QATAR'S NATIONAL EMISSION INVENTORY REPORT

We have adopted several initiatives that form, today, some of the most conspicuous concerns, where we placed the issue of development as priority by which we arrive at realizing our aspirations to build the homeland and improve the living standard of citizens and preserve our natural resources.

H.E. Sheikh Hamad Bin Khalifa Al-Thani, Father Emir, State of Qatar

[Opening Session of Doha Development Forum, 9th April 2005]

I may be wrong and you may be right, and by an effort, we may get nearer to the truth.

Karl Popper

QATAR'S NATIONAL EMISSION INVENTORY REPORT

Emission Inventories 1995-2015

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ABSTRACT

This report contains information on Qatar's emission inventories for the period 1995-2015. Sectors included in this report – a) Agriculture b) Energy c) Industry d) Solvent and other Product use e) Waste and, f) LULUCF

This report excludes bunker emissions (marine and aviation).

This Report also contains,

A glimpse of the development that has taken place in last two decades, environmental policies, and regulations, compilation of major environmental initiatives in the industrial sector, climate policy framework, environmental-related sustainable development goals and indicators, and international development aid.

Keywords: Emission inventory, GHG, Qatar, climate policy, SDG

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ABBREVIATIONS

BAT	Best Available Technology
CDM	Clean Development Mechanism
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
FTP	Foreign Trade Merchandiser
GCC	Gulf Cooperation Council
GHG	Greenhouse gas
GTL	Gas-to-Liquids
HFCs	Hydrofluorocarbons
ICU	International Cooperation Unit, MDPS
IPCC	Intergovernmental Panel Climate Change
JBOG	Jetty Boil-Off Gas
LDAR	Leak Detection and Repair
LNG	Liquefied Natural Gas
LULUCF	Land use, land-use change and forestry
MDPS	Ministry of Development Planning and Statistics
MMBBL	Million Barrels
Mmboe	Million barrels of oil equivalent
MMSCFD	Million standard cubic feet of gas per day
MMSCM	Million Metric Standard Cubic Meters
MMUP	Ministry of Municipality and Urban Planning
MoE	Ministry of Environment
Mpower	Messaied Power
MW	Megawatt
N2O	Nitrous oxide
NMVOC	Non-Methane Volatile Organic Compounds
Nox	Nitrogen oxides
OIC	Organization of Islamic Cooperation
PFCs	Perfluorocarbons
QA	Quality Assurance
QAFAC	Qatar Fuel Additives Company
QAFCO	Qatar Fertilizers Company
QAPCO	Qatar Petrochemical Company
QC	Quality Control
Qchem	Qatar Chemical Company Ltd
QEWC	Qatar Electricity and Water Company
QP	Qatar Petroleum
Qpower	Qatar Power
QVC	Qatar Vinyl Company
RGPC	Ras Girtas Power Company
RLPC	Ras Laffan Power Company

SF6	Sulfur hexafluoride
SO2	Sulphur dioxide
SWDS	Solid Waste Disposal Sites
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compounds

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PREFACE

It was an exciting moment for Qatar to host a climate summit – 18th Conference of Parties (COP18) – first in the region in 2012. The Summit has drawn appreciation and criticism alike. The appreciation was gleaned for hosting the Summit and the criticism was exacted for a lack of strong commitment to the concern and for being recognized as the country with the highest per capita CO_2 emissions. However, the country was not prepared to defend itself with factual information, often eclipsed with the vague terms and myths. Until this time, Qatar has produced only ONE national communication regarding emissions. This greenhouse gas (GHG) emission inventory is a humble effort to fill the data gap, dispel myths, and guide policymakers to make effective decisions that will help reduce national emissions. This Report provides factual information about the country's emissions over the course of time. Though it is far from complete, it is a first step. I sincerely believe that in the coming months the Ministry or other agencies will take this research forward and report the annual GHG emission inventory, including, providing full coverage of methane emissions from the oil/gas sector and emission reduction initiatives. This report should be of interest to policy makers, stakeholders at all levels in the oil/gas and manufacturing industries and academics in Qatar.

Before starting the inventory, I met colleagues from the Ministry of Municipality and Environment (formerly Ministry of Environment), Ministry of Development Planning and Statistics, and Qatar Petroleum to make a joint effort to build an authoritative inventory. Despite several attempts, I failed to convince participation by these authorities, as they were engaged in other priorities. Nonetheless, I managed to embark on the project alone; despite knowing the challenges of obtaining the data from all of the sectors. Many agencies were extremely reluctant to share data, and some made me wait for more than a year to share the data or just to tell that they could not share the data. Lack of cooperation and trust in exchanging the data, reports and other information are the major reasons for my frustration. The recent administrative changes have added further annoyance and inevitable delays. At times, it was very frustrating and on several occasions I decided to quit. Nonetheless, I decided to move on and finish what I started. It was a colossal task to develop an inventory for all of the sectors; the entire process took more than eighteen months. I contacted more than 30 companies, over a dozen agencies, sent several official letters and over 600 emails. Several emails were sent back and forth to clarify missing data, quality and reliability of data sources. Some agencies outrightly refused to share information, which partially affected the quality of the report. I made a conscious effort to take primary and secondary data directly from the source and from information published in national reports. In order to avoid any preconceived judgments, I read the reports prepared and published by various consultants and ministerial agencies. I spent time reading old reports archived in the libraries of the Ministry of Development Planning and Statistics and Ministry of Municipality and Environment.

I did my best to estimate emissions as detailed. Furthermore, I acknowledge a major shortcoming in this report, i.e. the lack of an estimation for methane emissions from the hydrocarbon sector. Most of the companies began to report GHG emissions as a part of their annual sustainability reports. Needless to say, this inventory is far from perfect, and I believe, in the upcoming inventories we should address all of the shortcomings faced in preparing this inventory. It is extremely challenging to combine all of the sectors together, especially the industrial sector, to avoid double counting. I made concerted efforts to *minimize* this error. If the reader's spot inconsistencies in the report, then I welcome their feedback and supporting information.

Over the last ten years, there were several positive developments in the industrial sector. However, there was no single document synthesizing these impressive achievements. I tried to compile some of these major initiatives in this report. Some companies were extraordinarily cooperative and supportive in sharing relevant information. Initiatives from the oil sector were missing because companies such as Qatar Petroleum, Shell GTL, and other mult-national companies (MNCs) refused to share information.

Initially, the Report was aimed to account for emissions until 2013, publish a follow-up report on emissions for 2014 and 2015 and provide extended recommendations for policy makers in mid-2016. Unfortunately, it did not go as planned. The first Report took an unusually long time because of unnecessary delays in collecting data from all of the stakeholders. Therefore, I decided to publish as one report instead of two. I caution the reader that the names of the institutions mentioned in the report are based on their names at the time of data collection. In the beginning of this year (2016) some institutions were merged, most notably, the Ministry of Environment (MoE) and the Ministry of Municipality and Urban Planning (MMUP). Now, it is called the Ministry of Municipality and Environment (MME). To avoid confusion, I maintained the name of the previous institutions while citing the sources of data.

This Report is an objective documentation of the facts available in the national reports and an impartial analysis of the development that has taken place over the period of two decades. Besides the inventory, the Report offers an extended analysis and broader framework of several issues such as climate policy framework, sustainable development goals, corporate initiatives in emission mitigation, fair emission reduction and the like. This report is complete with facts; some of which are known and some of which are unfamiliar to the world beyond the borders of the industrial cities of Qatar. The recommendations proposed in this report can be used as a broad guide for decision making. I hope the readers will objectively accept the views presented in this Report and I welcome your thoughts, feedback, and criticism. I invite you to challenge the data/information reported and offer constructive support to make this inventory comprehensive and robust. The content and opinions expressed in this report are the sole responsibility of myself and can under no circumstances be regarded as reflecting the position of the Institute.

EXECUTIVE SUMMARY

In late 2015, the COP21 Summit struck a landmark deal. All of the countries in attendance agreed to make their best efforts to mitigate emissions. Furthermore, the emission reductions should be fair and equitable. For developed countries, besides initiating a substantial reduction in emissions, it was determined that they should extend their support to developing countries through technology transfer, climate financing, and on-call technical assistance. This deal, if all countries remain true to their commitment, will sustain human and non-human life and avoid catastrophic climate impacts, i.e. maintain the temperature below 2°C. Impacts of climate change are real and disproportionate. The poor and vulnerable are often the worst affected. Countries should accelerate their mitigation and adaptation efforts to avoid widespread damage to their population, infrastructure and economy. As a major fossil exporter and one of the wealthiest countries, Qatar should do its fair share in reducing domestic greenhouse gas emissions, develop strong climate adaptation plans and support poor developing countries through development aid and infrastructure assistance.

The Report contains detailed information about Qatar's inventories for all years from 1995 to 2015. The format and structure of the Report are loosely based on the UNFCCC guidelines for reporting and review. I combined the reporting methods of national communication and GHG inventory; on some occasions, I tried to explain the industrial process in detail. I covered emissions of the following greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6). Additionally, the inventory includes calculations of emissions of the precursors NOx, NMVOC, and CO, as well as for SO_2. The total net greenhouse gas emission, including all sources and sinks, were 107 million metric tonnes CO_2 equivalents in 2015, a compound annual growth rate (CAGR) of 13.4% between 1995 and 2015. A major share of emission is from the oil & gas sector – 53.6%, followed by industrial sector (petrochemicals, fertilizers, metals) – 27.8%, power sector – 13%, transport – 5% and the rest 2% from agriculture, waste, and industrial solvents. The total net CO_2 removal from the LULUCF sector was 2.3 million tonnes in 2015. During the period 1995-2015, emission from all sectors increased substantially, and most notably, from the natural gas and mining sector. Equally, other sectors such as electricity production, transport, and the petrochemical sector saw a huge rise. The average annual growth in emissions in the following sectors are recorded as follows: natural gas (14%), oil (1%), petrochemical (8%), power (9%), metal (13%), mining (16%), transport (9%), waste (14%), and agriculture (5%), respectively. Energy-intensive and export-oriented industries, such as LNG, refining, petrochemical, and aluminium are significant contributors to Qatar's economy. The structure of Qatar's economy determines its greenhouse gas emission profile. This is concurrent to the gross national output of the mining and manufacturing sector. The emission profile projected to take place in the coming few years will rise gradually unlike previous decade. This is because the expansion of existing and new petrochemical plants were on hold and the LNG sector will remain constant. Emissions from the power sector will continue to grow as a direct result of ever-increasing domestic and industrial requirements. It is no surprise that emissions from the agricultural and livestock sector is negligible.

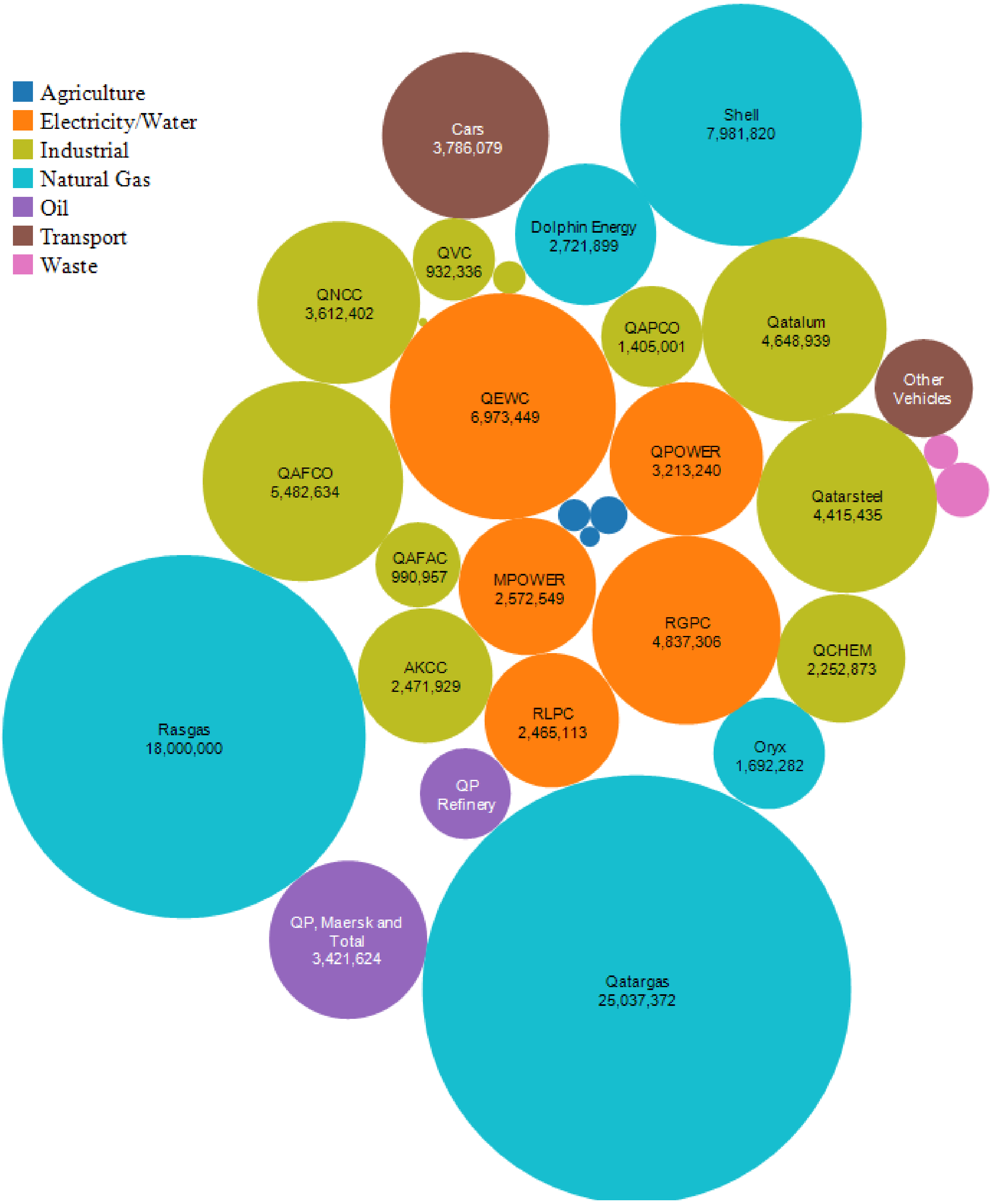
On the contrary to general perception, as a global natural gas exporter, the industrial and power sector is rather efficient. This is because of two main reasons. Firstly, the fuel used in most of the sectors is natural gas, which is relatively cleaner compared to coal and oil. On average, the lifecycle GHG emission intensity of natural gas is 499 tonnes CO_2eq/GWh compared to oil (733) and coal (888) respectively. Secondly, as a latecomer, it had an advantage of implementing some of the best-available technologies and industrial processes during its inception. Industries have taken several new initiatives for reducing greenhouse gas (GHG) and non-GHG emissions, and water and hazardous waste. The oil and gas industry received considerable attention, because, it is the source of revenue for the country. By far, flaring is the most obvious emission source. Fortunately, new initiatives have shown positive results. As a result of the coordinated effort of all industries, flaring emissions were reduced substantially. Nearly 12 percent of the emissions from the oil and gas sector was from flaring alone. Last year, one of the biggest environmental projects in Qatar with a total investment exceeding $1billion came into full operation - Jetty Boil-Off Gas (JBOG). JBOG is connected to the six LNG loading berths (one of the largest natural gas terminals) reduces 90% of flaring emissions and recovers 0.82 billion cubic meters of gas annually, which is enough to produce 750 MW of power. Qatar Petroleum's Flare Mitigation Project in the Natural Gas Liquids (NGL) Plant Complex Facilities showed a remarkable decline in flaring and economic savings. Over $1.57 million (5.7 million QR) was saved alone in 2008 by recovering 9,339 MT of NGL. Similarly, Maersk Oil Qatar reduced flaring by 91%, saving 95.6 MMSCFD of oil. Al Shaheen Oil Field Gas Recovery and Utlitization Project, the only CDM project, saved 10.5 million tonnes of CO_2eq since its inception (2007) until mid-2014 and is expected to reduce this amount further by 8.4 million tonnes by 2021. Rasgas, one of the leading producers of LNG in Qatar is on par with global LNG standards (ranked third of the 14 companies in terms of emission and energy intensity, 2014). Companies like MPower and Qatalum have installed the most efficient gas turbines and advanced aluminium production facilities. There was a considerable gain in energy efficiency when it comes to steel production. The previous electric arc furnaces (EAF1,2) requires 700 kWh/tonne of steel, with the new EAF (5), it consumes approximately 540 kWh, making it one of the most energy-efficient electric arc furnaces in the world. Likewise, there has been an adoption of new technologies resulting in substantial efficiency gains and emission reduction. Two notable cases worth highlighting: Between 2011 and 2015, QAPCO's emission intensity reduced by 55 percent, leading to savings of 2.2 million tonnes in 2015 compared to 2011. QAFCO reduced 1.8 million tonnes of emission in 2015 compared to 1999. Since the completion of the state-of-the-art domestic solid waste treatment centre, it treated over 2.16 million tonnes of domestic waste. In 2015, it generated 245 GWh of electricity; which is sufficient to power 70 percent of all big hotels in Qatar. Additionally, Qatar Petroleum and Qatar Electricity and Water Company agreed to build a solar power plant with an initial capital expenditure of $137 million. These developments offer grounds for optimism. If the government takes emission mitigation seriously, a gradual reduction in emissions without major economic impact will be realized. On the other hand, it will generate multiple benefits, such as reducing inefficiency and long-term protection of the terrestrial and marine environment.

There is a growing trend with companies reporting their emissions in their annual sustainability reports under the initiative of Qatar Petroleum and Ministry of Energy and Industry. Still, many companies failed to publish their reports online, and I urge the authorities to make this a regular exercise, demanding all companies (even multinational corporations) report their annual environmental status publicly. I strongly recommend that the government should make concerted efforts to gather reliable industry-level energy and emission data that will help to show which actions (and technologies) make major changes in the emission profile. Since the industrial sector is a key emitter, it is pragmatic to develop necessary policy instruments that can stimulate deployment of new technologies. There is no coherent policy at a broader sectoral level to reduce emissions or improve emissions/energy intensity targets. Climate mitigation efforts should take center stage in economic development strategies and city-scale urban planning and decision making.

State investment in environmental projects is abysmal (projects received only 0.16% of the total capital expenditures in 2014-15). The corporate investment of five companies alone totaled $112 million and the R&D investment in the energy/environmental sector increased to $289 million between 2009 and 2014. Regardless of these figures, one must understand that most of the companies are state-sponsored, and even the research budget comes from the state. However, the state should increase their direct investment in emission abatement technologies and create favorable policies that will encourage pollution-intensive firms to accelerate technology replacement. Also, I propose either tax be imposed on pollution-intensive firms or incentivize firms that are willing to reduce energy and emisison intensity. Although, this should be done with minimum distributive consequences. These tax revenues could be used to fund public abatement expenditures.

Also, I have developed a set of key indicators within the framework of sustainable development goals (SDGs) from an environmental perspective. As previous authors were inclined to inflate the significance of their own topic, I emphasized the necessity of developing composite environmental indicators. However, other topics are equally important and the government should find a delicate balance and workable action plan in achieving SDGs. A special policy framework must be designed to understand the various actors, policy interlinkages, and enabling conditions.

Emerging countries and industrialized nations should speed up their decarbonization efforts and reduce their fair share of emissions and support economically weak countries in their transition processes. Similarly, well-endowed rich countries should accelerate their transition to becoming a post hydrocarbon society. In this regard, Qatar's ongoing infrastructural development process is a blessing in disguise. This allows Qatar to leapfrog to better technologies and modes of development, avoiding locked-in infrastructures and facilitates the transition to a low-carbon and ecological and resource-efficient economy. With the current economic model and technology trajectory, each country has its own limits set for reducing emission unless we change the course of defining growth and prosperity. These are the greatest challenges of our time and world leaders and thinkers are struggling to find an agreement about kind of economy society needs.



Agriculture
Electricity/Water
Industrial
Natural Gas
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Waste
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QVC 932,336
QNCC 3,612,402
QAPCO 1,405,001
Qatalum 4,648,939
QEWC 6,973,449
Other Vehicles
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QAFCO 5,482,634
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AKCC 2,471,929
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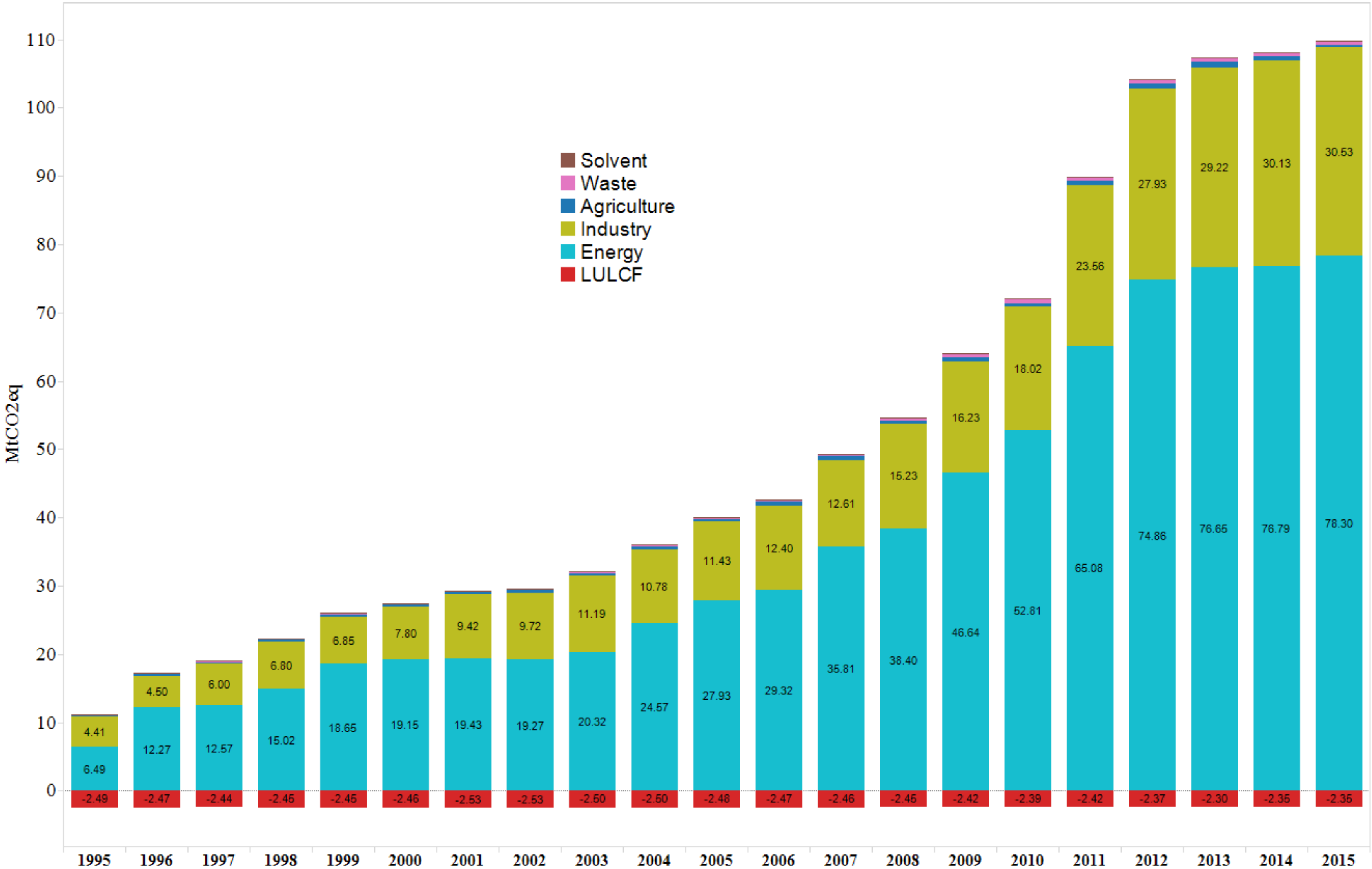

