissions from the Waste sector in Abu Dhabi Emirate in 2016

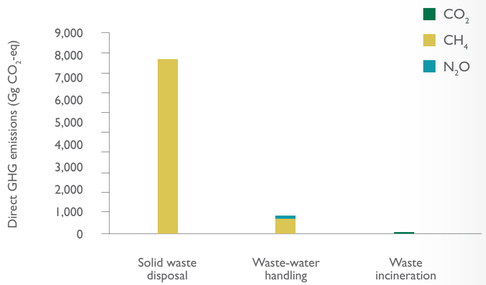


Figure 8.2: Breakdown of direct GHG emissions from the Waste sector in Abu Dhabi Emirate in 2016

[7] MSW includes household waste, yard/garden waste, commercial/market waste and organic industrial solid waste. MSW does not include inorganic industrial waste such as construction or demolition materials.

8.2 Trend of GHG Emissions in the Waste Sector

Between the years 2010 and 2016, total direct GHG emissions from the Waste sector decreased by 28.7% (Figure 8.3). Some variations in the trend of total GHG emissions were observed, as shown in Figure 8.4. The decrease in emissions in the last few years was mainly due to the decrease in solid waste disposed to landfills that was related to the decreased generation rate of waste and the increased conversion from landfills to recycling. The change in composition of waste material (lower degradable organic compound- DOC) and the improved wastewater treatment technology (lower biological oxygen demand and methane conversion factors) also contributed in the emission decrease to a small extent.

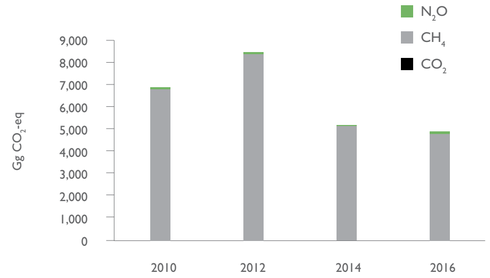


Figure 8.3: Trend of GHG emissions by gas from the Waste sector in Abu Dhabi Emirate during 2010-2016

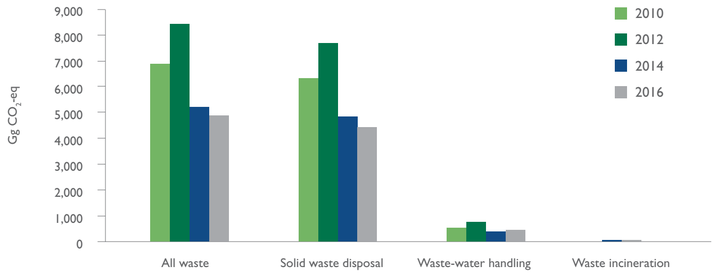


Figure 8.4: Trend of total GHG emissions by Waste subsector in Abu Dhabi Emirate during 2010-2016

8.3 GHG Emission Projections for the Waste Sector

Analysis of the Historical Trajectory emission scenario for the Waste sector indicates that, without mitigation, the future GHG emissions would be increased to more than triple (a factor of 3.13) the 2010 GHG levels by the year 2030.

If development plans continue according to the Business-As-Usual scenario as in the year 2016 (BAU2016), future GHG emissions from the Waste sector are expected to increase and reach 10,503 Gg CO_2-eq by the year 2030 (Figure 8.5).

The studied waste management strategies and plans (Mitigation Path scenario) will reduce the Waste sector's emissions to 2,429 Gg CO_2-eq in the year 2030; about 76.9% (8,074 Gg CO_2-eq) reduction from BAU2016 emissions in the year 2030.

The whole reduction will occur in solid waste emissions. In comparison with the emirate's total potential of emission reduction (113,489 Gg CO_2-eq in 2030), the contribution of the Waste sector in emission reduction is expected to be small (7.11%).