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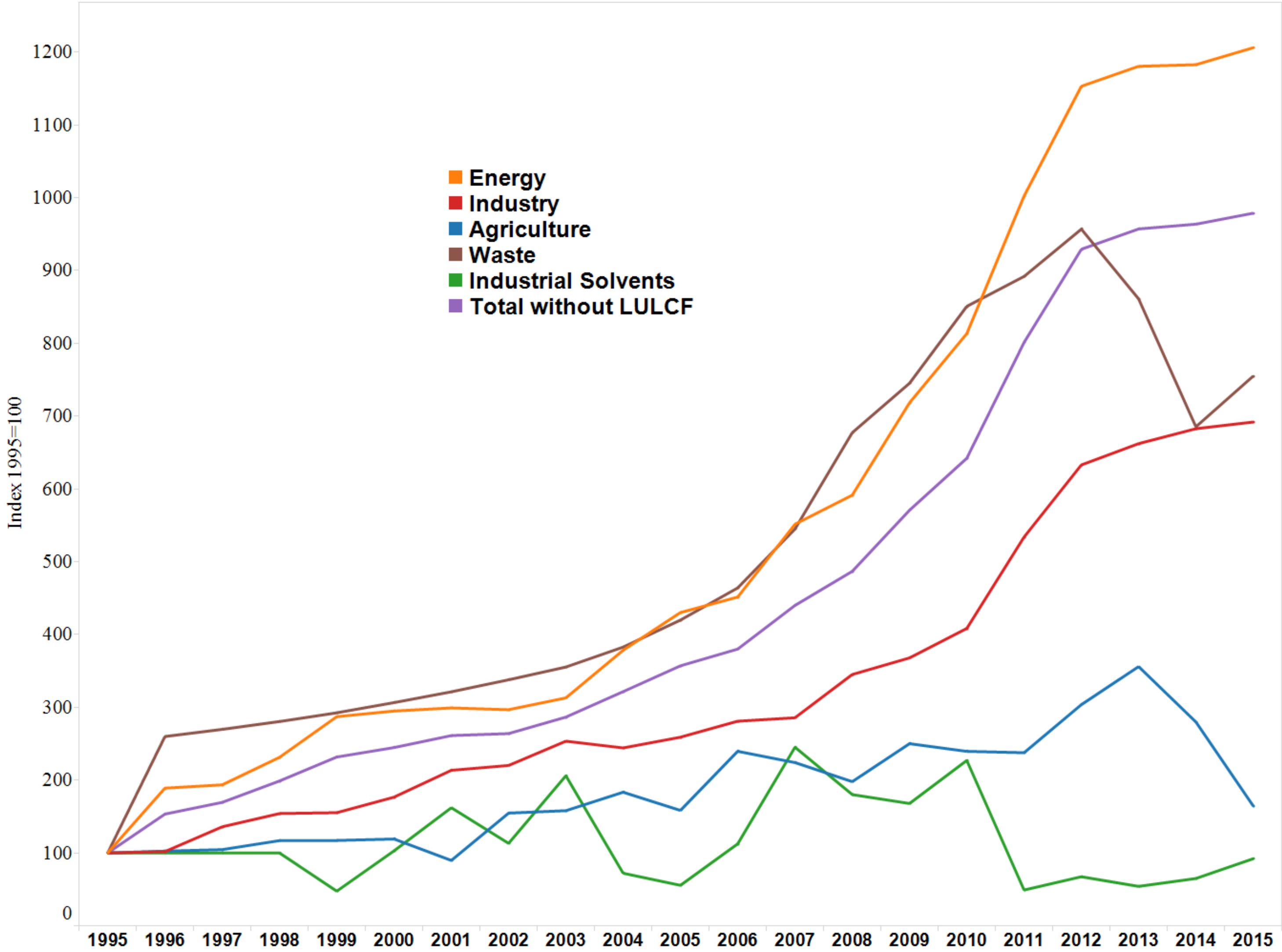
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A NOTE FOR POLICYMAKERS

Industrial Policies

In the last few years, the concept of environmental sustainability has slowly become mainstream both in the public and private sectors in Qatar. Many state-backed energy companies were formed and some were scaled up, bringing significant revenue to the country. Mounting environmental pressure led to the development of new initiatives in several companies. Many companies invested heavily in replacing old turbines, boilers, and furnaces, minimizing GHG and non-GHG emissions, and wastewater discharge. The new companies that were set up in last decade adopted the best available technologies (BAT), and they are on a par of excellence with the global environmental standards. Because of national targets to minimize flaring emissions, all of the oil and gas companies marshaled under the national initiative by setting goals, allocating investment and monitoring the yearly changes. So far, this initiative has been remarkably successful. For example, the direct benefit of flaring reduction resulted in savings of natural gas and emissions.

The government should hasten its steps in developing a comprehensive climate policy framework addressing all sectors, with a special focus on energy-intensive industries. The industrial sector is the major contributor to country's economy and will continue to retain this status for the next several decades. Therefore, the government and the industrial sector must prepare a comprehensive roadmap and strategic framework under the broader climate policy framework, such as "Industrial Decarbonisation Strategy." The strategy must assess all possibilities of decarbonising the industry and set ambitious goals to minimize GHG emissions for the short and long-term. Along with that, the framework should focus on potential structural changes in the global market, technological dynamics or deployment of disruptive technologies, domestic institutional reforms, and relevant policies that can support decarbonization. The policy should foster the development and implementation of wide-ranging innovative low-carbon technologies, processes, standards, norms and legislations that enable decarbonisation of the sector by 2050. The legislative instruments should include emission caps, internalizing social and environmental costs and taxation on emissions for the industrial sector. This is also echoed in the first Natural Resource Management Strategy. The government should press ahead with this proposition; expediting the creation of new regulations, developing a strong support system for large and small/medium sized industries and ensuring transparency and accountability. Methane is the second major source of emission from natural gas production and processing facilities. Many companies failed to measure/monitor methane emissions from their facilities. I suggest that the MoE undertake a Methane Monitoring Initiative to measure methane emissions from extraction to delivery and also to prepare a standardization method for estimating and reporting emissions from different sources.

The Ministry must create an effective, well-functioning, transparent and less bureaucratic support mechanism for companies (medium/small scale industries) that lack technical and financial capacity. As I mentioned previously, there are several piecemeal initiatives started by different companies that are already helping in this direction. However, they are fragmented, lack coherence, monitoring, and reporting. It is important to compile all of the initiatives and develop key performance indicators and analyse the trend. So far, there is only one project accredited under the Clean Development Mechanism (CDM)(Al Shaheen Oil Field Gas Recovery and Utilization Project, started in 2007). It is unclear why no new CDM projects were proposed or accredited. The government should exploit all possible opportunities with regard to reducing emissions and increasing economic savings. These are remarkable achievements and these companies must be recognized for their activities. Likewise, policymakers should capitalize on these efforts and raise the bar and set definitive goals and strict timelines for implementation.

According to the Resolution of the Council of Ministers No. 15 of 2011, the respective agencies must propose policies and action plans to reduce GHG emissions and set up a database within the requirements of the UNFCCC convention and Kyoto protocol. Unfortunately, there was no tangible response to this Resolution. So far, Qatar has published only one national communication. Under the initiative of QP HSE, many companies started to publish their emission data in their annual sustainability report, however, some companies continue to withhold the data. Since it is a voluntary process, there is no incentive for companies to report. Therefore, we strongly suggest that the Ministry of Municipality and Environment (MME) and Ministry of Energy and Industry (MoEI) issue a joint decree for a mandatory GHG and non-GHG pollution monitoring and disclosure framework. The disclosure framework must include a well-designed surveillance system to ensure transparency and accountability. Additionally, the disclosure framework will be useful in documenting the trend of overall emissions and how the new policies, regulations and technological replacements are shifting the trend. As a result of documenting emission trends, one can notice the effectiveness of energy management initiatives, which provides opportunities and encourage other companies to learn from best practices. Companies that emit more than 25,000 tonnes CO2eq should quantify, verify and publish in a single-window system that can be accessed by other ministries and the public alike.

Institutional Development

Institutional transparency and coordination is a prerequisite for effective implementation of policies. The autonomy and interplay between different institutions requires considerable attention and a mechanism to resolve this intractable latent struggle. Currently, there is a lack of cooperation and openness between ministries and, in fact, many departments within the ministries do not interact with each other. This often leads to poor planning and deters the development of sound policies. The technical experts in one department should get an official letter from their Department Head directed towards another Department Head requesting access to data or information. At times, the tension between different agencies soars, leading to the abandonment of initiatives. Moreover, the interaction between academics and ministries is very weak, and there are general concerns about trust and territorial encroachment. This could be resolved through mutual dialogue, cooperation and by building a strong alliance that brings mutual benefit to all. During the recent administrative changes, every department engaged in playing a defensive role, highlighting the importance of their activities and protecting the information it gathered. If this current trend persists, there is a slim chance of institutional development, innovation, and creativity. Besides institutional cooperation, institutional continuity is an important factor for the steady growth of the country. The ever-changing nature of the public administration poses structural problems. One such case is Qatar Petroleum's Sustainability Reporting Initiative. Between 2010 and 2013, the initiative managed to attract major companies to publish annual sustainability reports. With the recent administrative changes in 2014-2015 in QP, the initiative lost its sheen and eventually perished.

Over the last two decades, the institutional evolution was sporadic. Some institutions gained ground and expertise, whilst for others it lost its significance. One particular case to highlight is the Ministry of Development Planning and Statistics (MDPS). MDPS is a progressive, active, transparent and user-friendly organization that made substantial gains in the quality and content of data and reports. Many new outlets such as Monthly Statistics, Qatar in Figures show the evolutionary development of institutional innovation. The institution deserves merit and praise for its openness and transparency.

Some ministries and several state-owned/multinational enterprises are facing a transparency and accountability deficit. This could be overcome through the implementation of strong legislation, the introduction of norms and standards and the promotion of a culture of transparency and accountability across the sectors. This idea is well resonated in the Qatar National Vision 2030 (…the efficient delivery of public services; and transparent and accountable government). The role of "independent" regulatory institutions must be reinforced. Currently, the MME/MoEI has little influence over the activities happening within the three industrial areas. This weak sphere of influence makes it difficult to enforce tangible policy interventions. The government should go beyond setting up empty and inactive committees and task force groups. The proposed committees should provide necessary policy recommendations; while addressing the solutions to overcome in mainstreaming with existing policy instruments. In addition, the government must continue to support and encourage new initiatives that were started by different agencies that advance national objectives and goals. Sadly, many good and well-intentioned initiatives were started with too much hoopla, and over the course of time, the initiatives lost steam because of internal political struggles, the key player's being promoted or replaced (or left the country in the case of expats), loss of budget, institutional volatility, and lack of creativity to attract and maintain the interest of stakeholders.

Additionally, the recent administrative changes and decline in oil prices have forced many companies/institutions to reduce their budgets for environmental projects and headcounts in the environment/sustainability division. This will be counterproductive to the ultimate environmental goals. The government should allocate a stable fund for emission abatement technologies and encourage companies to increase their investment in pollution prevention.

Transparency through Numbers

During the COP18 summit, Western media outlets ridiculed the decision to host a climate summit in a country that has the highest per capita emissions. Unfortunately, neither the ministry nor the academia/fledgling civil society defended against these remarks. One must understand that the per capita measure is certainly not an accurate indicator for Qatar, which has an extremely small population and export-oriented energy-intensive sector. The government, academic and civil society have to confront this fact by creating alternative indicators and metrics that actually reflect the true nature of environmental initiatives and policies. Moreover, there is a general tendency for international observers, especially Western journalists and academics, to lambaste the Gulf countries for inefficiency and wastefulness. The reality is different. At least from the Qatari perspective, they have some of the most sophisticated industries that can easily rival European environmental standards. The fault for any misperceptions lies partially within the ministry or academia for not making a conscious effort to document activities and sustainability initiatives. That said, I must acknowledge that some sectors are performing very poorly and require a complete overhaul of existing policies.

The general content of the latest Annual Statistics Bulletins has declined compared to the mid-1990s and early 2000. In one instance, the industrial sector reports the production quantity of all major industrial products. But in the later years, this is not the case. The Environmental Chapter is the least covered text of the Annual Statistics Bulletin. The information is erratic. Furthermore, the latest ASB shows a disturbing trend. The air quality data speaks for itself. In previous reports, the Environmental Chapter reported the actual air quality values from three monitoring stations. But in the latest released chapter, instead of actual values, it is reported in nonstandard indicators such as "clean" and "normal." This action suggests that the Ministry of Municipality and Environment is trying to elude public scrutiny and governmental pressure. The poor reporting of the Environmental Section is also due to a lack of support from MME, MoEI, QP and other agencies. I advocate that MDPS expand the capacity of the Environmental Statistics Department and also the coverage of environmental issues. It is advisable to report sophisticated indicators such as environmentally adjusted national accounts and inclusive wealth index as a part of their annual statistical bulletin. These indicators help to gauge our real progress towards sustainability. Also, I recommend MDPS, in coordination with the MME and other academic organizations report the "State of Natural and Human Environment of Qatar" on an annual basis. The 2030 Agenda for Sustainable Development provides a unique opportunity to incorporate strong environmental policies into comprehensive sustainable development strategies. The MDPS has a major role to play in collecting the necessary information from all institutions in developing sustainability indicators, evaluating those indicators and creating necessary policy interventions. Developing sustainability indicators is an interactive process between scientists (natural and social), statistical experts, policymakers, interest groups and the general public. Additionally, I urge all of the ministerial stakeholders to publish their rules, regulations, ministerial decrees, policy documents and reports (done by consultants and ministries) and digitally archive old reports for public use (example, QALM website, managed by MDPS).

Education and Awareness

It is vital to have a strong civil society to spread awareness of various environmental issues. To my knowledge, Friends of Environment and Qatar National History Group are the only two independent organizations that organize outreach programs and spread awareness about local biodiversity. However, their reach is limited to middle and high-income expatriates. Currently, much of the environmental awareness and outreach is done by the state and private enterprises companies. They teamed up with other organizations during high-profile conferences/events to organize environmental-related activities with little success. Some are outright farcical. The campaigns for children and youth are limited to painting and beach cleaning. Others are limited to paper recycling and replacing plastic shopping bags. Additionally, many of the awareness campaigns are limited to youth, but adults are the decision-makers in the household, business, and policy sectors. Social and environmental change happens when there is a profound understanding of our natural systems and its interaction with social systems. There should be parallel grassroots awareness programs for all age groups. As UNESCO points out, “Learning needs to be seen as a lifelong process which empowers people to live useful and productive lives.” In order to become an ecologically-conscious society, one must go beyond superficial awareness programs and integrate sustainable living in schools and religious/cultural programs.

Unfortunately, there is no institutional public space to deliberate environmental issues, and most of the discussion is limited to social media – Twitter and Facebook. The country needs an active public space where citizens and residents can come together and discuss wide-ranging issues related to the environment and development, without the fear of punishment or deportation. Public space can help to generate new ideas and promote social and environmental change. Based on my discussions with several young people, the oft-repeated complaints are a lack of access and ability to do or change things because of state bureaucracy. The excessive reach of the State stifles creative solutions to the environmental problems we face.

In a vision to become a knowledge economy, the country is investing in R&D capabilities by building world-class universities and labs. Sustainability has found its own niche in the new academia. New postgraduate programs were started at Hamad Bin Khalifa University and Qatar University. Unfortunately, the current research topics in academic/research institutes are disappointingly narrow. There is a significant focus on technological aspects, but very limited attention is paid to social, economic, political and cultural dimensions for sustainability. For the society to embrace new values, norms and behaviours that can advance sustainability, we need to understand the challenges and barriers faced by a different segment of the population and ways to overcome it. I strongly recommend the academic institutions bring an interdisciplinary, multidisciplinary and transdisciplinary approach to postgraduate sustainability programs. The academic institutions have much to offer to the government, by providing policy advice and much-needed capacity.

International Cooperation

Domestic mitigation efforts would be insufficient to meet its fair share of mitigation, in order to compensate, the government should support financially weak and vulnerable countries in their mitigation and adaptation efforts. In 2012, the Qatari government provided more than a billion dollars in foreign aid, and most of it was allocated to humanitarian aid. Most of the OIC member countries are vulnerable and face severe challenges such as drought, desertification, flash floods, loss of biodiversity, water scarcity and loss of agricultural productivity. Deterioration of the natural environment endangers thousands of livelihoods resulting in competition for scarce resources which in turn result in conflict and violence. Many OIC countries in Sub-Saharan Africa and other regions lack adaptive capacity and financing to mitigate climate risk. Qatar could redirect its financial aid (bilateral/multilateral and charitable) to support mitigation and adaptation efforts in OIC and non-OIC member states. The aid packages should be allocated to issues such as rural infrastructural development, ecological restoration, livelihood protection, climate-resilient agriculture, and the like. This requires a complete shift in its foreign policy from short-term humanitarian aid to long-term strategic aid following a "livelihood-based approach" and a "right-based development approach" with a central focus on ecological sustainability. The good news is that most Qatari charitable foundations are already based in several OIC member states and are rich with experience about local ecological challenges. The government should capitalize on their expertise and channel funds directly or through multilateral environmental agencies that are already on the ground.

Alternative Development Pathway

Currently, Qatar is undergoing a second wave of development in infrastructure. Consequently, this makes it a timely opportunity to rethink the way infrastructure is built and ensure that it is not energy and carbon intensive. The government should integrate climate risk into their investment decisions and infrastructure planning. Additionally, the newly built state-of-the-art infrastructure aims to cater to the Qatari (rightfully so) population and upper-class expatriate communities. The low-income labour workers, which represents over 50 percent of the population is deprived of such infrastructure. This systematic deprivation of access to physical infrastructure is very prevalent; one notable example is the metro network. The metro network connects to luxury communities such as Pearl Qatar and densely populated Qatari and high-income non-Qatari residents. The industrial area, where the majority of low-income workers reside is not connected to the railway lines. The upcoming low carbon infrastructure should not only be energy efficient but also socially equitable.

It is inevitable for all countries, small and big, rich and poor, to take efforts to reduce GHG emissions within their financial limits and developmental needs. There is a general sentiment among policymakers that Qatar's contribution to global emissions is insignificant and as a non-Annex country, it has no obligations to reduce emissions. As much as I agree with that assertion, it is time to move beyond that rhetoric and embrace new development model(s) that integrates comprehensive, and far-reaching environmental policies. This will help Qatar follow a low-carbon development trajectory that can avoid future risks and financial losses. As an exceptionally wealthy country, it has a moral imperative to accelerate its mitigation process by identifying and exploiting potential emission mitigation opportunities. The current development pathway is unsustainable, and the pace of extraction and consumption of natural resources is bringing unforeseen challenges and emptying the state coffers (18 billion QR in subsidies related to production, 2014). Qatar National Vision 2030, first National Development Strategy 2011-2016 and Qatar National Development Framework highlight the significance of sustainability. Regrettably, the policies are inadequate and require radical intervention to bend the unsustainable development pathway.

In the upcoming National Development Strategy, the authorities must ask tough questions. Can Qatar combine its ambitious development project with a strong commitment to ecological sustainability and resource efficiency? Is it possible to achieve this combination with the current development practice? Can we redefine prosperity and human development in a different way? These are the burning questions, the policymakers, bureaucrats, academics, civil society groups and citizens should answer.

CHAPTER 1

1. BACKGROUND

The State of Qatar, in the last two decades, evolved rapidly from a small, underdeveloped city-state into a thriving metropolitan city, a major natural gas/petrochemical supplier, attracting foreign investment, skilled and unskilled workers from all over the world and speedily climbing the global charts (economic and social indicators). Thanks to the massive reserves of natural gas and leadership that put Qatar into a spotlight, besides its reputation as a global natural gas exporter, it is increasingly becoming a global hub for cultural and sports activities. A few statistics will suffice to show this fact. The national GDP (in current prices) increased 25 times from 1995 to 2014: from $8.13 billion to $206.2 billion. The oil and gas (O&G) share to the national GDP is on a continuous decline, yet, it has a substantial share of government revenues as shown in figure 1.1. Between 2000 and 2014, the relative share of the O&G sector is 56.6%. Per capita income increased from $16,238 in 1995 to $94,946 in 2014. The surplus to GDP has doubled from 8 to 16 percent between 2002-03 and 2014-15. Imports and exports between 1995 and 2013 increased 11 and 39 times respectively. The maximum export value increased in 2013 to a total of $136.7 billion. Capital expenditures increased 30 times from 1995-1996 to 2013-2014: $0.35 billion to $10.94 billion, reaching its highest peak after 2010-2011 ($9.46 billion). Energy and public infrastructures like energy/water production, petrochemical plants, and roads/highways received a huge share. For instance, the investment in energy infrastructure increased nearly six fold ($0.36 billion in 2002-2003 and $1.48 billion in 2013-2014). Similarly, road infrastructure (along with drainage) increased from $0.53 billion in 2006-2007 to $2.83 billion in 2013-2014. Figure 1.2 shows the breakdown of capital expenditures in various subsectors. Electricity production increased nearly eight times: from 5.31 TWh to 41.5 TWh. The number of passenger cars increased four times from 207,605 in 1995 to 992,651 in 2015. The population quadrupled between 1995 and 2015. The primary school attendance is 100%. By the end of 2012, the life expectancy was 78.4, which is two years above the same statistic in 1995. The quality of life increased significantly for the majority of local citizens and expatriate community, especially, white-collar professionals. Three household (Qatari) surveys show the growing accumulation of wealth and access to basic-to-luxury products/services.

Qatar and other GCC countries managed to secure markets to export industrial products such as fertilizers, petrochemicals, and metals. Qatar’s industrial growth was remarkable. The GDP contribution of the hydrocarbon and manufacturing industries between 1995 and 2014 increased a whopping 3427%. The GDP of hydrocarbon and manufacturing industries continues to increase with a dip in 2009 because of the global financial crisis and rebound to its original state in 2010. Undoubtedly, the majority of it comes from hydrocarbon sources. To reduce the nations’ income dependence on hydrocarbon resources, Qatar diversified its industrial output to petrochemical products (ethylene), industrial chemicals (benzene, helium), chemicals (urea, ammonia) and metals (steel, aluminium). In the last two decades, many new industries were established and in some cases expanded production units like QAPCO, QAFCO, and others. As a result of this massive expansion, the manufacturing sector GDP in

2014 was $9.4 billion (in constant prices, 2004), up from $1.8 billion in 1995. The total manufacturing output, excluding natural gas and crude oil, increased from 4.53 million tonnes in 1995 to 23 million tonnes in 2015 (Fig 1.3). This expansion would not have been possible without strong support from the government by setting industrial parks, low-cost natural gas as a feedstock, subsidized electricity and water, and tax breaks. Many petrochemical industries were established and expanded as shown in table 1.1 and figure 1.4 in the last 20 years.

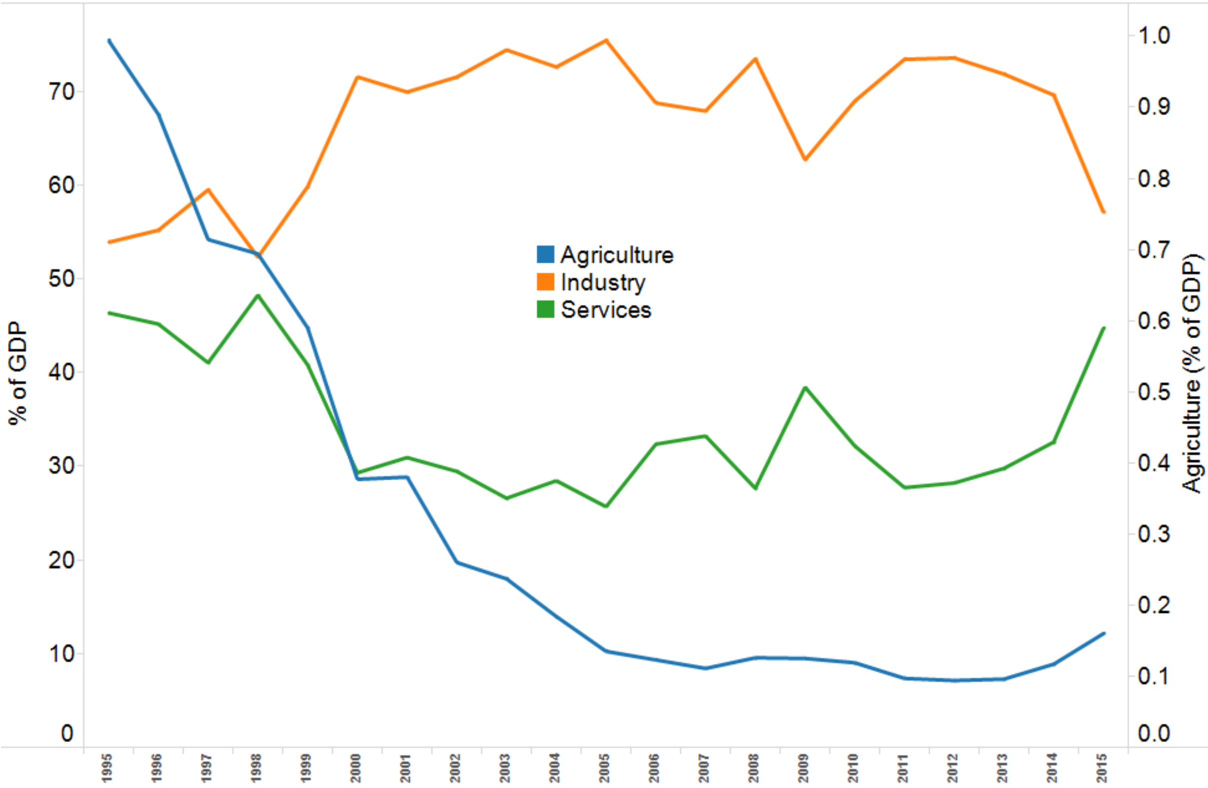

Figure 1.1 Composition of Qatar's GDP between 1995 and 2013 (Note – The agricultural contribution to the national GDP is on continuous decline and reached saturation since 2011)

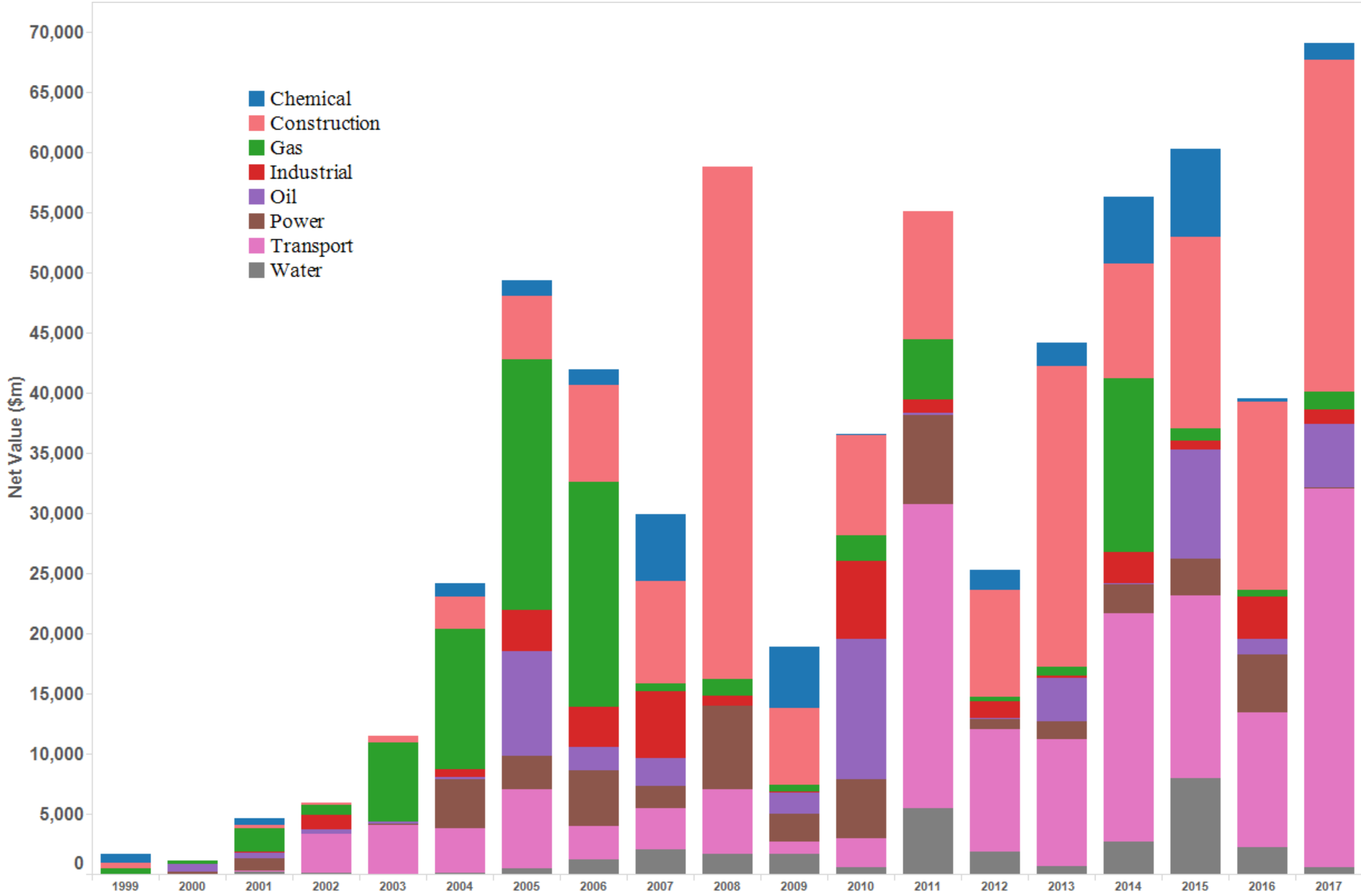

Figure 1.2 Breakdown of infrastructure spending for various sectors (In the early 2000s, natural gas, industrial and chemical sector received substantial funding, however, in the last half a decade of 2000s, the investment has shifted to construction and transport) (Source: MEED)

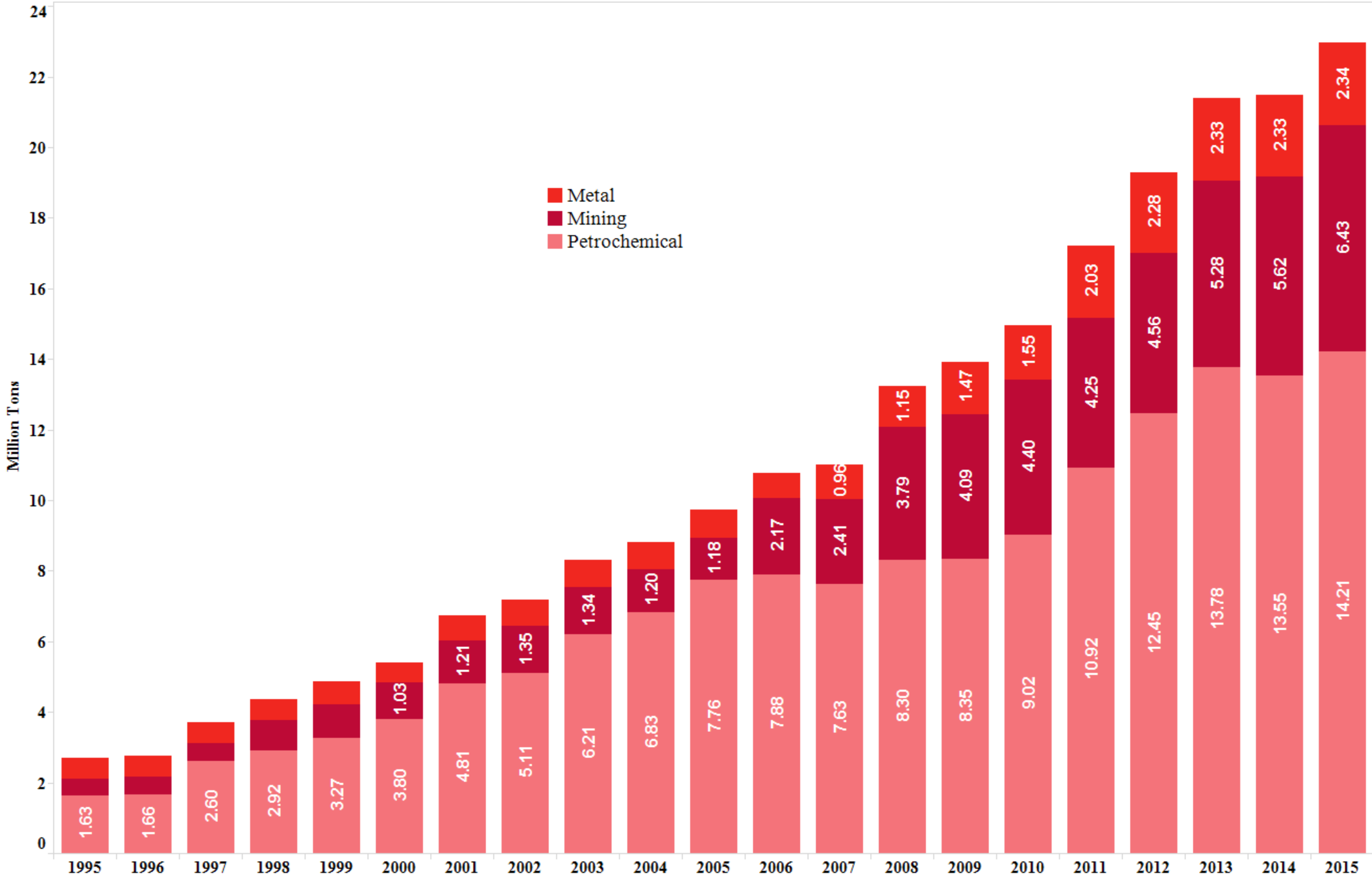

Figure 1.2 Industrial output of all major commodities, excluding oil and gas products (Source: Author)

	1995	2014/2015	% increase
Steel	601,100	2,123,000	253%
Cement	475,380	6,432,240	1253%
Aluminium*	468,789	640,000	37%
Urea	885,966	5,670,000	522%
Methyl tertiary butyl ether**	256,880	688,450	168%
Methanol**	90,965	1,118,210	1129%
Ethylene/LDPE/Polyethylene	460,700	5,225,645	1034%
Caustic Soda/Ethylene Dichloride/Vinyl Chloride Monomer#	375,400	849,028	126%
Helium##	1,900	3,700	95%

*The production started in 2011; ** The production started in 1999; #The production started in 1999; ##values from 2009

Table 1.1 Increase in production of major exported products

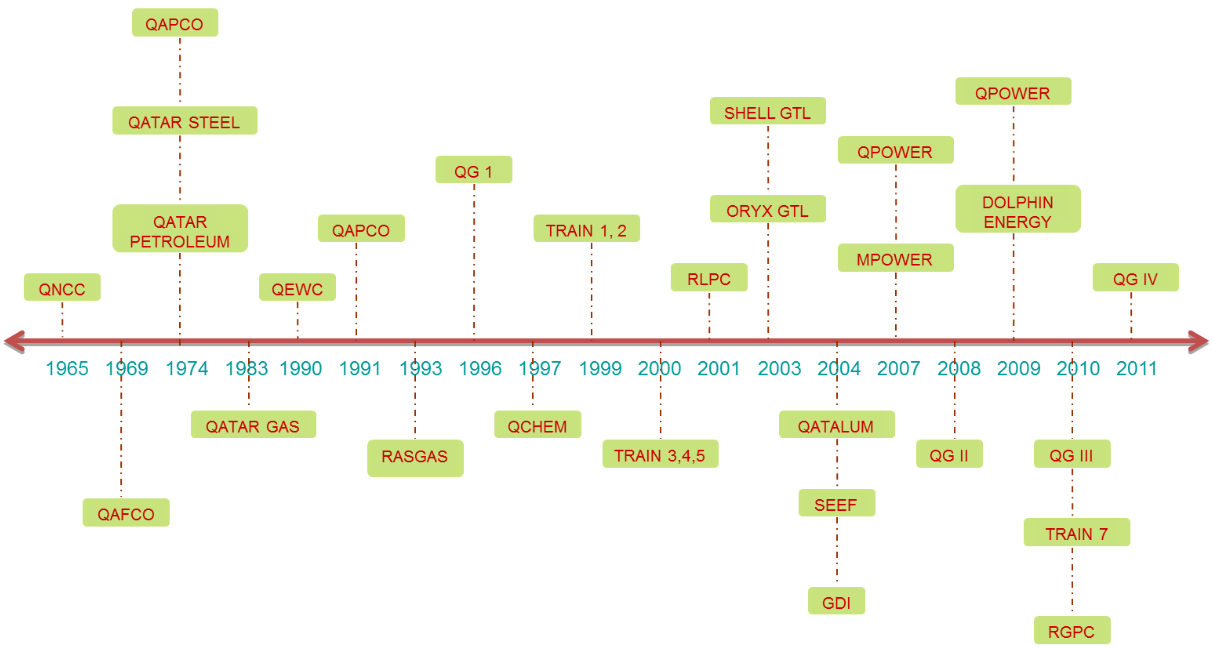

Figure 1.4 Companies established in Qatar. Full production happened much later. For instance, Qatalum was established in 2004, but its full production was in 2011

1.1 LATE DEVELOPMENT AND MISSED OPPORTUNITIES

In the mid-1990s, when the former Emir took control of the country, the objective was to tap the country's massive hydrocarbon resources and become a global leader in supplying liquefied natural gas. Years of investment followed that were directed not only in the energy sector, but also in social sectors like education, healthcare, institutional and capacity building. The lack of a domestic labour force was compensated for by the import of cheap labour from Asia and high-skilled labour from Europe, the US and the Arab world. As a new city-state, the priority was to provide basic services like education, electricity, water, sanitation and health care. This accelerated the development and industrialization process meant to "catch up" with other advanced and regional countries. To illustrate, Qatar's share of the GCC's economy between 1995 and 2015 increased from 3.1 percent to 12 percent, respectively (similarly, compared with the Arab economy, Qatar's share increased from 1.3 to 6.6 percent over the same period). As a result of this fast-paced development, several challenges were posed to the state in the form of traffic congestion, poor urban air quality, ever-increasing investment in basic infrastructure like energy/water/roads, and extinction and overexploitation of marine and terrestrial species. This is mainly because of a lack of sustainable planning. The word sustainable is denoted as "strong sustainability." Like many other cities in the South, the city (state) planning took an erroneous turn. The direction was the "Western model or precisely American model" of city building. However, this industrialized-based model of development was failing in most American and European cities causing major environmental challenges. In the 1990s, following the widespread rhetoric of sustainable development and growing concern about climate change and pollution, several European and North American (esp. Canadian) cities were (are) restructuring to build "green" cities. It is ironic that cities (including Dubai, Doha) in developing countries adopted this failed model. This model includes skyscrapers, industrial smokestacks and increased vehicle ownership that represent a sign of prosperity and wealth (Nayyar 2013; Salama & Weidmann, 2013; Davuvergne, 2008; Escobar, 2012).

The city-state continues to expand with little consciousness of sustainability, be it in the building sector, landscaping, transportation, industrial corridors and the like. For instance, the transportation system is based on the American model with extensive reliance on passenger cars. In the last few years, this has resulted in road congestion during peak hours, soaring air pollution, and an unending expansion of road networks. To put it in perspective, the number of cars (including light commercial vehicles) increased four times during this period. The road infrastructure (possibly includes sewerage), expenditures tripled in less than seven years, from $0.53 billion in 2006-07 to $1.8 billion in 2012-2013. There are several factors that influenced this unsustainable pattern. One of them, the rapid pace of development, outpaced the institutional capacity to manage it. Another major factor is outsourcing the development planning to international consultants (mostly from Western countries). The development model proposed by these consultants are replicas of industrialized-based city planning. After years of expansion, the country realized just a few years back that it needed to diversify mobility by increasing bus and rail transit. The blind imitation of the Western planning brought significant damage. There were several missed opportunities to build the State by leapfrogging not only obsolete technologies but also obsolete development processes. Not everything is bad news; however, as a latecomer country still enjoys multiple benefits.

The latecomer countries have demonstrated higher economic growth, faster technological innovation and diffusion, and industrial upgrading. This is particularly true for most East Asian and Asian countries. One of the pioneering scholars of "latecomer countries," Alice Amsden notes:

> The rise of "the rest" was one of the phenomenal changes in the last half of the twentieth century. For the first time in history, backward countries industrialized without proprietary innovations. They caught up in industries requiring large amounts of technologies without initially having advanced technological capabilities of their own. Late industrialization was a case of *pure learning,* meaning a total initial dependence on other countries' commercialized technology to establish modern industries. This dependence lent catching up its distinctive norms. (Emphasis original)

An extended passage from Joseph Stiglitz's new book is worth highlighting:

> The most important "endowment," from our perspective, is a society's learning capacities (which in turn is affected by the knowledge that it has; its knowledge about learning itself; and its knowledge about its own learning capacities), which may be specific to learning about some things rather than others. …that a country's policies have to be shaped to take advantage of its comparative advantage in knowledge and learning abilities, including its ability to learn and to learn to learn, in relation to its competitors, and to help develop those capacities and capabilities further. Even if it has the capacity to learn how to make computer chips, if a country's learning capacity is less than its competitors, it will fall behind in the race. But each country makes,

> effectively, decisions regarding what it will learn about. There are natural nonconvexities in learning, benefits to specialization. If a country decides to learn about producing chips, it is less likely that it will learn about some other things. There will be some spillovers to closely related technologies—perhaps to, say, nanotechnology. The areas to which there are spillovers may not lie nearby in conventional product space. There may, for instance, be similarities in production technologies (as in the case of just-in-time production or the assembly line). That is why the evolution of comparative advantage may be so hard to predict.

We can include the GCC countries as latecomer industrialized countries along with Asian and East Asian countries, but they are less competitive and innovative when it comes to global market share and technological advancement. Besides several limitations, Qatar enjoyed tremendous benefits as a latecomer by implementing some of the best available technologies (in terms of efficiency) in the market, primarily in the field of petrochemical and metal production plants. To illustrate, many new industries established between 1995 and 2015, and to our knowledge, the state-supported companies have acquired the best technologies. Qatalum, a major aluminium producer has deployed state-of-the-art technology that surpasses international standards of productivity, energy efficiency and emissions. Another example, Messaied Power (MPower) installed the most efficient gas and steam turbines for power generation. There are many cases highlighted in Chapter 9. That said, environmental policies for the industrial sector were very weak for a long time. Despite the growing scholarship of the environmental impact by the industrial sector in the 1990s, the government has not made any serious attempt to integrate issues such as monitoring, pollution prevention, integrated water management, solid waste management, and the like. In order to expedite the completion of industrial infrastructure in the early years, environmental issues were compromised, leading to an increase in the cost of clean-up in the last few years. Principle 4 of the Rio Declaration in 1992, made it resoundingly clear, "In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it." Missed opportunity bears cost and sometimes, it is too late to make any changes.

1.2 NATIONAL ENVIRONMENTAL REGULATIONS

Due to the unprecedented and rapid growth in the country, human capital falls short significantly when it comes to environmental planning, legislation, regulation and enforcement. The Qatar government is slow to respond to environmental issues as other issues become predominant like providing basic services and completing the much-needed infrastructure for the effective functioning of the State. The government missed several opportunities to put the environment at the heart of the planning and execution phases of all large and small projects. The construction of major projects happened in early 2004 and lasted till 2009. This "first-develop-clean-up-later" syndrome is typical throughout the world, and Qatar is no exception. Notwithstanding, the government established the Environmental Protection Committee that reports to the Supreme Council for the Environment and National Reserves (SCENR). On 29th September 2002, a new decree was passed called Promulgating the Law of the Environment Protection (Law No. 30 of 2002). The decree contains 80 articles addressing various aspects of environmental protection. Additionally, the Ministry of Municipality and Agriculture (currently Ministry of Environment) prepared a detailed document – Environmental Protection Standards. Although, the country is fraught with major challenges, many large-scale and medium/small scale projects have undergone a “thorough” environmental assessment as shown in figure 1.4a. However, the rigorous of these assessments is unknown. There is no detailed independent study on the process of evaluation of the projects. The Ministry of Environment (MoE) established policies, legal and administrative frameworks for the oil/gas and petrochemical companies. And all of the companies should comply with these regulations. To my knowledge, the policies and regulatory standards are weak and inadequate. Additionally, there is no publicly available information. For example, whether the companies exceed regulatory limits, whether the companies get a suspension and their “consent to operate” is revoked. In some cases, the companies receive special concessions if they do not abide regulatory standards. On what grounds these concessions were provided is unclear. As outlined below, Qatar Petroleum acts as an oil producer, investor, and also as a regulator. It seems that MoE (MME) has little control over the operations within Ras Laffan, Messaied, and Dukhan Industrial Cities. Based on a personal conversation with experts in the field from private companies (operating within Industrial Cities), all of the companies submit environmental reports regularly to QP, while less emphasis is given to MoE.

In this report, I highlight only the point-source emission limits from the industrial sector and the ambient air quality standards. The interested reader can contact the Ministry of Environment to get the regulatory standards for water emissions and hazardous waste limits. Between 2011 and 2014, the number of environmental-related cases increased from 1,682 to 2,664. None of these cases were registered as criminal cases, but demeanors, with a maximum penalty of $265. Also, these cases were mostly construction-related activities. What happens in cases of oil spills or excessive flaring or hazardous chemicals discharge from offshore facilities is unknown.

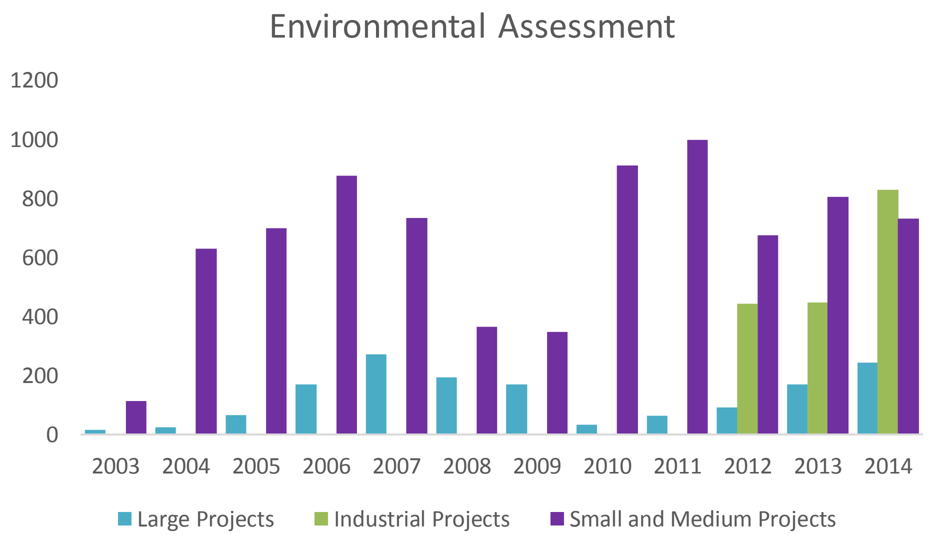

Figure 1.4a Environmental assessments of major and minor and industrial projects in Qatar

Air Emission Parameter	Emission Limit, mg/Nm^3			
	Qatar Environmental Standards			RLIC* Standard
	Oil, LNG & Gas Production (onshore)	Petroleum Refining	Petrochemical Plant	Petroleum& Petrochemical Entities
Unburned Hydrocarbons	20	-	-	-
Hydrogen Sulphide (H_2S)	15	15	5	-
Oxides of Sulphur	100	500	500	500
Oxides of Nitrogen				
Gas Fired	240	-	240	240
Oil Fired	360	360	360	-
Particulate				
Gas Fired	5	5	5	-
Oil Fired	50	50	50	-
Carbon Monoxide	-	-	-	-

*Ras Laffan Industrial City

Pollutant	Unit	Averaging Period	Concentration
Sulphur Dioxide (SO2)	µg/m^3	1hr	1300
		3 hr	800
		24 hr	365
		Annual	80
Particulate (PM-10)	µg/m^3	24 hr	150
		Annual	50
Oxides of Nitrogen (as NO_2)		1 hr	400
		24 hr	150
		Annual	100
Photochemical Oxidants (as O3)	µg/m^3	1 hr	235
Carbon Monoxide	mg/m^3	1 hr	40
		8 hr	10
Lead	µg/m^3	3 month average	1.5
Hydrocarbons (corrected for Methane)	µg/m^3	3 hr	160
Hydrogen Sulphide	µg/m^3	1 hr	40
		24 hr	20

Qatar is a signatory or party to several regional and international environmental conventions.