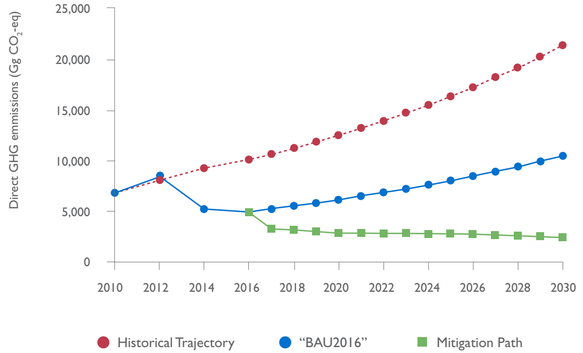


Figure 8.5: Projected total GHG emission scenarios for Waste sector in Abu Dhabi Emirate

CHAPTER 9

LESSONS LEARNED AND RECOMMENDATIONS

This work demonstrates an improvement in the understanding of the relationship between GHG emissions and anthropogenic activities over time, and represents a step forward in the inventory compilation process. The scope and method of the inventory were expanded, and the collected data was improved compared to the first and second GHG inventories due to the continuous strengthening of stakeholder engagement and building partnerships.

Abu Dhabi GHG success stories and the leading pro-active approach of implementing the requirements of emissions inventories in accordance with the Revised IPCC 1996 Guidelines, while voluntarily testing and applying the updated IPCC 2006 Guidelines with the 2013 Wetlands Supplement, has contributed to building knowledge and enhancing capacity for future requirements of measurement, reporting and verification of emissions.

It is clear that the GHG inventory compilation process is naturally continuous, and must revolve through cycles to iteratively improve the quality of the inventory. Emission inventories require complex data, making high-level stakeholder commitment and stakeholder capacity-building essential. Data collection is one of the major tasks in the inventory compilation that requires substantial effort and time. Also, suitability of emission factors to the local circumstances is a key factor in reflecting the actual emissions and performance of local mitigation measures.

For future iterations, local emission factors should be developed where possible, especially those that are affected by the climate conditions or driven by the local-specific technology or process. In addition, data collection should be improved by establishing a comprehensive live data acquisition system for all atmospheric emissions including GHG data, air pollutants, mitigation measures, local capacities and finance support. This data acquisition will serve all emission inventories and eventually support the national measurement, reporting and verification (MRV) to the UNFCCC, as part of the National Communications Biennial Update Reports (BURs).
To better understand emissions from supply and demand chains, and in order to set disaggregated GHG emission targets at emirate, corporate and activity level, consistent GHG inventories should be performed and incorporated at multiple levels: community or city, corporate, and sector levels.

For emission projections, the project provided a second iteration of projections and analysis that need to be reviewed and updated in close coordination with the relevant stakeholders. More involvement is required from the stakeholders with reliable data about the sectors' development plans and targets. However, there is a particular need for a robust GHG integrated model that is capable to assess emission scenarios and mitigation strategies against their environmental, economic, and technical sustainability.

All activities related to GHG data and mitigation measures should be coordinated at the emirate level as well as at the national level. A climate change expert working group is recommended to be established for Abu Dhabi Emirate, comprising of representatives from all relevant stakeholders, to coordinate communications between relevant entities as well as to facilitate insights for management of GHG emissions and for MRV of GHG data.

Acknowledgements

This project is part of EAD's strategic priority to protect air quality and mitigate climate change and adapt to its impacts in Abu Dhabi Emirate. A multidisciplinary team was involved in developing the 3rd cycle of Greenhouse Gas Inventory and Projections for Abu Dhabi Emirate, which could not have been produced without the commitment, data and review from the experts of many different sectors.

EAD would like to thank all the individuals and organisations for their contributions to the Abu Dhabi GHG Inventory and Projections Report.

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- Abu Dhabi Police
- Department of Energy (DOE)
- Khalifa University - Masdar Institute (MI)
- Statistics Centre - Abu Dhabi (SCAD)
- Department of Transport (DOT)
- Abu Dhabi Waste Management Center (TADWEER)
- Abu Dhabi Airports Company (ADAC)
- Abu Dhabi Ports (ADP)
- Abu Dhabi Agriculture and Food Safety Authority
- Department of Urban Planning and Municipalities (DPM)
- Abu Dhabi Sewerage Services Company (ADSSC)
- Industrial Development Bureau (IDB)
- Abu Dhabi Quality and Conformity Council (QCC)
- Emirates Global Aluminium (EGA)
- SENAAT
- Emirates Steel
- Arkan Building Material

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