1. Vienna Convention on the Protection of the Ozone Layer, and Montreal Protocol and amendments thereof
2. The Agreement on Conservation of Immigrating Wildlife Species
3. The Convention on International trafficking in endangered species
4. Basel Convention on hazardous materials and trans-border movement thereof
5. UN Convention on Biological Diversity
6. UN Framework Agreement on Climatic Change and Kyoto Protocol
7. UN Drought Control Convention
8. Kuwait Regional Convention on Protection of Maritime Environment and protocols thereof (1987)
9. Convention on Control of Vessel-related Pollution
10. Convention on Control of Sea Pollution (London Convention 1972)
11. International Convention on Overseas Intervention (1969) and protocols thereof (1972)
12. Agreement on Civil Liability in Maritime Claims 1976
13. UN Convention on Maritime Law
14. Agreement on Civil Liability for Oil Pollution Damages
15. International agreement on establishing an international fund for Compensation of Oil Pollution Damages
16. PIC Agreement
17. Convention on Prohibition of Production, Use and Storage of Chemical Weapons and Destruction thereof
18. International Agreement on whales
19. International Agreement On Plant Protection
20. Agreement on Permanent Organic Pollutants (POPs)
21. International Agreement on Wet Lands (Ramseur Agreement)
22. Agreement on the Protection of International Heritage
    Regional Agreement on Conservation of Wildlife and Habitat thereof at the GCC States

https://www.gcc-sg.org/eng/indexce82.html

Unfortunately, there is no publicly accessible information about the reports from the Qatari government on any of these treaties. This makes it difficult to assess the country's position on various environmental fronts on international platforms. For instance, all of the parties were asked to submit their Intended Nationally Determined Contributions before the COP21 summit. The Qatar government submitted a six-page document containing no commitments and no relevant information whatsoever regarding emissions reduction.

To my knowledge, the most celebrated and widely used "idea" in Qatar is Qatar National Vision 2030, which was formulated in 2008 and eventually formed the basis for every forthcoming policy. There is no dearth of usage of QNV 2030. The QNV2030 has become synonymous with "sustainable development." Any idea could be part of QNV 2030, regardless of how vacuous it could be. Nearly all policymakers, bureaucrats, international consultants, and academics lipsync the idea of QNV 2030. Yet, very few of them understand the essence of it. Just like the way sustainability or sustainable development. The environment is one of the key pillars of the QNV 2030, which gives impetus for organizations to consider environmental issues in their organizational planning, design, and research. Interestingly enough, the document contains key terms such as, “tipping the environmental scales irreversibly” and “intergenerational justice.” However, these words barely glean attention in the public discourse and there are no policies to actualize these concepts.

Qatar’s first Environmental Sector Strategy (ESS) and National Resource Management Strategy (NRM) was formulated in 2010 as a result of recognition of the environment as a key pillar in the Qatar National Vision 2030 and providing background material to the first National Development Strategy 2011-2016. The ESS outlines “strategic directions and key initiatives” and seven outcomes for the period 2011-2016:

- Improve the environmental performance of the country in practical ways, such as by lowering Qatar’s carbon footprint, encouraging more efficient management of the country’s waste stream, and the wise use of water and energy resources
- Make Qatar a healthier, more comfortable and more inspiring place in which to live and work
- Raise public awareness of the need to take environmental sustainability more seriously, and it will mobilise all sectors of society to take appropriate action
- Strengthen the country’s reputation as a nation which is committed to creating a knowledge-based economy, to encouraging innovative environmental problem solving and to investing in sustainable solutions that will benefit future generations

The ESS was prepared in consultation with the Ministry of Environment, Ministry of Municipality and Urban Planning and Qatar Petroleum. The ESS acknowledges the challenges posed by the rapid industrial and urban development and that the current policies and actions are inadequate. In this Report, we focus on the policies related to energy and emission reduction.

According to the ESS report,

> “Presently, Qatar does not have a national CO_2eq mitigation strategy or emission reduction targets. In fact, Qatar does not have a bottom-up baseline of CO_2 emissions because *industries are not required to monitor or report their emissions.*” (pp.37-38, emphasis added)
>
> “There is also no national flaring policy, although some companies have established their own internal policies.”

One of the recommendations was to reduce flaring emissions under the National Flaring and Venting Reduction Project. The high-level target through this project was to reduce flaring intensity by 50 percent in 2016 against a 2008 baseline. However, the ESS report failed to propose a comprehensive emission mitigation policy plan. I believe in the upcoming development strategies there will be a strong emphasis placed on emission reduction considering the changes in the global environmental platform. Another key factor that was briefly alluded to in the ESS report was "Monitoring and Evaluation." Again, the report failed to provide any detailed plan on the roles and responsibilities of institutions, such as: Who will monitor the progress. What will be monitored? How will it be evaluated? What happens if targets are not met? Will the progress be published annually for the public and policymakers alike? These key questions remained unanswered.

1.3 EQUITY AND DEVELOPMENT

Development is unequal. Many Western countries industrialized in the late nineteenth and early to mid-twentieth century. The fossil-based industrialization and development process resulted in rising per capita income, economic growth and prosperity. The unintended consequences of this process led to several environmental challenges like transboundary air pollution, greenhouse gas emissions and transportation of hazardous waste. The industrialized countries are largely responsible for climate change. As developing countries are catching up with the global Western-style economic development process, increasingly, they are also contributing to global climate change. However, the developing countries started their "development" process after they gained their independence from colonialism and imperialism. The developing countries primary objective is to address pressing issues like poverty, employment, and basic services such as health and education. Despite two decades of intense economic and financial globalization progress in the developing countries, the results are dismal. Millions of people in the developing world face grinding poverty, loss of livelihoods and are extremely vulnerable to global financial shocks. In addition, climate change exacerbates the situation unequally, with the poorest countries being the worst affected even though they are least responsible. Increasingly, climate change poses a threat to development and to contain this threat, there is an appeal to all countries to take effective action. In 1992, all of the countries agreed to "common but differentiated responsibilities and respective capabilities." However, the discussion about "differentiated responsibilities" is far from over. As one author puts it rightly,

> Developing countries interpreted the "common but differentiated" language with great precision industrialized nations would need to take the lead by cutting their own emissions and transferring large sums of environmental assistance to the South. However, developed countries saw more room for selective interpretation. (Roberts & Parks, 2007)

Presently, the issue of equity and development remain contentious. In every international climate negotiation, developing countries call for developed countries to take swift action in reducing GHG emissions and support developing countries through technology and financing. Developing countries are asking for their "fair share" of emissions reduction that will allow them the ability to grow and not derail the development process. Also, developing countries demand equitable sharing of atmospheric and development phase. However, the rhetoric of equity cannot be used much longer during international negotiations considering the dire situation. I believe countries in the developing world with a strong fiscal situation and low poverty levels should take tougher measures to reduce GHG emissions.

I strongly argue that Qatar, like other developing countries, has the right to develop. Qatar receives undue criticism for its highest per capita emission status; however, its global emission share is 0.13%, compared to 2010 global emissions. In the last two decades, the country managed to achieve basic development goals like helping people out of poverty and decent access to basic services (in fact, Qatar has far exceeded other countries when it comes to per capita income). I underscore Qatar's right to development and any commitment to reduce emissions should be fair and equitable. However, it is a moral imperative for Qatar to invest in a development model, which is "far away from consumerist, Western-inspired ideals to truly sustainable, resource–lean alternatives with a much higher quality of life." (Bidwai, 2012).

1.4 IMPACT OF CLIMATE CHANGE IN QATAR

It is an undisputed fact that negative impact of climate change is real and has far-reaching economic and social consequences to all the citizens. This is especially true for developing countries and poor communities that are highly vulnerable yet are the least responsible for it. Mitigating the impact is of paramount importance to society. To do so, developed and developing countries should come forward to reduce its fair share of GHG emissions. I stress that developed countries should take a broader share in reducing greenhouse gas emission and support developing countries in adaptation, technology transfer, and technical assistance. Also, developing countries have an equally important role in mitigating the impact of climate change through proactive and transformative urban planning, leapfrogging to better and cleaner technologies, and investing in institutions that will protect vulnerable communities. Also, the developing countries should focus on building resilient communities through capacity building and redistribution of natural resources and disaster risk management strategies.

Before discussing the impacts of climate change, I highlight the measures the Qatar government envisions for change. The national reports and Resolution of Ministers underscored the impacts of climate change and proposed to develop national policies to mitigate the impacts of climate change.

National Development Strategy 2011-2016

> Qatar will develop a national policy to manage air pollution, greenhouse gas emissions and the broader challenges of climate change. (pp.21)
>
> The environmental management strategy envisions a broad shift in laws, regulations, management systems, technologies, and attitudes, working towards seven outcomes:
>
> • Cleaner water and sustainable use.
> • Cleaner air and effective climate change responses (pp. 23)
>
> Climate change presents special challenges. As a major energy producer, Qatar's carbon dioxide emissions contribute to greenhouse gases. As a small coastal country, Qatar is vulnerable to predicted rising sea levels. (pp. 214-15)

Resolution of the Council of Ministers No. 15 of 2011

Article 1. 2

To propose national policies and action plans regarding the reduction of greenhouse gas emissions in the State

Article 1. 3

To ensure that governmental and non-governmental organizations in the country implement the obligations of the Convention and the Protocol and to prepare the studies and reports required in this regard

Article 1.4

To set up databases in accordance with the requirements of the Convention and the Protocol

Article 1.5

To contribute to the preparation of periodical national assessment reports in accordance with the Convention and the Protocol

In 2011, the Council of Ministers established the "Climate Change and Clean Development Committee," headed by the Assistant Undersecretary for Environmental Affairs at the Ministry of Environment. The members of the committees are comprised of professionals from different agencies, including the Ministry of Foreign Affairs, Ministry of Business and Trade, Qatar Petroleum, General Civil Aviation Authority, and Qatar University. The Resolution stipulates that the committee propose national policies regarding the reduction of GHG emissions, create databases and assess the possibilities of clean development mechanism (CDM) projects. The same resolution requires submitting a report from the committee to the Council of Ministers every six months. The reports are not available (if there are any) for public access. To my knowledge and available information, there is very limited action on the proposed resolutions. I requested (through emails) the Ministry of Environment and Al-Meezan portal service send updated reports of the resolution. Unfortunately, I have not heard from the MoE, and Al-Meezan Services has no relevant information. So far, Qatar has produced only one national communication from 2007 that released in 2011. Unfortunately, there is no concerted effort to release this information on an annual basis for the sake of its own development. During COP18, Qatar pledged to produce 2% of its electricity from renewable energy by 2020 and agreed to reduce emissions voluntarily. Recent tenders by the utility company shows they are on track to achieve 2 GW by the end of 2020. Also, there is considerable interest, which in turn resulted in forming an exclusive Climate Change Department under the Ministry of Environment. However, the scope of the department is uncertain at this moment. Based on brief discussions, various topics related to climate change will be addressed in consultation with other national stakeholders.

Undoubtedly, Qatar's role in global climate change is insignificant because of its negligible global share of greenhouse gas emissions. However, in recent years the emission trend is growing and Qatar's role cannot be ignored. Besides its reduced role in global climate change, its impacts on Qatar are severe. Unfortunately, there are very limited studies on the impact of climate change in Qatar, which makes it difficult to document the impacts on all sectors. Until now, neither government agencies, nor academia has taken any serious steps to address this vital information gap. Based on communication with the MoE and MMUP, they plan to issue a tender individually to assess the impact of climate change on urban systems and the environment at large. In the wake of budget cuts, it is difficult to say whether these initiatives will materialize. In this section, I document the existing, yet limited information published by the World Bank and other intergovernmental and academic institutions. Studies of this nature are mostly conducted on a larger geographic scale, such as for the entire Middle East, and the impacts are lumped together. Based on the reports reviewed, I identify several threats posed by climate change in the Gulf region such as sea-level increase, precipitation change/temperature increase, ocean acidification, the intensity of sand storms and increased desertification.

Qatar's ecosystem is fragile and exposed to acute water stress. Excessive withdrawal of groundwater for irrigation is contributing to seawater intrusion and deteriorating water quality making the water unfit for irrigation. This excessive withdrawal is compounded by higher temperatures (evaporation) and erratic annual rainfall minimized the groundwater recharge, adding severe limitations in maintaining/expanding food and fodder production. Also, the warmer and drier climate is projected to impact food production because of declining crop yields and length of growing period. Temperatures are expected to rise 1.8°C by 2040 and 3.6°C by 2070. Jeremy and Elfatih (2015) predict the temperature (T_{max}) is likely to exceed 55°C and humidity will increase near the coastal studies and make it difficult to survive as shown in figure 1.5.

> Annual TW_{max} (wet-bulb temperature) increases monotonically in the different locations surrounding the Gulf (Fig. 1.5). By the end of the century, annual TW_{max} in Abu Dhabi, Dubai, Doha, Dhahran and Bandar Abbas exceeds 35°C several times in the 30 years, and the present-day 95th percentile summer (July, August, and September; JAS) event becomes approximately a normal summer day (Fig. 1.6). During the summer, warm north westerly (Shamal) winds frequently blow from Turkey and Iraq across the Gulf, where they gain moisture and transport high TW to most of the cities in the Gulf. The primary exceptions are Kuwait City and Bandar-e Mahshahr, which are protected from such extreme TW conditions owing to their geographic position to the north of the Gulf. Heat extremes will be prevalent and especially pronounced in summer. (Pal, Eltahir, 2015) [Figure numbers are modified]

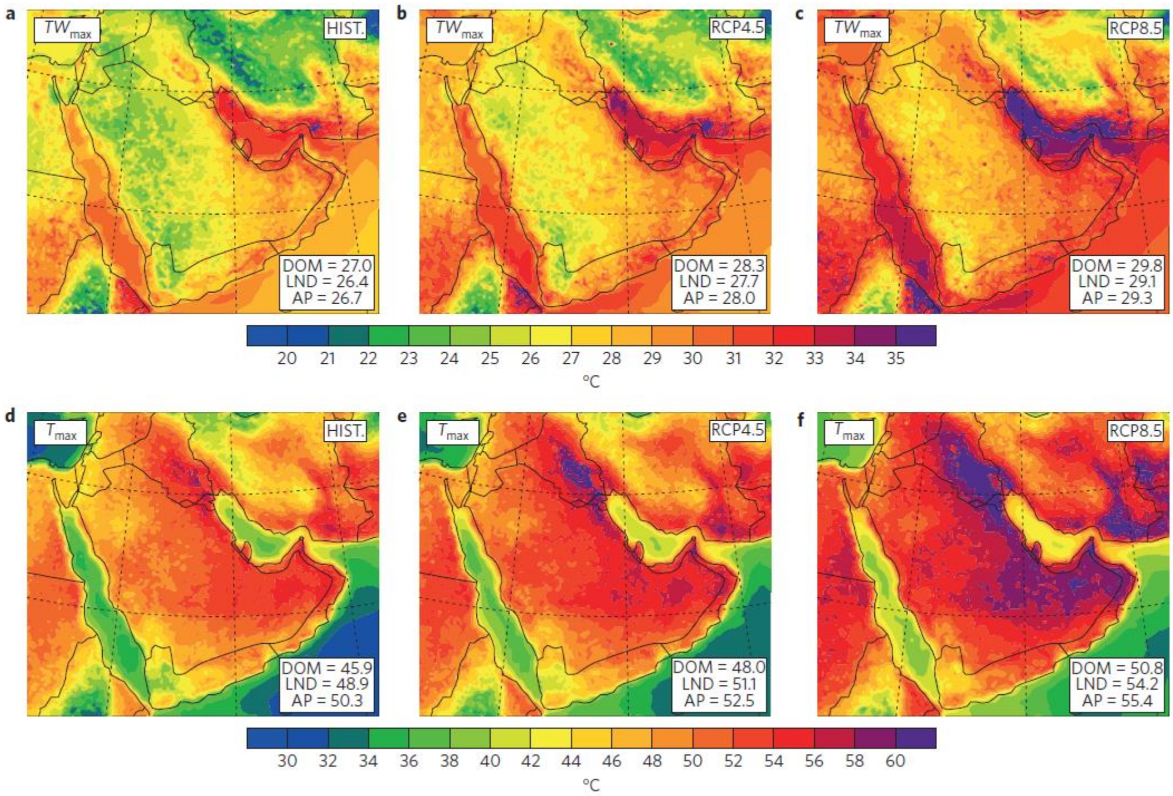

Figure 1.5 Spatial distributions of extreme wet bulb temperature and extreme temperature. **a**–**f**, Ensemble average of the 30-year maximum *TW*max (**a**–**c**) and *T*max (**d**–**f**) temperatures for each GHG scenario: historical (**a**, **d**), RCP4.5 (**b**, **e**) and RCP8.5 (**c**, **f**). Averages for the domain excluding the buffer zone (DOM), land, excluding the buffer zone (LND) and the Arabian Peninsula (AP) are indicated in each plot. *TW*max and *T*max are the maximum daily values averaged over a 6-h window.

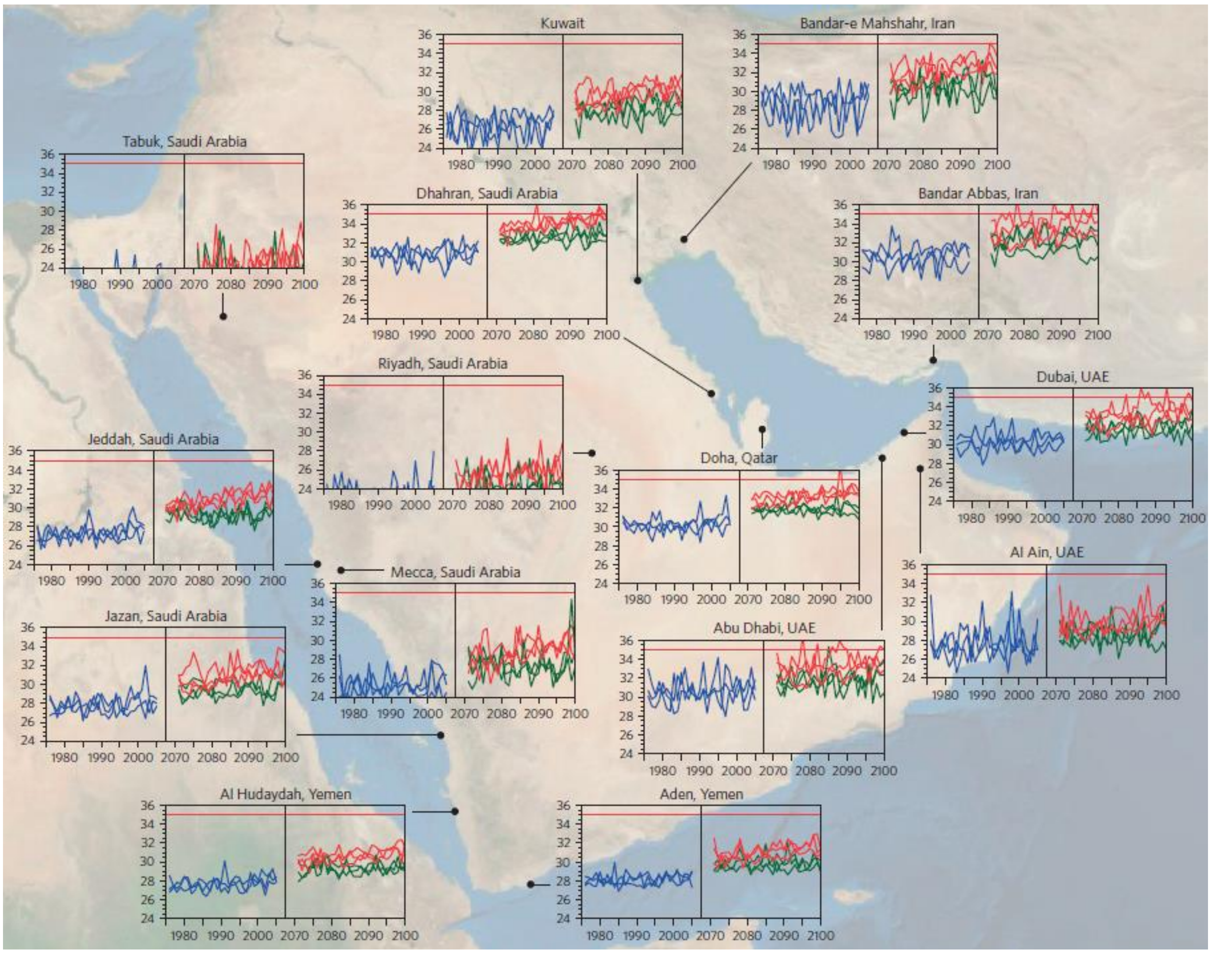

Figure 1.6 Time series of the annual maximum *TW*max for each ensemble member and GHG scenario. Blue, green and red lines represent the historical (1976–2005), RCP4.5 (2071–2100) and RCP8.5 (2071–2100) scenarios, respectively. *TW*max is the maximum daily value averaged over a 6-h window. The background image was obtained from NASA Visible Earth.

An increase in the sea-level is another major threat that all of the coastal Gulf cities will face in the near future. Dasgupta et al., predicts Qatar is highly exposed to an increase in the sea level. A one-meter sea-level rise will impact over 2% of the land area and if the sea-level rises by 5 meters, nearly 13% of the land will be affected. Nearly 2 percent of GDP and over 20 percent of the wetlands will be lost if the sea-level rises by one meter. The wealth generating industrial and commercial complexes are situated in the coastal areas. These infrastructures are highly vulnerable to the rising sea level and occasional coastal flooding. Increasing sea temperature and acidification are other growing global phenomenon. Studies show that marine biodiversity like coral reefs and fish stock is highly vulnerable. The Persian Gulf is also vulnerable to natural and man-made interventions like red tide, temperature, oil spills, brine discharge and industrial discharge. Fish mortality is recurrent in the last few years. During the "summer of 1996 and 1998, massive amounts (40 Tonnes) of dead fish were recorded, and the similar case was observed in August 2015." Studies show that it is attributed to increases in temperature and low levels of dissolved oxygen. The sea-surface and seabed temperature recorded between 35.65 and 36.20°C and 35.76 and 35.92°C (Gulf Times, 2015). With the increasing temperature in the region and increase in brine and plume discharge, there is a possibility that the marine communities will collapse.

1.4 GREENHOUSE GAS EMISSION INVENTORY

Qatar ratified the UNFCCC convention on 18th April 1996 and officially entered into force on 17th July 1996. All the Parties – Annex I and non-Annex I (see Appendix 1) are required to report national inventories and national communications. The Annex I Parties must submit a GHG emission inventory, which includes detailed information regarding methods and uncertainties and then proceeds with a multistage peer review process. The non-Annex I Parties should submit national communications, including climate change activities and emission inventory. From 2014, all the latter parties should submit reports every two years with a recent inventory of emission and removals (UNFCCC, 2011). Also, Qatar ratified the Kyoto Protocol in 2005 in non-Annex status with no legal commitments to reduce GHG emissions.

> A national GHG inventory provides critical information regarding a country's emissions profile and it can be an important tool for assessing progress toward meeting national emissions reduction goals and for prioritizing policies and actions. (Damassa, T et.al, Feb 2015)

> Emissions data are needed to understand how to influence the emissions trajectories of different sectors, support policies such as emissions trading schemes that require emissions information from facilities, set realistic policies and evaluate their effectiveness, help reporting entities assess their climate risks and opportunities, and provide information to stakeholders. (Singh. N, and Bacher. K, 2015)

Building an authoritative, reliable and accurate greenhouse gas (GHG) emission inventory is essential for Annex I and non-Annex countries. This inventory helps to understand the trend and take appropriate actions to mitigate the impacts of climate change and also fulfills the objectives of the convention. Accurate, consistent and internationally comparable data on GHG emissions is essential for the international community to take the most appropriate action to mitigate climate change, and ultimately to achieve the objectives of the convention. Communicating relevant information in the most effective way to reduce emissions and adapt to the adverse effects of climate change also contributes towards global sustainable development.

This is Qatar's first GHG time-series inventory from 1995 to 2013. This time-series inventory is especially helpful for the nation to analyze the trend and identify the potential sources of GHG emissions and take necessary actions. The rationale for choosing the base year 1995 instead of 1990 is the country's shift in political, economic and social transformation at that time. In 1995, the former Emir took power and made a series of reforms thereafter, which resulted in the major economic shift of the nation becoming a leading exporter of natural gas and attaining the highest per capita income in the world. But the real economic and construction activities began in early 2003. Therefore, the period before 2003 provides a good trend of development pattern. I followed standard procedure (shown in figure 1.7) to estimate GHG emissions and relied extensively on the IPCC methodological reports, European Union (EU) inventory methods and local facility data.

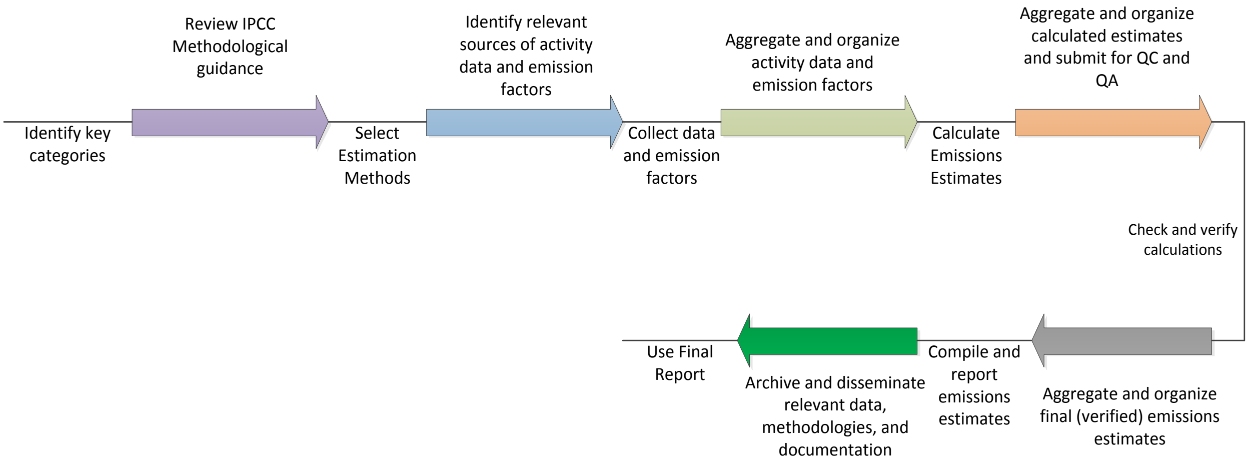

Figure 1.7 Steps in a General National GHG Inventory Development Process

1.5 DATA COLLECTION

1.5.1 CURRENT STATUS OF DATA COLLECTION

Data collection is a painstaking process. Collecting present and historical data is always a challenge, particularly if there is a no central agency to collect the data relevant to environmental matters. This is true for most developing countries. However, in the last few years, environmental issues are gaining notable attention because of its worsening impact on the population, livelihoods, infrastructure, and economy. Environmental policies are no longer straightforward. It is becoming extremely complex and interconnected with various disciplines – economy, culture, infrastructure, and public health. The growing recognition of "big data" will help to make informed policy decisions. With the advent of Sustainable Development Goals, new indicators were developed to measure social, environmental and economic progress. These indicators require extensive data from all sectors and require a comprehensive policy on data collection and reporting standards. A glimpse of environmental-related SDG was given in the section below.

In Qatar, collection and reportage of the national data are under the authority of the Ministry of Development Planning and Statistics (formerly known as Central Statistical Organization 1980-1998 and Statistics Authority under General Secretariat 1999-2013). In the last few years, the Qatar Statistics Authority (now, Ministry of Development Planning and Statistics) developed a sophisticated process of collecting, archiving and distributing the data to stakeholders and the general public. The Statistics Authority (or MDPS) publishes a statistical report annually called "Annual Statistics Bulletin" with chapters ranging from economy, trade, prices, health, labour, population and several others. Besides the Annual Statistics Bulletin

(ASB), the Statistics Authority publishes regular household surveys, national census, public opinion surveys, etc. Unlike other ministerial agencies, MDPS is a progressive, active, transparent and user-friendly organization when it comes to data reportage. This change happened under the leadership of H.E. Hamad Bin Jabor Al Thani. Under his guidance, the organization managed to streamline the efforts of data collection from various agencies and standardize the procedure by building capacity within the organization. New initiatives were established which resulted in a one-stop platform to access data for the above sectors. Previous reports are archived and published along with the new reports. A separate website, which is managed by the Ministry, is dedicated to the reports.

The new reports have less statistical data compared to earlier reports. The industrial sector, electricity/water, and environmental chapters are so far the weakest of all chapters. The oil & gas companies continue to use 'security reasons' as a guise to protect the data and refrain from sharing information with MDPS. Even the disaggregated electricity/water/fuel consumption in different sectors is deliberately omitted, and one can find many observations like this by comparing the information provided currently to earlier reports. The environmental sector is grossly overlooked; the data collection is weak and fragmented. In many cases, the ASB completely ignores the environmental statistics chapter, and in some years, there was partial reporting of data on coastal water and outdoor air quality. The actual reason for the poor reporting is unknown; however, there are three possible explanations. Firstly, lack of cooperation between other ministerial agencies. Secondly, a lack of interest and capacity of the respective institutions to gather and document data on a regular basis. Thirdly, the information is considered to be a state secret or may create negative publicity or dissent from the citizens.

The government strongly supports the exchange of information through legislation and national reports. In 2009, the Emiri Resolution No. 52 of 2009 stipulates:

1. Conducting, *inter alia*, economic, demographic, social, **environmental** and labour force statistics. The Authority shall periodically make the results available to users in various forms;

12. Coordinating with bodies entrusted with the development of National Development Visions and Strategies to **help them benefit from the results of official statistics**;

13. **Coordinating, in collaboration with competent authorities, with regional and international agencies and providing them with necessary data and information.**

Similarly, Law No. 2 of 2011 on Official Statistics 2/2011, amending the previous Resolution; the private establishments and government agencies must cooperate with the Statistical Authority and share required data.

According to the Article 4 of Law No. 2 of Official Statistics

- Governmental bodies shall cooperate with the Authority, furnish it with all requested statistical data, and follow the technical instructions when preparing the various statistics according to the quality standards and technical requirements and the dates prescribed by the Authority.

- Private establishments, families and individuals shall furnish the Authority's personnel assigned to undertake censuses and surveys with all the required statistical data that reflect an official count of the population, except data related to military and security institutions.

The lack of transparency in reporting and sharing data is well captured in the National Development Strategy (NDS) 2011-2016 and strongly encourages all the ministries, industries, academics and other agencies to share data, information for effective policy making. Below are some of the excerpts from the report:

> A culture of evidence-based policy-making will be needed, backed by information systems that ensure both informed decisions at the outset and continuous monitoring to guarantee compliance and, over time, measure impact. To make concrete the principles of gathering and sharing better information, the Ministry of Environment will mandate new reporting requirements, with all major industrial companies submitting quarterly environmental performance reports covering their emissions, water discharge and hazardous waste treatment. It will also provide a template for all companies to use for these reports. (Page 23)
>
> Comprehensive and accessible documentation will be needed at all levels. Knowledge sharing—across ministries and between government and the private sector—will be encouraged. Private sector actors, academics, and research institutes will be fully informed and given incentives to seek solutions to particular environmental challenges. To make concrete the principles of gathering and sharing better information, the Ministry of Environment will mandate new reporting requirements, with all major industrial companies submitting quarterly environmental performance reports covering their emissions, water discharge, and hazardous waste treatment. Policy-makers will provide a template for all companies to use for these reports.
>
> Gathering such assessments in an environmental information database, accessible to the public, could eliminate inefficiencies. Currently, such studies are neither centrally stored nor accessible. Companies often undertake studies that others have already completed.
>
> A central information repository could combine data from Qatar’s Biodiversity Database, its Air Quality Management Project and its Waste Management Project. Keeping this information base current, coherent and accessible will facilitate links between science and environmental policy.

Target

• Create a searchable electronic information source at the Ministry of Environment. (Page 230-231)

Information and communication technology: easy to use one-window service

• Offer one-window services online across institutions.
• Establish a common government information platform, with data sharing.
• Engage citizens by involving them virtually. (Page 246)

1.5.2 DATA COLLECTION FOR THIS STUDY

In this inventory, I compiled data from multiple sources, contacted more than four ministries, five government agencies, and over 30 companies (see table below). It took more than 18 months and over 500 email correspondences with regular follow-ups to get data from the respective agencies. I collected historical data from the reports archived in their libraries. My initial source of reference for information is the national statistical reports, i.e. Annual Statistics Bulletin (ASB). The ASB is published in the last quarters of the following year, at times as individual chapters or as a whole report. The ASB is well documented by MDPS and archived in the QALM website for public use. Along with ASBs, I used other reports published by MDPS such as census, infrastructure reports, monthly statistics, and Qatar in figures. In some cases, the data reported in the official documents like the ASB are inconsistent, and I contacted the respective agencies to get accurate data. On a rare occasion, the data for some years was not recorded or available; I made an educated guess to fill the data gaps. Some ministries such as MDPS were extremely cooperative and helpful, shared data without complications, while others, I found it hard to convince the ministries to provide basic information.

Obtaining data from companies was extremely difficult. Most of the companies have gathered data but they are unwilling to share that information with the general public. Some industries took more than 15-16 months to tell me that they **cannot** provide any information. Aside from sharing with academics/researchers, many agencies/ministries/industries are reluctant to share with other ministries due to mistrust, poor communication, insecurity and public scrutiny. Often these four characteristics take the shape of “sensitive or classified data.” There is a widespread “culture of confidentiality” among the oil/gas and petrochemical sectors since the O&G sector is highly competitive and the fear of sharing information may result in losing competitive advantage. Multinational Corporations (MNCs) and state-owned companies aggressively guard information that they perceive to be “sensitive information.”

A new trend emerged in 2010. The HSE Regulations and Enforcement Directorate (DG) of Qatar Petroleum started a new initiative called, “Sustainability Reporting Initiative” to fulfill the objectives of Qatar National Vision (QNV) 2030 and Qatar National Development Strategy (QNDS). This initiative aims to report the “sustainability” activities of the industrial sector in Qatar. One of the objectives is “to provide public access to accurate, up to date information” that includes the reporting of GHG emissions, air pollution, and efforts to reduce environmental impact. Since 2010, some of the industries have published annual sustainability reports based on the Global Reporting Initiative (GRI) guidelines. The number of sustainability reports doubled in the last four years as shown in figure 1.8. Increasingly, many companies published their reports online for public access during 2014. Although Qatar Petroleum started this initiative, it never published sustainability reports for public use. Irony abounds. Overall, the initiative has attracted momentum and gained recognition at the highest level, and the best initiatives were acknowledged by the Ministry of Energy and Industry at an annual event. However, this initiative was short-lived. It officially came to an end in early 2014 because of notable changes in authority in the Ministry of Energy and Industry and Qatar Petroleum. Uncertainty prevails; with the change in roles and responsibilities of different departments it is uncertain whether the Ministry or Qatar Petroleum will continue to publish sustainability reports.

After a thorough review process, the reports are published, and some industries have taken serious and adequate steps to monitor and report their activities objectively. The quality of reports (regarding reporting points) has increased over time. Some industry reports are fair and transparent (QAPCO, Rasgas, Dolphin Energy, etc.), but by and large, this is not the case. These reports include a significant chapter about the emissions from their processes and operations. In my calculations, I relied heavily on this report to get the facility data, though; there is no explanation of the methodology used to estimate the emissions. There are several methods for estimating emissions from the source and each has its own levels of accuracy and uncertainties. Many companies have established advanced emission monitoring facilities, and most of the companies were audited by third-party overseers. Therefore, I accepted these values with confidence assuming all of these reports go through a thorough quality assurance/quality check (QA/QC). I extrapolated the earlier data by taking the earliest emission intensity reported in their documents. I followed a rigorous procedure provided in the IPCC guidance reports. In many cases, I used the Tier-3 method because of the availability of detailed data. I believe, in future inventories, as the process of data collection increases, I might use a higher level of tiers in estimating emissions for all key sectors. In some cases, I copied the process information from the companies to give an accurate description.

To understand their sustainability initiatives thoroughly, I sent questionnaires to all of the energy and emission intensive industries. To my surprise, I received an overwhelming response from most of the companies and details are reported in chapter 9. I made thorough use of annual reports (financial and sustainability) to get as much as information as possible about the companies, operations, and environmental initiatives. The idea of environmental protection and sustainability is increasingly becoming mainstream in the oil/gas, petrochemical, and mining companies. In the last few years, there is a growing recognition of environmental issues such as water management, flaring reduction, and the like. I noticed a surge in investment in environmental protection primarily in wastewater treatment and emission reduction. As a part of their investment, most of the companies, if not all, have installed sophisticated emission monitoring (or tracking) units, replacing old gas turbine units, and tail emission control technologies. Based on my discussions with an expert from the HSE department (name of the person and company name not disclosed), the common complaints are a lack of adequate capacity, insufficient skills, carelessness/neglect and poor maintenance of equipment. This results in poor collection and documentation of emission data. In some cases, I have taken excerpts of the production process of different products from various sources to avoid inconsistency and technical flaws.

I tried my best to get most of the information through formal protocols. Unfortunately, I was unable to secure the necessary data to complete the inventory with an accurate estimation of emissions. So, **<u>I take no responsibility for overestimating or underestimating the emissions from the process</u>**. Table 1.2 shows the activity data and respective data sources. Also, I highlighted the industries/agencies that did not provide data. My intention is by no means to disparage or vilify them, but to maintain transparency.

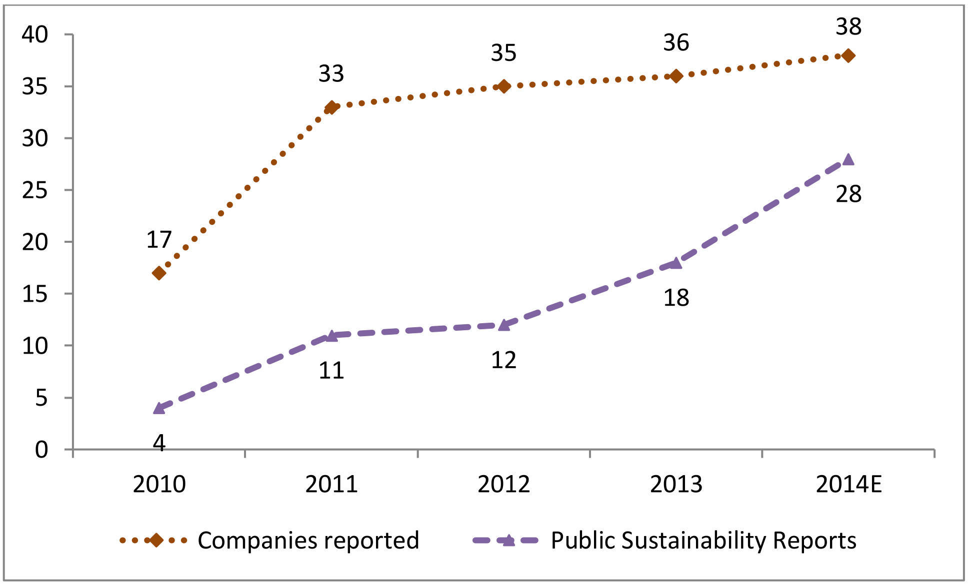

Figure 1.8. Number of companies published annual sustainability reports

Categories	Activity Data	Data Sources
Agriculture	Cultivated area	MoE
	Livestock	
	Organic Fertilizers	MDPS
	Synthetic Fertilizers	FTS
Energy	Electricity and Water Production	QEWC, Qpower, Mpower, RLPC, RGPC
	Number of cars, petrol/diesel consumption	MoI, MDPS, Woqod
	Jet fuel consumption	
	Oil consumption, drilling rigs	OPEC

	Natural Gas	QatarGas, Rasgas, Dolphin Energy, Oryx GTL, MoEI, MDPS
Industrial Processes	Steel	QatarSteel
	Aluminium	Qatalum
	Cement, Lime	QNCC
	Ammonia/Urea	QAFCO
	Ethylene, Polyethylene, Methanol, LDPE	Qchem, QAFAC, QAPCO, MoEI, MDPS
	Ethylene Dicholoride, Vinyl Chloride Monomer	QVC, MoEI, MDPS
	Normal Paraffin, Alkylene benzene	SEEF
Solvents	Lubricants	FTS
	Paraffin Wax	FTS
	Asphalt	Al Jaber, Bin Omran, CCC-TCC-JV, Marbu, UCEQatar, BOTC, Galfar, Boom construction, Jabmak, AJEQatar
Waste	Wastewater	Ashghal
	Sludge	Ashghal
	Domestic waste	MDPS, MoE
General Information	Economy, Population, Budget, Labour, and other general information	MDPS, Qatar Central Bank, Economist Intelligence Unit, Ministry of Business and Commerce, Qatar National Bank
	Legislation, National Reports	Emiri Legislations, Ministry of Justice
Organizations did not provide information	Important data (refinery, GTL, cement, etc.)	Qatar Petroleum, Shell GTL, Oxy Qatar, Al-Khaliji Cement,

Table 1.2 Activity data and respective sources (Note: For the sake of readers to avoid confusion; I combined data in one table instead of citing throughout the document.)

2. TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 DIRECT GREENHOUSE GAS EMISSIONS

In 2015, the total amount of greenhouse gas emissions without LULCF expressed in carbon dioxide equivalents, were 109.8 million tonnes, which is a 1.6 percent increase compared to 2014. The total net CO_2 removal from the LULUCF sector was 2.35 $MtCO_2eq$ in 2015, which is on average 2 percent of overall emission. The net greenhouse gas emissions, including all sources and sinks, are approximately 107.44 $MtCO_2eq$ in 2015. Between 1995 and 2015, total greenhouse gas emissions have increased nearly ten times, i.e. from 11.21 $MtCO_2eq$ to 109.8 $MtCO_2eq$. Figure 2.1 and Table 2.1 shows the emissions from different sources. There is no doubt that the majority of the emissions are from the energy and industrial sectors. Nearly 98 percent of the emissions are from energy and industrial processes. Figure 2.2 shows the emission trends of greenhouse gases from 1995 to 2015. During the study period, all sectors saw an upward trend, even the dormant economic sector – agriculture as illustrated in figure 2.3. The energy sector outpaces all other sectors. After 2008, emissions from the energy sector increased rapidly compared to earlier years and they continued to increase until 2014 because of completion of LNG and GTL facilities. The industrial emissions between 2010 and 2011 have seen a remarkable increase because of the increased production capacity of fertilizers, cement, metals and petrochemical products. The waste sector is catching up with the same pace as the industrial and energy sectors except in the last two years. This is primarily due to a reduction in landfill emissions. Emissions from the solvent sector remained insignificant throughout the period because of an incomplete database of consumption of industrial solvents. Figure 2.4a-b shows the trend of greenhouse gases compared to 1995. As a result of substantial growth in economy and population, increasing overall output from the hydrocarbon and industrial sector, the emission rate has increased significantly.

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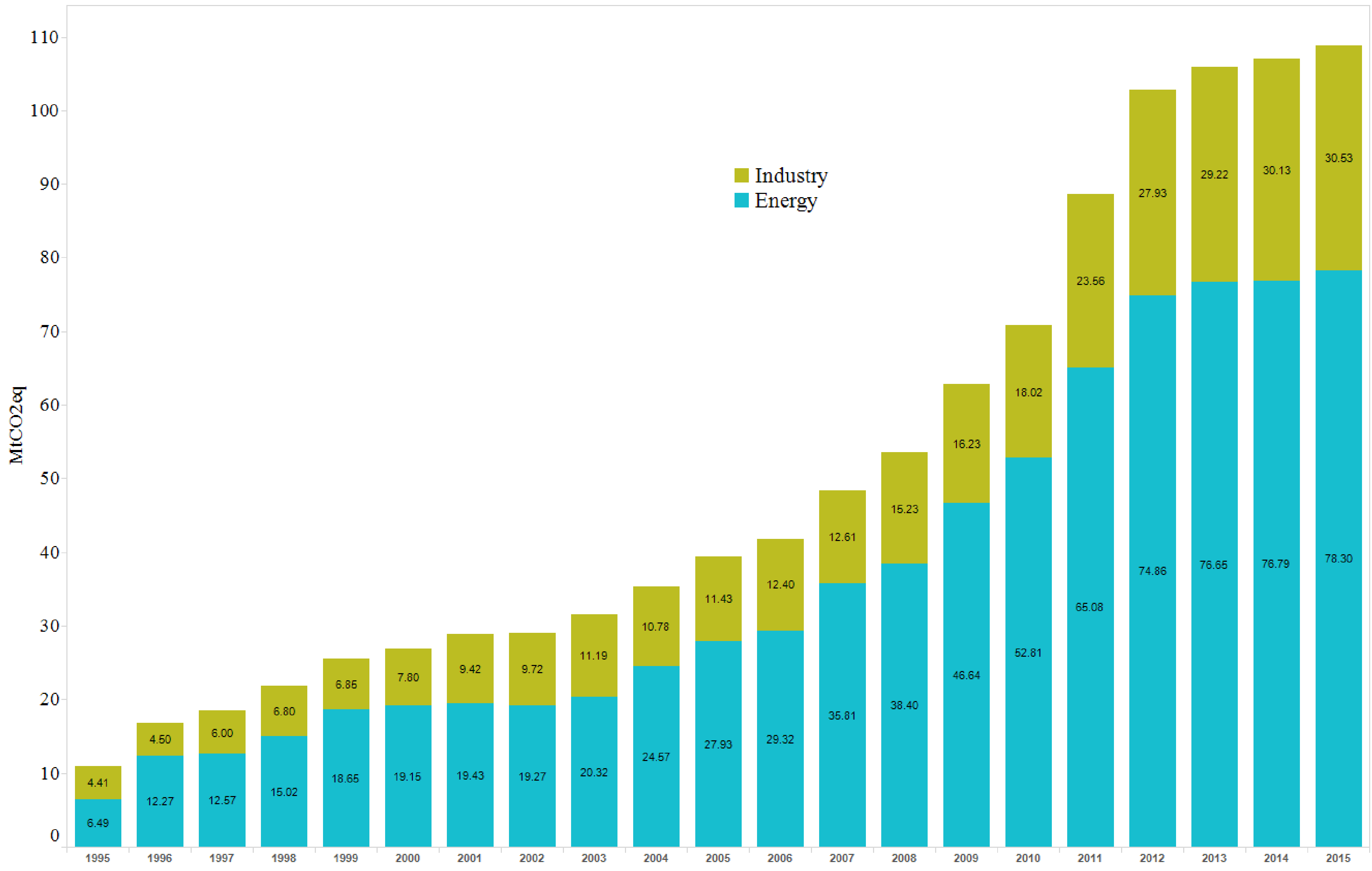

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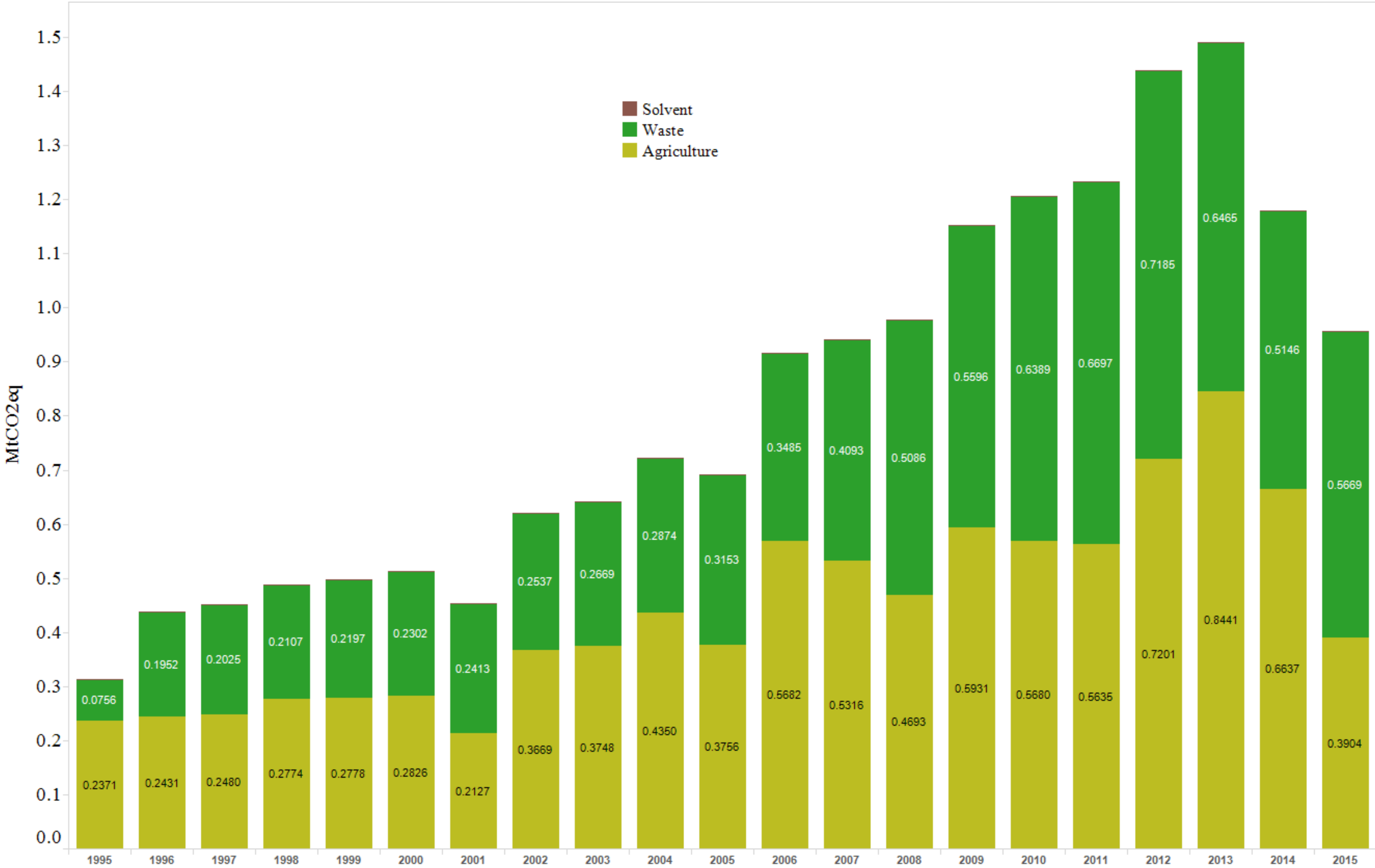


Figure 2.1 Total emissions of greenhouse gases by source and removals from LULCF (in Mtonnes CO_2 equivalents). The figure is divided into two to show the share from all of the sectors.

Year	Energy	Industry	Agriculture	Waste	Industrial Solvents (Tonnes)	Total without LULCF
1995	6.49	4.41	0.24	0.08	80.28	11.22
1996	12.27	4.50	0.24	0.20	80.28	17.21
1997	12.57	6.00	0.25	0.20	80.28	19.02
1998	15.02	6.80	0.28	0.21	80.28	22.31
1999	18.65	6.85	0.28	0.22	38.14	26.00
2000	19.15	7.80	0.28	0.23	82.62	27.46
2001	19.43	9.42	0.21	0.24	130.15	29.30
2002	19.27	9.72	0.37	0.25	90.92	29.61
2003	20.32	11.19	0.37	0.27	165.44	32.15
2004	24.57	10.78	0.44	0.29	57.91	36.07
2005	27.93	11.43	0.38	0.32	44.57	40.05
2006	29.32	12.40	0.57	0.35	90.29	42.63
2007	35.81	12.61	0.53	0.41	196.88	49.36
2008	38.40	15.23	0.47	0.51	144.65	54.61
2009	46.64	16.23	0.59	0.56	134.83	64.03
2010	52.81	18.02	0.57	0.64	182.32	72.04
2011	65.08	23.56	0.56	0.67	39.41	89.87
2012	74.86	27.93	0.72	0.72	54.08	104.23
2013	76.65	29.22	0.84	0.65	43.45	107.36
2014	76.79	30.13	0.66	0.51	52.16	108.10
2015	78.30	30.53	0.39	0.57	73.93	109.79

Table 2.1 Total greenhouse gas emissions and removals from sources and sinks in Qatar 1995-2013. All the emission values are in $MtCO_2eq$, except the Solvents, represented in tonnes.

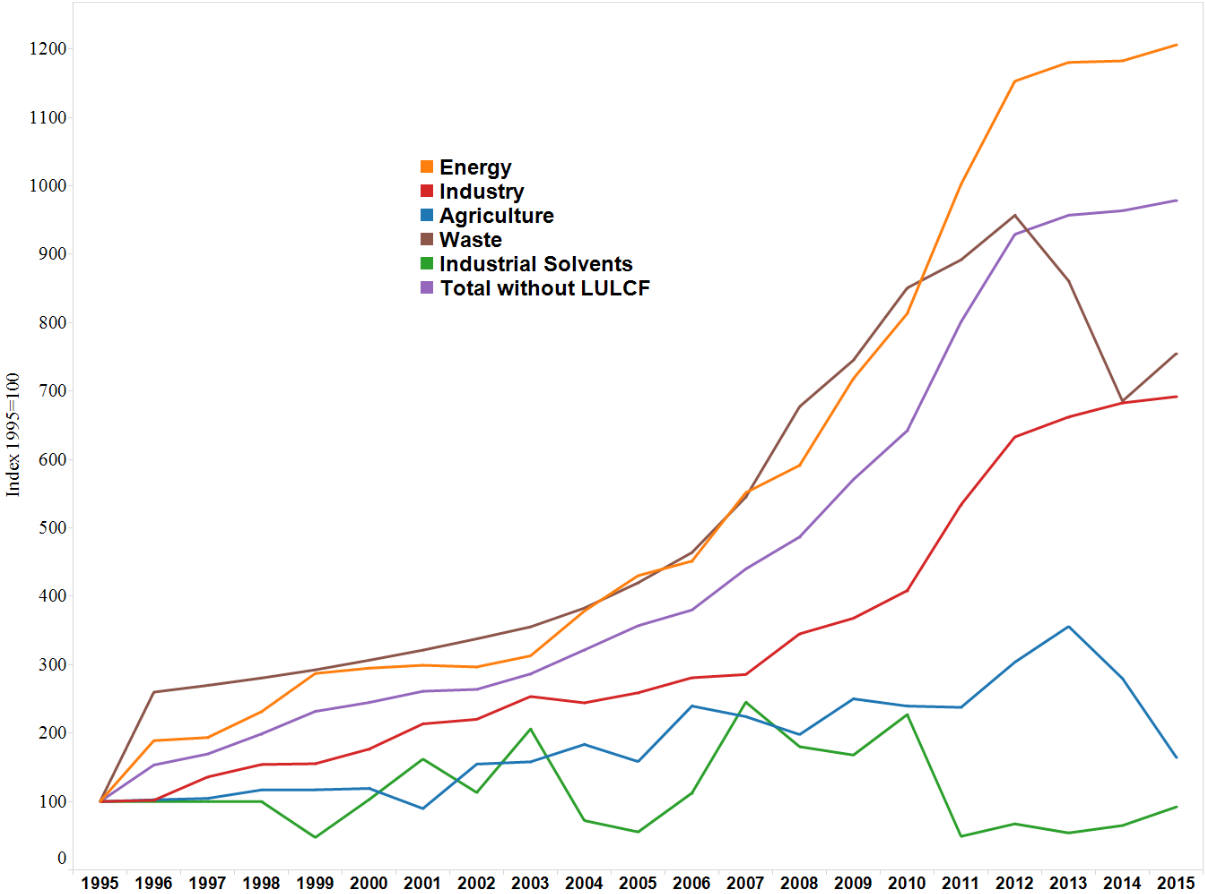
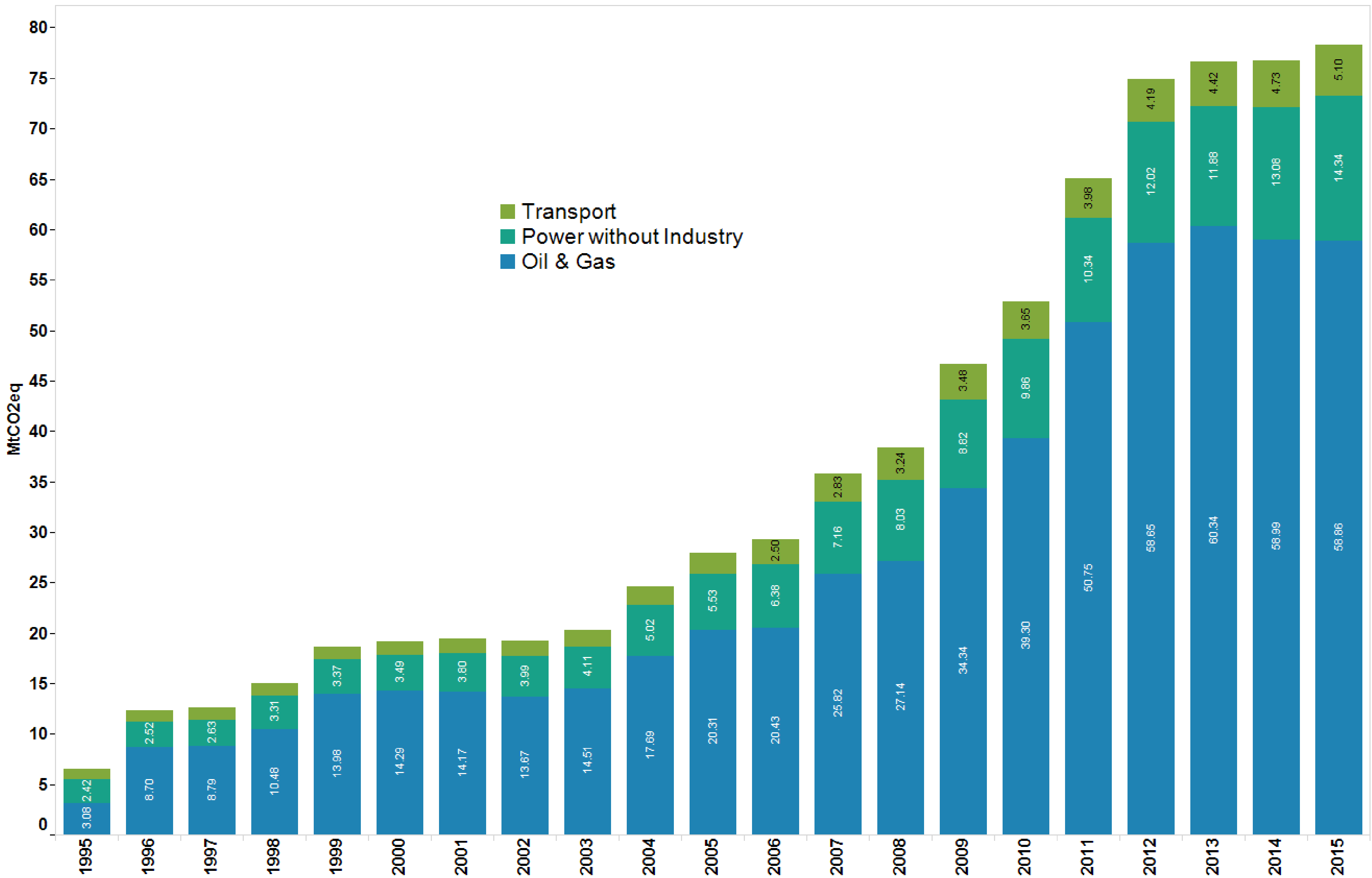


Figure 2.3 Changes in total greenhouse gas emission from different sectors during the period 1995-2015 (1995=100)

Figure 2.4 shows the breakdown of emissions from different subsectors. As discussed, the emission rates of the energy and industry sectors increased significantly. This is primarily because of new industries reaching full production and some companies expanded their existing facilities. The last column of Table 2.2 shows the companies in full production. Beginning with the energy sector, in 1996 (67.3%, compared to their previous years), 1999 (25.2%), 2004 (24.8%), 2007 (25.8%), 2009 (16.8%), 2010 (27.2%), and 2011 (22.8%) respectively. Similar cases are observed in the industrial sector, 1998 (15.33%), 1999 (33.69%), 2000 (31.37%), 2003 (16.69%), 2011 (52.25%), and 2012 (17.9%) respectively.



Transport
Power without Industry
Oil & Gas
MtCO2eq

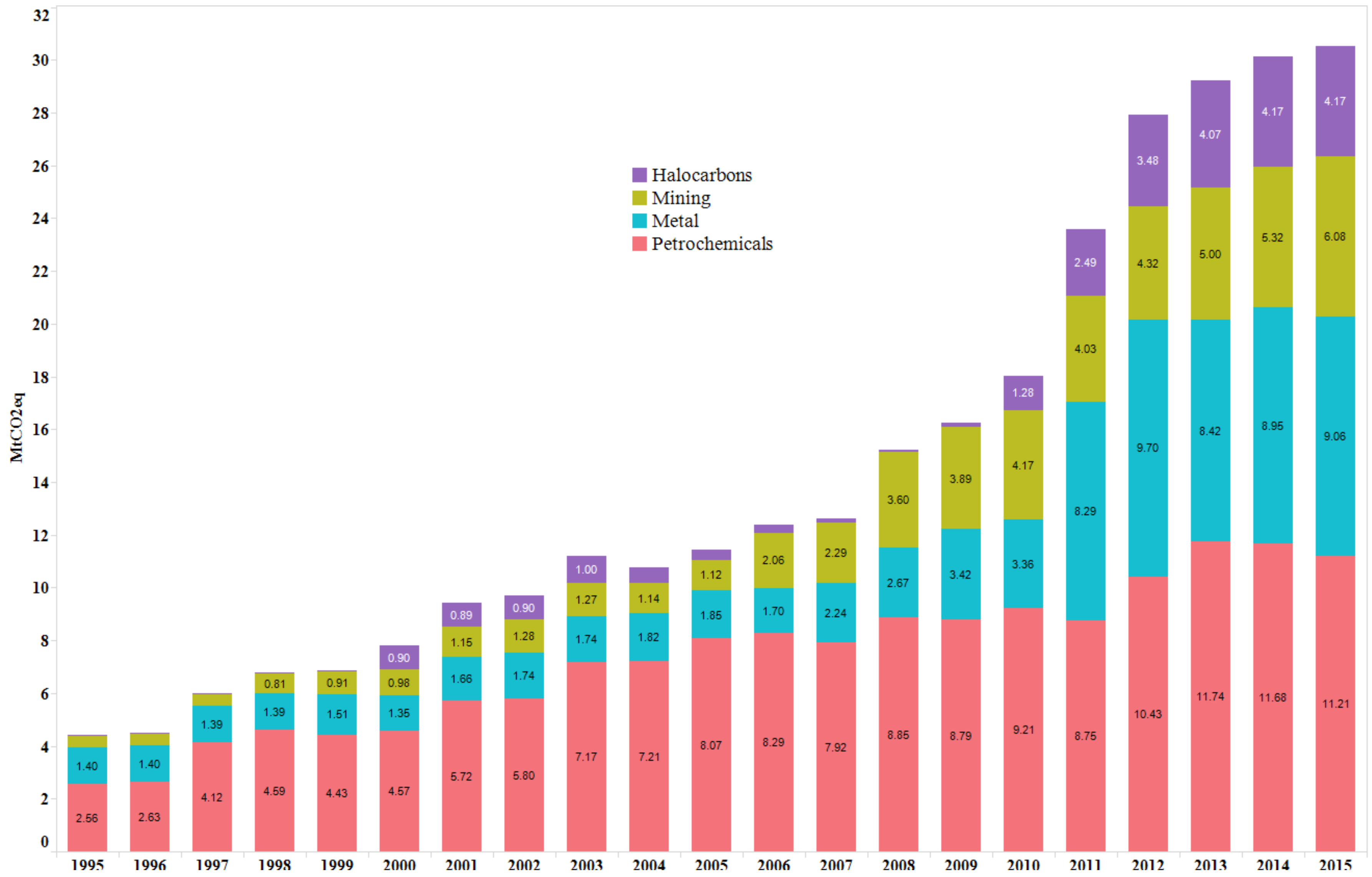


Figure 2.4 Emission breakdowns of energy and industrial subsectors

	Energy and Industry	Companies in full production
1995	10.90	
1996	16.77	QG1
1997	18.57	
1998	21.82	
1999	25.50	RG1,2
2000	26.95	QAFAC,
2001	28.85	
2002	28.99	QVC
2003	31.51	Qchem,
2004	35.35	RG3,
2005	39.36	RG4, RLPC
2006	41.72	Seef,
2007	48.42	RG5, ORYX, DE
2008	53.63	
2009	62.87	QG2, RG6, Qpower
2010	70.83	QG3, RG7
2011	88.64	QG4, QATALUM, RGPC, MP
2012	102.80	SHELL
2013	105.87	
2014	106.92	
2015	108.84	

Table 2.2 Companies in full production and its associated increase in emissions

Unfortunately, very little CO_2 is sequestrated because of the nature of the geography. As an arid climate, the diversity of land use is limited. The area of forest, grasslands, mangroves and cropland is insignificant compared to the overall land area. In 2015 the total land used for perennial crops and mangroves was 15,677 hectares. I excluded marine biomass in this study. The net sequestration, in 2015, in the LULUCF sector was 2.35 million tonnes CO_2eq, which would offset only 2.14 percent of the total greenhouse gas emissions. Figure 2.5 illustrates the change in carbon stocks from the living biomass between 1995 and 2013.

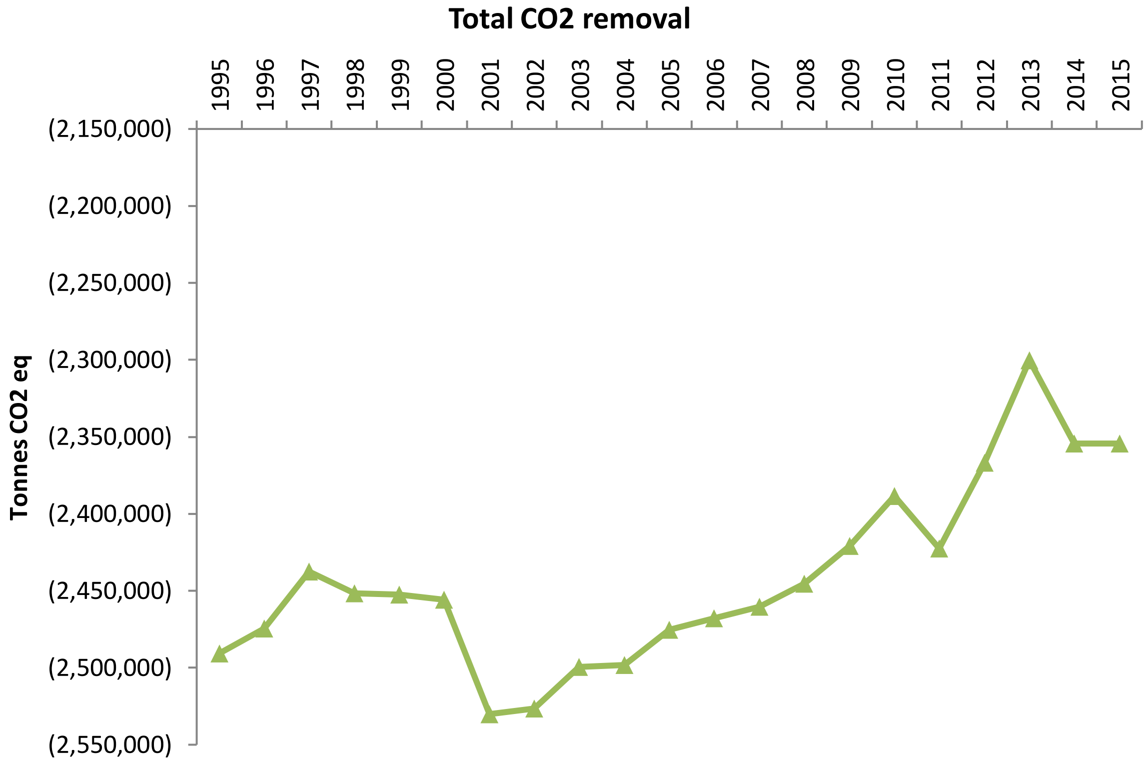
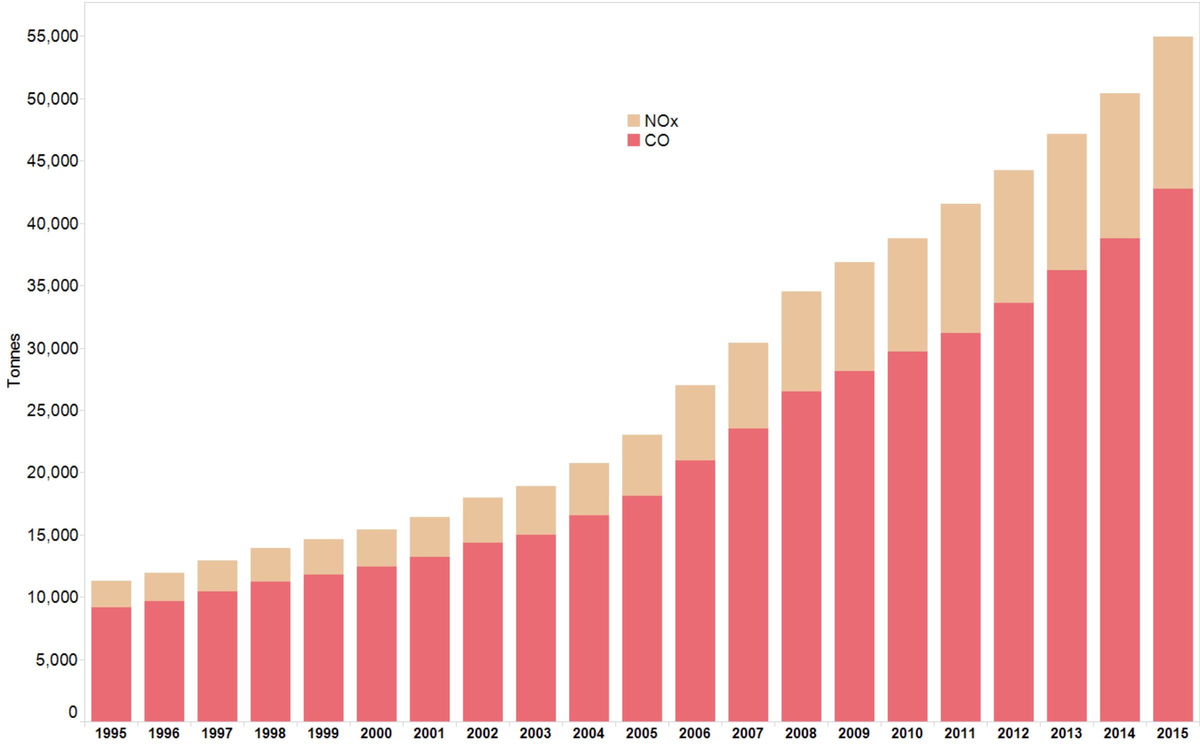


Figure 2.5 Emissions removals from living biomass, 1995-2015

2.2 INDIRECT GHG EMISSIONS

In this section, we estimated indirect greenhouse gases such as carbon monoxide (CO), oxides of nitrogen (NOx), particulate matter (PM_{10}, $PM_{2.5}$), sulfur dioxide (SO_2) and non-methane volatile organic compounds (NMVOCs). The emissions reported in this section are far from complete. Figure 2.6 shows the indirect GHG emissions from the transportation sector and NMVOC is from asphalt consumption. The emission factors used to measure the indirect GHG emission from different vehicle categories is given in the Energy section. NMVOC is reported only from 2002 because of a lack of availability of data for the previous years. Needless to say, the oil/gas, petrochemical and other industries emit indirect GHG emissions. Very limited information is published, and there is no effort from the Ministry or the companies to report in their Annual Reports. So far, a handful of companies reported indirect GHG emissions. Thanks to QAFCO, Rasgas, and Dolphin Energy, which are consistent in reporting indirect GHG emissions. Figure 2.7 shows the NOx and SOx emission and the latest available data is from 2002. There are huge variations in emissions, but the reasons are unclear. However, in the last few years, many companies have taken proactive measures to reduce NOx and SOx emissions. To illustrate, in 2012, QAPCO installed NOx and SOx reduction burners in their process plants and the emission of sulphur oxides (Sox) decreased by 48%. Another case in point, Qatargas, Rasgas has sulfur recovery units; with an average recovery rate of 95-97%. The recovered sulfur is stored in a sulphur pit and shipped as a product. For more details, please see Chapter 9.



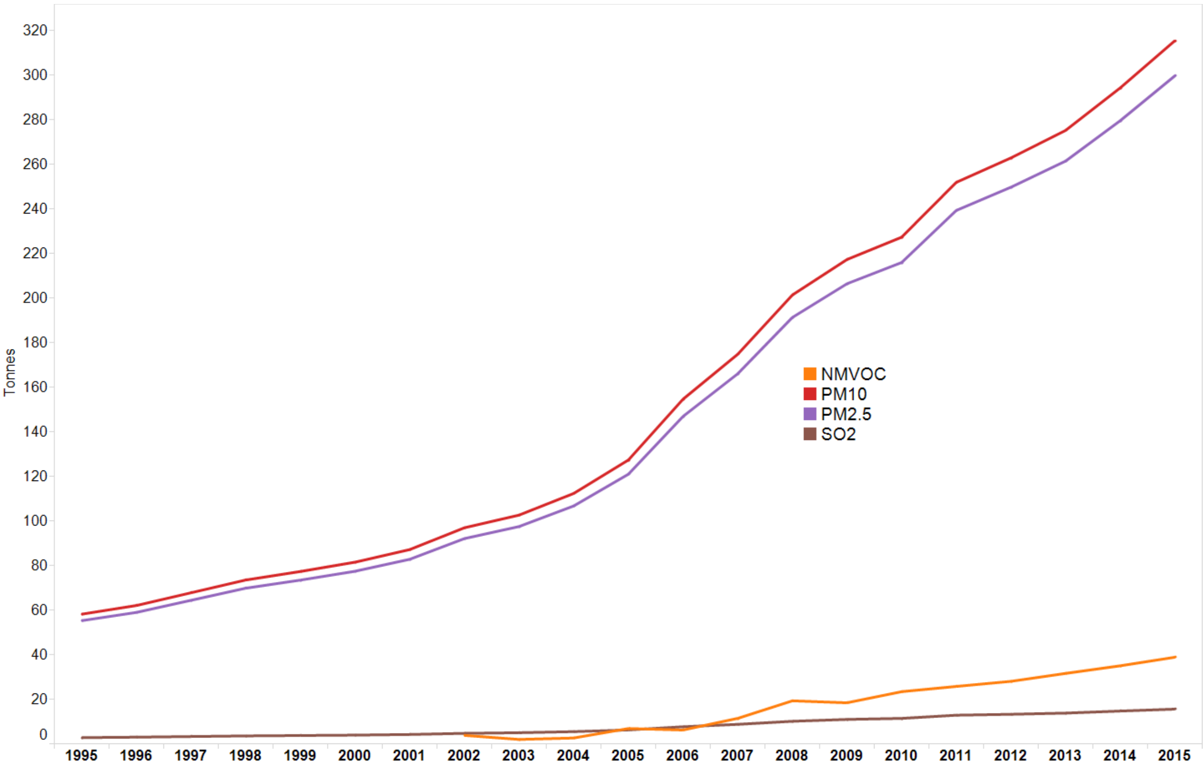


Figure 2.6 Indirect GHG emission trends from the transportation sector and asphalt consumption 1995 to 2015 (except NMVOC from 2002).

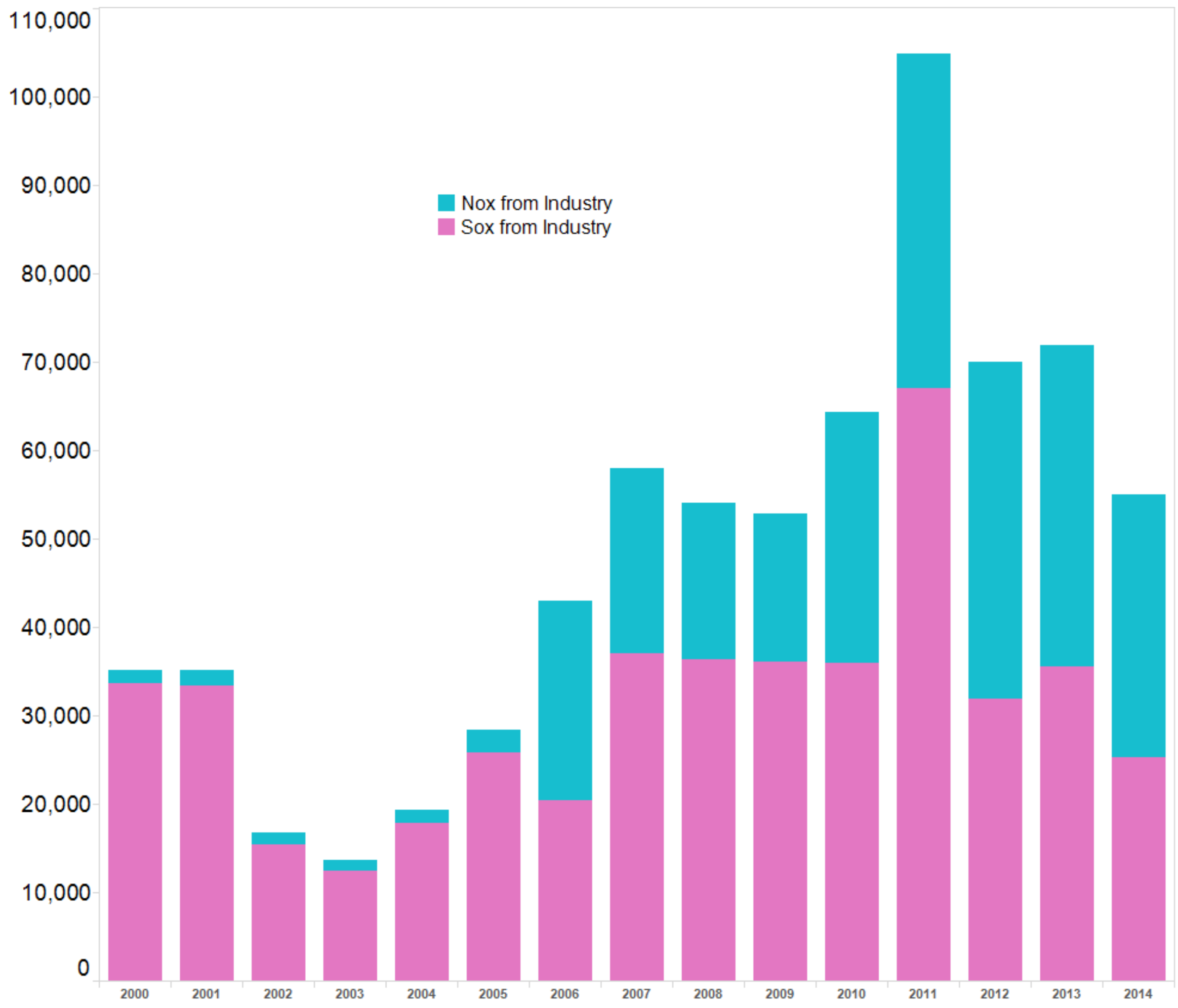


Figure 2.7Indirect GHG emission trends from the industrial sector

3. ENERGY SECTOR

In 2015, the energy sector emitted 78.3 $MtCO_2eq$, which is 73 percent of the total national inventory. The energy sector is by far the fastest growing emission sector in Qatar, with an average annual growth rate of 15 percent. The average annual growth rate was much higher in the first decade (18% against 11% in the latter decade). Between 1995 and 2015, emissions from the energy sector increased by 1106%. Undoubtedly, most of the emission resulted from oil and gas emissions. On average, 75 percent of the total emissions are from the oil and gas sector, followed by electricity generation (18%) and transport (7%), respectively. Figure 3.1 shows the trend of greenhouse gas emission from the energy sector. The pace of emission growth from the oil/gas sector was higher because of the continuous expansion of crude oil and LNG & GTL production facilities during the study period. However, in the last few years, emissions from the LNG sector and oil sector declined slightly. This is because in last three years, oil production has declined and the flaring reduction initiative has helped to reduce emissions. In the coming years, emissions from the petroleum/natural gas sector will remain constant because of an existing moratorium and the inexistence of a major expansion of the oil fields. The power and transport sector will see modest growth in the next five years.

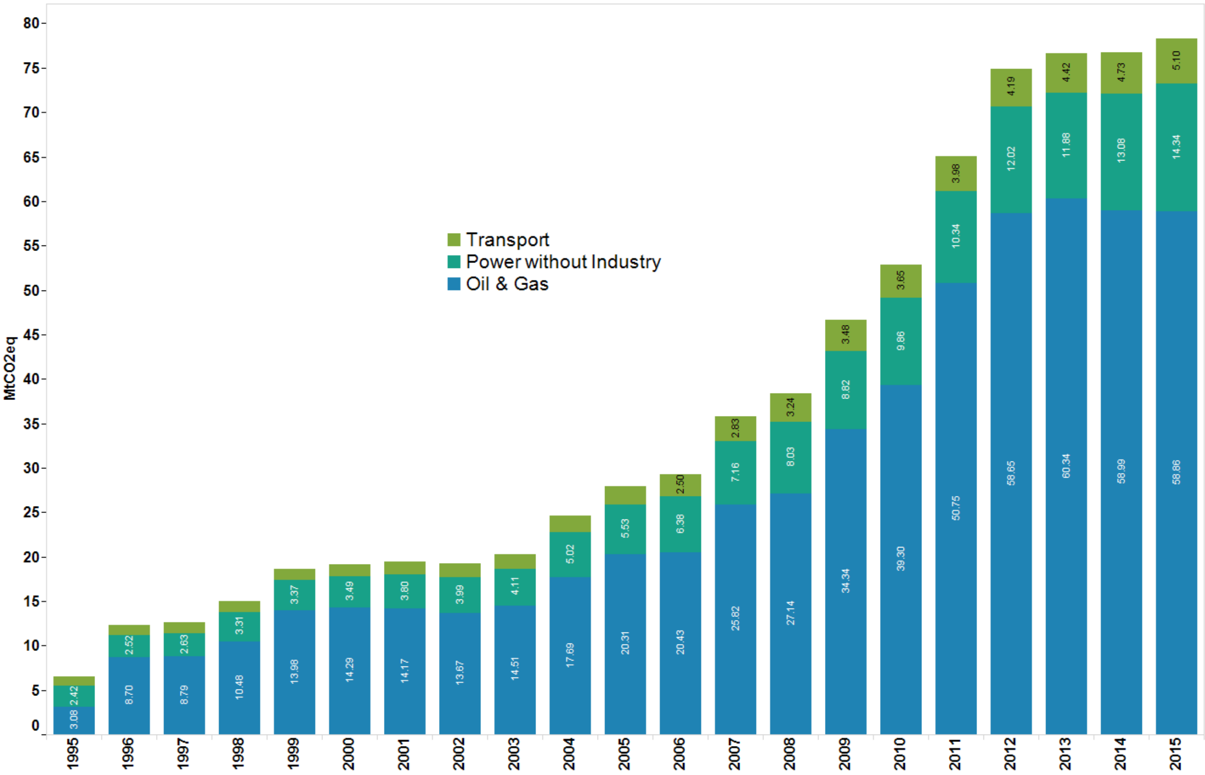


Figure 3.1 Emissions breakdown of the Energy Sector

This chapter includes emissions data from three major sectors:

a. Electricity generation sector
b. Transport sector
c. Oil and gas sector

I deliberately excluded the industrial sector from this chapter because it is covered extensively in the Industry Chapter (see Chapter 4). The reason for its exclusion to a different chapter is given below. In general, there is a diverse fuel mix used for stationary combustion like biomass, coal, oil, natural gas, waste, etc. In the case of Qatar, all of the power plants and petrochemical companies use natural gas (or its derivatives) as fuel for stationary combustion, whereas petrol, diesel and jet fuel are used for mobile combustion.

In conventional inventory reports, the energy sector includes emissions from all sectors that primarily use energy in one form or another. For instance, the inventory includes stationary and mobile combustion, which includes emissions from the industrial process, aviation, road transport, electricity production and the like. In the case of Qatar, the data are limited; many industries have no records of electricity and fuel consumption to complete the industrial process. It has only been in the last five years that industries stepped forward to report electricity (and fuel) consumption of their processes in annual sustainability reports. The same reports estimated the emission that includes process emission. It is extremely difficult to distinguish the source of emission – fuel combustion or from the process itself. To reduce inconsistency, I used facility data (Tier-3 approach) in all my industrial calculations, unless otherwise stated. For mobile combustion, I used the methodology described in the IPCC Guidelines.

	CO_2	CH_4	N_2O	PFCs/SF_6	Tier	Key Category
Stationary Combustion	Y	Y	Y	NA	Tier-3	Yes
Transport	Y	Y	Y	NA	Tier-3	Yes
Oil and gas sector	Y	Y	Y	NA	Tier-1/3	Yes

3.1 STATIONARY COMBUSTION

In 2015, electricity and water production (without the industrial sector) contributed 13 and 18 percent of the emissions from the energy sector and national inventory. The average annual growth of emissions for the period 1995-2015 was 9 percent. Over the last two decades, electricity generation has increased nearly eight times; domestic and industrial sectors increased five and fifteen times, respectively as shown in figure 3.2. The rate of electricity consumption in the industrial sector is high because of the addition and expansion of large-scale, energy-intensive industries. Between 1995 and 2015, the compound annual growth rate (CAGR) of domestic and industrial consumption was 8 and 14 percent, respectively. Despite energy-intensive industries, the domestic sector accounts for an average of 64 percent of the total electricity supply. Electricity and water production will continue to increase in the coming years because of an increase in the population and industrial activities. The total electricity installed capacity increased from 1288 MW in 1995 to 8560 MW in 2015 and is expected to reach about 11,000 megawatts in the first half of 2018.

In May 2015, Qatar Electricity and Water Company announced that it will build the largest combined power and desalination plant in the south of the country with a total capacity of 2520 MW electricity and 136.5 MIGD (million gallons a day) of potable water. Until the early 2000s, the State was in charge of producing and distributing electricity and was later privatized as a part of its wider restructuring program. Today, there are five companies, namely: QEWC, QPower, MPower, RLPC, and RGPC respectively. Except for QEWC, all power plants were commissioned after 2000. Based on surveys, all of the new power plants have been commissioned with sophisticated gas turbines, which are very efficient compared to the global average. Many new technologies were commissioned such as efficient gas/steam turbines, pumps, and other accessories to reduce energy waste and pollutants from the processes. Currently, there are four cogeneration power plants and one stand-alone power plant. All power plants use natural gas as fuel for combustion. Decentralized electricity generation at residences or commercial complexes existed before the grid integration in remote locations; diesel-powered generators were commonly used. Oil was also used until 2004, however, in a very small quantity. With the upscaling of grid infrastructure, decentralized electricity generation was ceased.

Freshwater availability is extremely scarce because of a lack of freshwater sources. The groundwater sector is used for irrigation; whereas, desalination is the only source of domestic water. Desalination plants are integrated with the electricity production units reusing the exhaust steam from the steam turbines. Desalination plants are primarily Multi-Stage Flash (MSF) which is energy intensive compared to other technologies. However, they are robust and reliable. The desalinated water produced in 1995 was 80 MCM (million cubic meters) and increased to 533 MCM in 2015.

All of the power companies signed a long-term fuel supply agreement with Qatar Petroleum at a highly subsidized price. Figure 3.3a shows that natural gas consumption in the power generation sector increased from 2,915 MMSCM in 1995 to 13,029 MMSCM in 2015. The oil (44 thousand barrels, 1999) and diesel (332 thousand litres, 2003) consumption was very low, and it phased out after 2004 when the entire country was connected to the grid. All of these companies export electricity and water to Kahramma securing contracts of up to 25 years under the Power & Water Purchase Agreement (PWPA). Kahramma is the sole distributor of electricity and water to all the consumers in the country. Ever since the transmission network was fully established, on-site power generation was restricted to energy-intensive companies like Qatalum, Rasgas, and others. There are two types of in-kind subsidies: one received by the power companies in the form of low-priced natural gas from Qatar Petroleum and customers receive heavily subsidized water and electricity (free to Qatari households). The industrial sector’s tariff is flat, even for unlimited consumption. At the time of writing, the government increased the electricity tariffs for non-Qatari households and commercial enterprises. With sliding oil prices and a shrinking state budget, it is highly likely it may follow suit with the industrial sector.

Methodological Issues

Activity Data

I estimated emissions for electricity consumption in the domestic sector. Most of the companies report indirect emissions resulting from electricity consumption. To avoid double counting, I deducted the emissions resulting from the electricity consumption supplied to the industrial sector. The electricity (which includes water production) emission is

Electricity Emissions = Total Emissions resulting from supplying electricity to all the sectors – Total Emissions from supplying electricity to the industrial sector

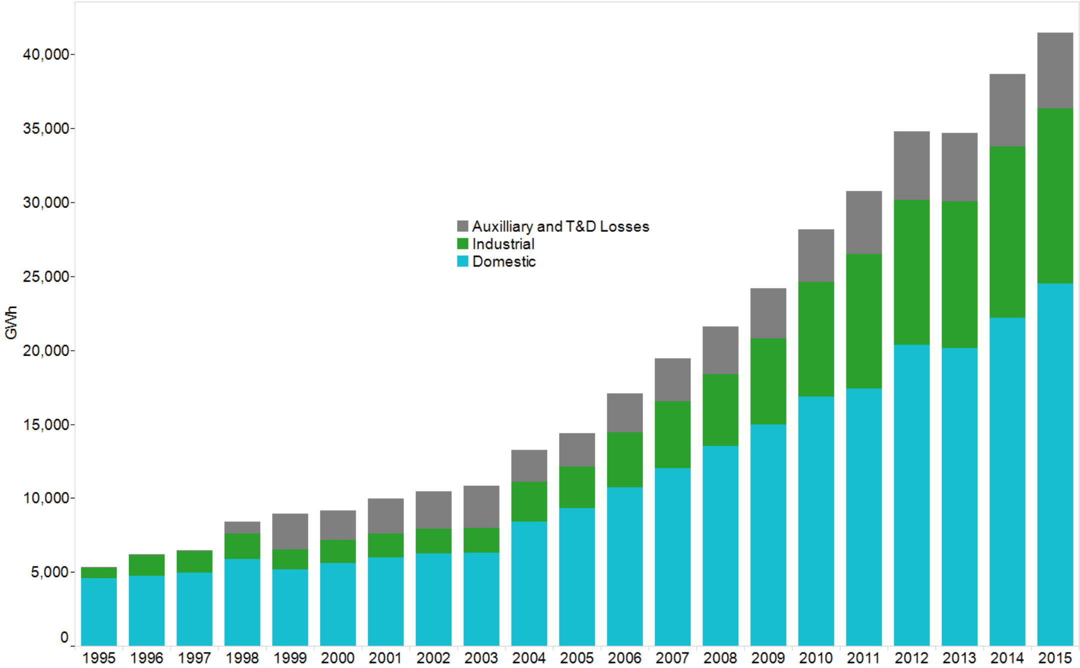


Figure 3.2 Sectoral electricity consumption between 1995 and 2015

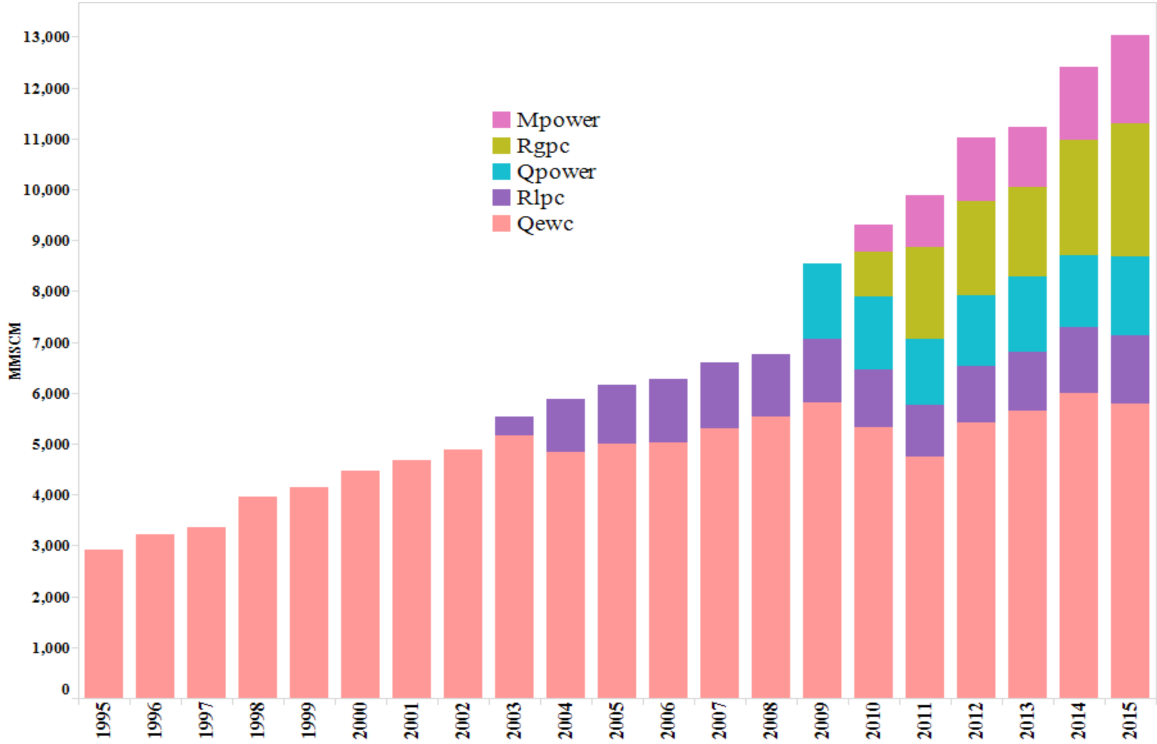


Figure 3.3 Natural gas consumption in various power plants

Emission Factor

I used plant-specific data to estimate the emissions from electricity and water production. Fuel combustion occurs in the power generation process and heat from the gas turbines used for desalination process. From 2010, four of the five major electricity producing companies reported their annual emissions. Based on my survey, I received further details on the emission factors. The emission factor (CO_2eq) of companies differs from 0.46 to 0.63 Tonnes/MWh. Newly established companies have the lowest emission intensity; for instance, Messaied Power (MPower) has an average of 0.46 Tonnes/MWh, also it is the only stand-alone power plant, the remaining are all cogeneration power plants. To avoid inconsistencies, I estimated the emissions from the power sector using averaged emission intensity. The averaged emission factor used was 0.53 CO_{2eq}/MWh.

Tonnes CO2eq/MWh	2010	2011	2012	2013	2014	2015
Mpower	0.49	0.47	0.44	0.44	0.32	0.30
Qpower	0.59	0.60	0.57	0.59	0.63	0.62
RLPC	0.55	0.63	0.59	0.61	0.58	0.58
RGPC	0.60	0.50	0.50	0.50	0.53	0.51

The total emission from electricity/water production in 2015 was 14.34 million tonnes, up from 2.42 million tonnes in 1995 as shown in figure 3.4. Emissions increased rapidly between 2004 and 2012 because of the increase in construction of mega-scale infrastructure projects and the quadrupling of the population.

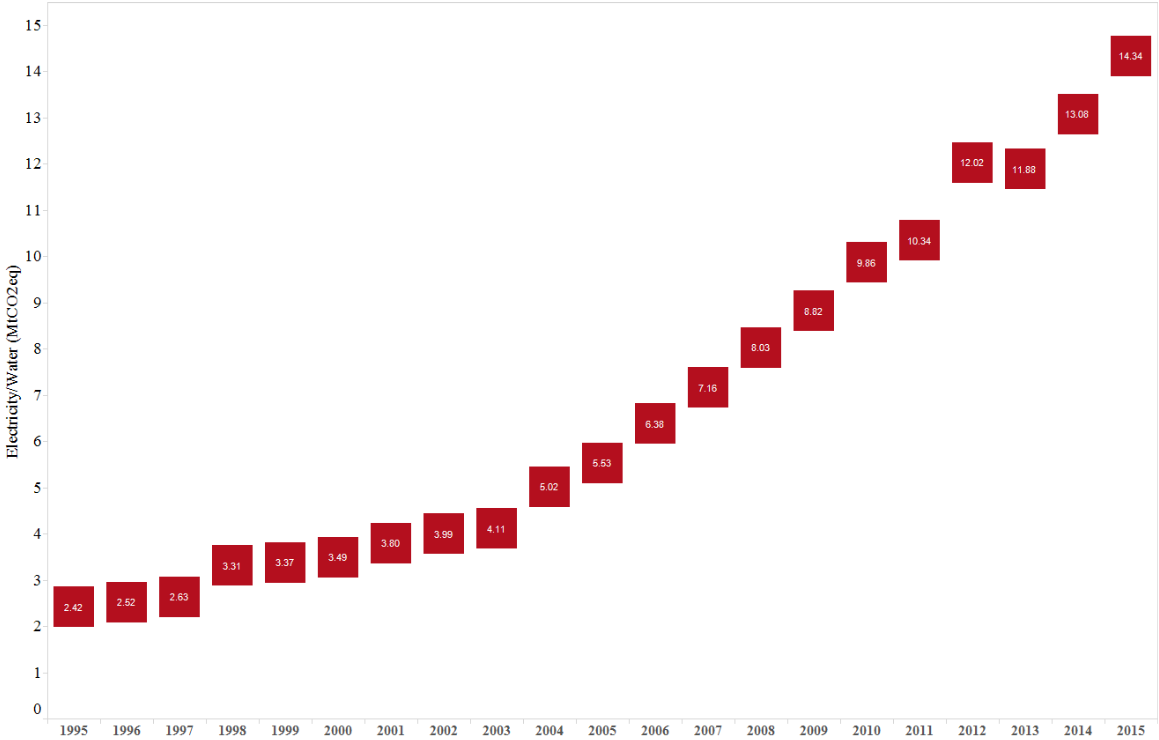


Figure 3.4 Emission from electricity and water production from 1995 to 2015

3.2 TRANSPORT EMISSIONS

In 2015, the transport sector emitted 5.1 MtCO_2eq, which is 6.5 and 4.7 percent of total energy emissions and national inventory. The annual average growth in CO_2 emissions from transportation in the period 1990-2012 was 9 percent. Between 1995-2005 and 2005-2015 the annual average growth rates were 9 and 10 percent, respectively. Over 99 percent of the transport emission is from road transport. In 2015, the total distance travelled by private cars was 14 billion km, far higher than any other vehicle categories. The passenger car rate grew at a rapid pace in last two decades because of the dysfunctional public transportation system and poor safety record for biking/cycling and walking. The number of deaths in the last four years from pedestrian crossings was 68, the third highest rate since 2009. The number of passengers using public transport declined more than half between 2007 and 2015 and remained relatively flat for the last four years. With the current infrastructure, it is extremely unsafe to use public transport because of a lack of shaded space, pedestrian areas, subways to cross the roads, etc. The government should diversify the mode of public transport and encourage the public to use this form of transport. With the new metro network, the existing problem will be partially addressed.

I estimated emissions for the transportation sector, primarily from the road transport and domestic aviation statistics. In 2015, the number of road transport vehicles (which includes cars, heavy vehicles, and buses) was 1.07 million; of which passenger cars take a lion's share of 91.5%. I omitted the emissions from sea transport and non-road machinery (agriculture) because the number of boats was only 507 (2013) and agricultural tractors were 89 (figures from 1999). In the last few years, information regarding tractors was not reported. This is understandable as the machinery used for agriculture is very limited because of the insignificant amount of agricultural activities that transpire.

3.2.1 TRANSPORT – CIVIL AVIATION

The IPCC report suggests that aircraft engines emit 70 percent CO_2, a little less than 30 percent and less than 1 percent each of NOx, CO, SOx, and NMVOC. Also, the new engines emit very little CH_4 and N_2O emissions. Domestic aviation in Qatar is negligible. Most of the aviation fuel is used for helicopters. Helicopters are used only for airlifting operations in emergency/health issues and transporting employees to the oil and gas rig. At times, the Ministry of Interior and others use helicopters for surveying the country. Based on the estimations, emissions from domestic aviation in 2015 is 526 tonnes CO_2eq.

Methodological issues

I used the Tier 2 method to estimate emissions. Woqod is responsible for supplying fuel to the aviation industry. The annual fuel recorded in the reports does not distinguish the consumption for domestic and international users. Based on discussions with representatives of Woqod, 5%

of annual jet fuel consumption is domestically used as shown in figure 3.6, and 95% is sold to Qatar Airways (national air carrier). In the last few years, the overall jet fuel consumption increased significantly because of a higher number of aircraft arriving and departing from Qatar. This is reasonable because of limited activities. Also, we assume all movements of air vehicles (helicopter/jets) are below 1000 m. The Tier-1 equation to estimate aviation emission is:

Emissions = Fuel Consumption * Emission Factor

The emission factor for CO_2, CH_4, N_2O is 71500 kg/TJ, 0.5 kg/TJ, and 2 kg/TJ respectively. These values are taken from the IPCC reports.

The domestic jet fuel consumption increased significantly over the last two decades as shown in the figure.

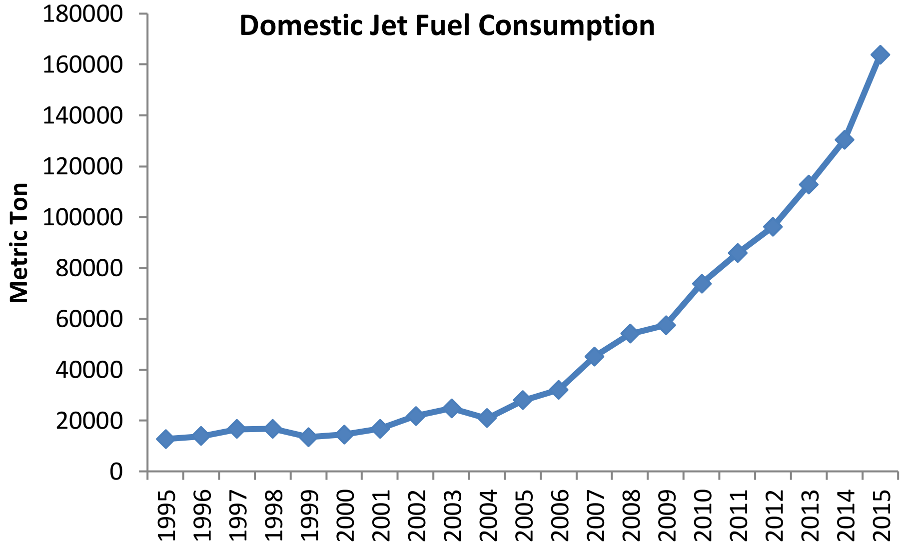


Figure 3.5 Jet fuel consumption of domestic aviation

Emissions

Emissions from the civil aviation sector increased 1188 percent between 1995 and 2015 as shown in figure 3.7. Aviation emission is less than 0.005% of total emissions.

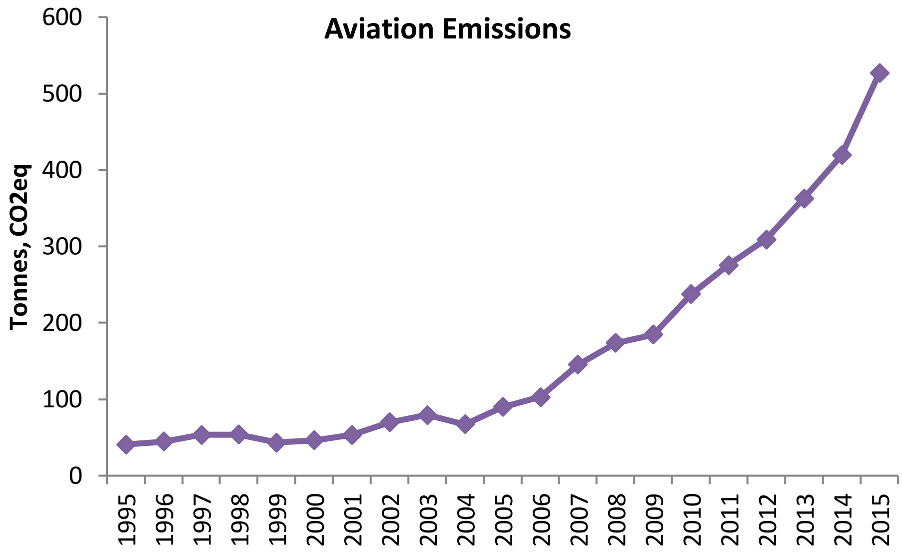


Figure 3.6 Aviation emissions from 1995 to 2015

3.2.2 TRANSPORT – ROAD*

The road transport alone contributes nearly 4.54 percent of total CO_2 emission. Over three-fourths of emissions is from passenger cars alone and 22% (average of 1995 and 2013) from heavy equipment and trailers and the remaining 2% from other vehicle categories.

Between 1995 and 2015, the number of vehicles grew significantly; passenger cars increased nearly five times, heavy equipment (including trailers) increased over eight times. Nearly 92% of the total vehicles are passenger cars (which includes taxis and light commercial vehicles), 6% trailers and heavy vehicles, and 2% buses and motorcycles. The rise of household income, lack of reliable public transportation attributed to increasing the personal ownership of passenger cars. Likewise, the massive growth in the construction sector (both non-energy and energy) contributed to the increase in heavy vehicles.

In 2015, the number of cars per 1000 people was 410, which is comparable with developed countries. Figure 3.8 shows the trend of per capita passenger car ownership in Qatar which depicts the per capita car ownership is declining, but the overall car growth is increasing. One of the main reasons for this decline is the growing working class (in local terms – blue collar workers) population, who are unable to afford a car. In a recent household survey of 2013, 64% of Qatari households have more than three cars; whereas, over 60% of the non-Qatari households have only one car (see Table 3.1).

*Thanks to Dr. Rita Chamoun for her support in this section.

Since 2004 the number of new cars registered annually has significantly increased as shown in figure 3.9. There was a brief lag in 2009 because of the economic crisis and this figured rebounded after 2011. Diesel and petrol are commonly used fuels. The overall fuel consumption increased more than in the vehicles. In last two decades, petrol and diesel consumption increased from 0.73 to 5.05 billion litres. The annual average growth in petrol and diesel consumption in the period 1995-2015 was 9 and 13 percent, respectively. Between 2003 and 2008, the annual average growth in petrol and diesel consumption was 11 and 27 percent, which is highest than in any other period. Recently 40 buses were tested with CNG; the results are noteworthy. With the appropriate infrastructure in place, Mowasalat will scale-up CNG use for heavy vehicles. Bioethanol, biodiesel, LPG is not used in any of the vehicles.

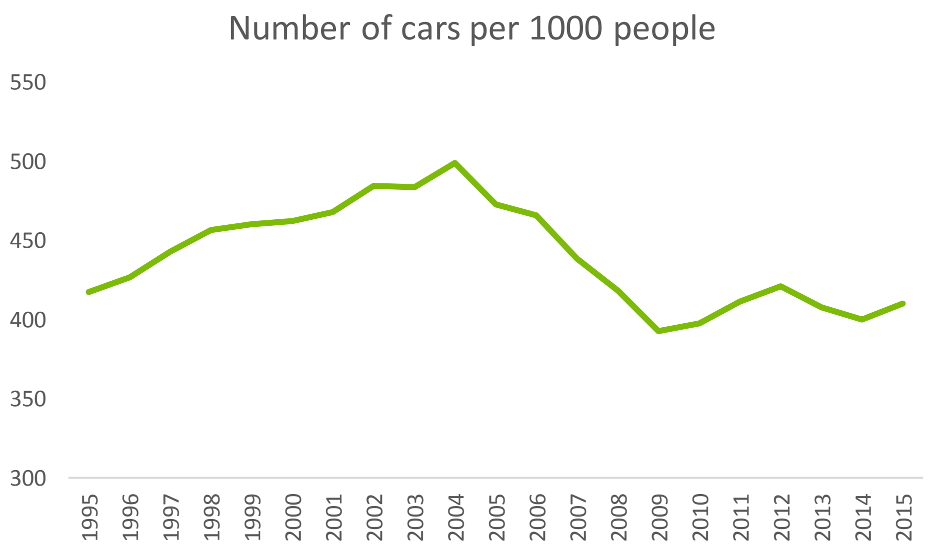


Figure 3.7 Number of cars per 1000 people in Qatar from 1995 to 2013

No of cars	Qatari Household (Avg. HH size 8.65) (%)	Non-Qatari Household (Avg. HH 4.32) (%)
3+	64.11	5.9
2	26.49	23.45
1	8.92	61.81
0	0.47	8.84

Table 3.1 Number of cars in Qatari and non-Qatari households based on a national household survey

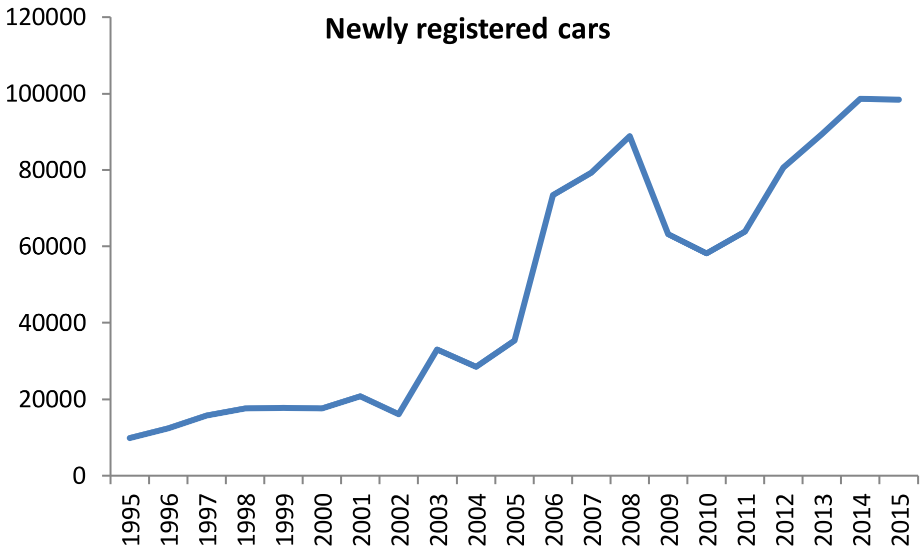


Figure 3.8 Annual registered cars between 1995 and 2013

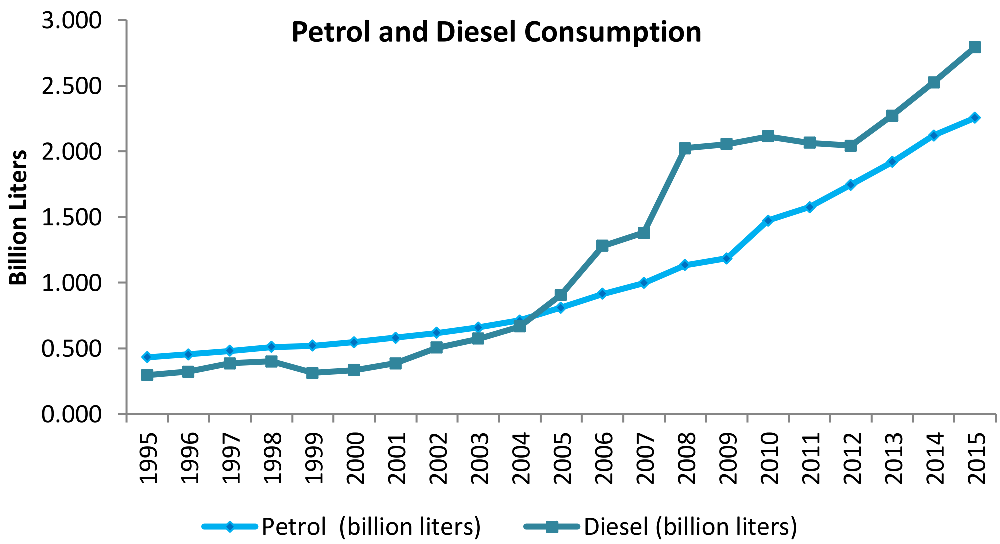


Figure 3.9 Petrol and diesel consumption between 1995 and 2013. In 2005, diesel consumption surpassed petrol consumption because of the increase in heavy vehicles

Methodological Issues

I conducted an extended analysis of road transport emissions. The vehicle data are taken from the Ministry of Interior (MoI) office, which is reported to the MDPS as shown 3.11. I was unable to get disaggregated information about the type of cars. Consequently, I did a small survey and categorized the passenger vehicles into three types: Sedan (55%), sports utility vehicles (SUVs) (40%), and luxury cars (5%). The distance travelled by the passenger cars is divided into three tiers:

Tier 1 - 10% of total cars driving > 100 km/day

Tier 2 - 60% of total cars driving 60 km/day
Tier 3 - 30% of total cars driving 40 km/day
Some assumptions were made in this analysis:

- Nearly 70 percent of the total registered cars are on the road on a daily basis
- The average distance of the trailers/heavy equipment and motorcycles is 150 and 30 km/day
- Motorcycles drive only 150 days between October and March
- The averaged distance travelled by the taxis and buses is 350 km and 46 km respectively (Communication with Mowasalat).
- 95 percent of the country is urbanized. Therefore, I assume all vehicles travelled within urban perimeters

Figure 3.12 shows the overall distance travelled by all vehicle categories in Qatar. It is apparent that the distance travelled by the cars is far higher than other vehicle categories. In 1995, the total distance travelled was 3.35 billion km and reached 16.07 billion km in 2015. On average, 86% of the total distance is travelled by passenger cars.

The emission equation for Tier-3 is:

CO_2 Emissions = $\sum_{a,b}[Distance \text{ x } EF]$

Emission	= CO_2 emission (kg)
$Distance_{a,b}$	= distance travelled (VKT) (km)
$EF_{a,b}$	= emission factor (kg/km)
a	= fuel type (e.g., gasoline, diesel)
b	= vehicle type (e.g., cars, trailers/heavy vehicles, buses and motorcycles)

Assuming all the vehicles are operating in urban areas (as 95% of the population is living in urban areas and most of the activities are concentrated in the city).

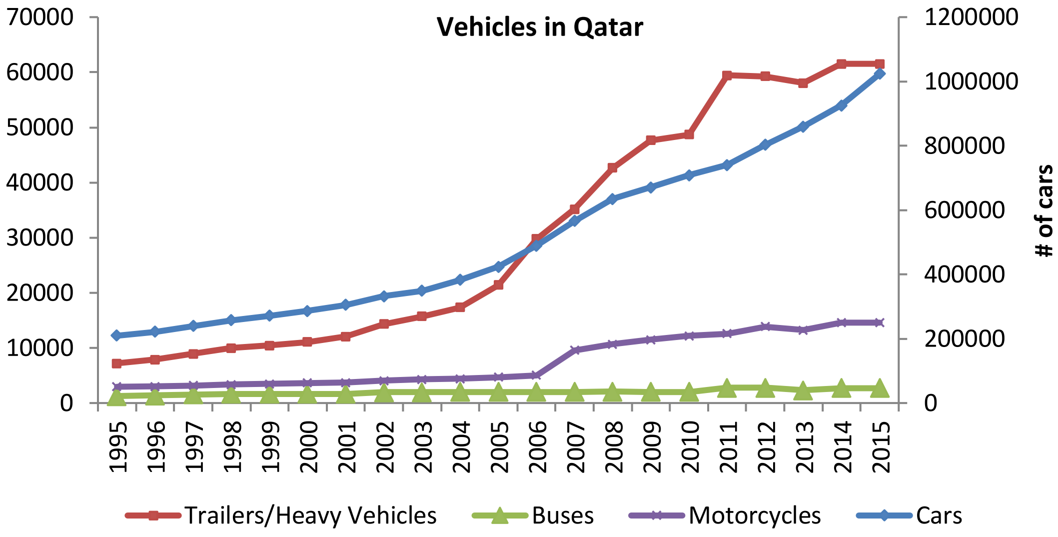


Figure 3.10 Total vehicles in Qatar (left axis – number of cars)

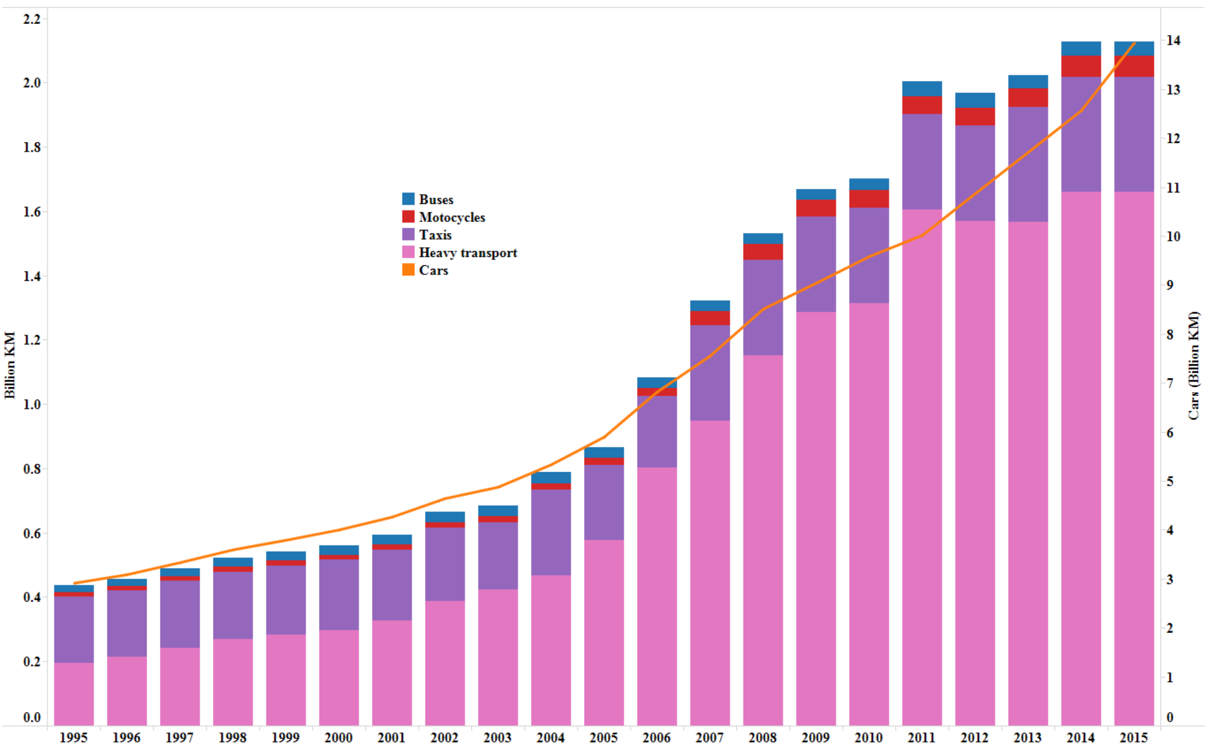


Figure 3.11 Total distance travelled by all vehicle categories in Qatar

Emission Factors

All of the vehicles in Qatar are imported from Europe, Japan, South Korea, and the USA. I took the emission factors from the UK DEFRA's emission factor database. The emission factors for various vehicle categories are given below in Table 3.2. Nearly 99% of the passenger cars and light commercial vehicles use petrol, and heavy vehicles and buses use diesel. Biofuel/CNG is not used, except for the previously mentioned pilot study of CNG-run public buses.

Per km	kg CO_2	kg CH_4	kg N_2O
Sedan Cars	0.26005	0.00014	0.00056
Dual Purpose 4x4 cars	0.27611	0.00014	0.00056
Luxury Cars	0.34494	0.00014	0.00056
Bus	0.58487	0.00022	0.00606
Heavy Equipment and Trailers	0.71984	0.00027	0.00746
Motorcycles	0.11606	0.00225	0.0006

	g/km	g/km	g/km	g/km	g/km	g/km	g/km
Vehicle Categories (g/km)	NOx	PM_{10}	$PM_{2.5}$	CO	VOC	NH_3	SO_2
All cars	0.42284256	0.01532969	0.0145632	2.86722823	0.157143	0.010872	0.000638
Buses	6.45230681	0.08065036	0.07661784	0.72953615	0.151202	0.003	0.004359
Heavy Equipment and Trailers	3.60266767	0.05826278	0.05534964	0.68873501	0.101109	0.003	0.003783
Motorcycle	0.21489645	0.01352555	0.01284927	9.85818546	0.855494	0.001949	0.000349

Table 3.2 GHG and non-GHG Emission factors for various vehicle categories

Emissions

In 2015, emissions from road transport exceeded 5.1 million tonnes CO_2equivalents, which is 4.7 percent of national inventory. In two decades, the overall emissions from road transport increased 415% as shown in figure 3.13. Over three-fourths (78%) of emissions is from passenger cars alone and 21 percent from heavy equipment and trailers and the remainder is from other vehicle categories. However, from 2004, the share of emissions from heavy vehicles has increased markedly. This illustrates the nature of transportation and consumption of goods due to the construction of mega infrastructure projects in energy and non-energy sectors. The emission distribution among the vehicle categories is shown in figure 3.14. Non-GHG emission trend is reported in section 2.

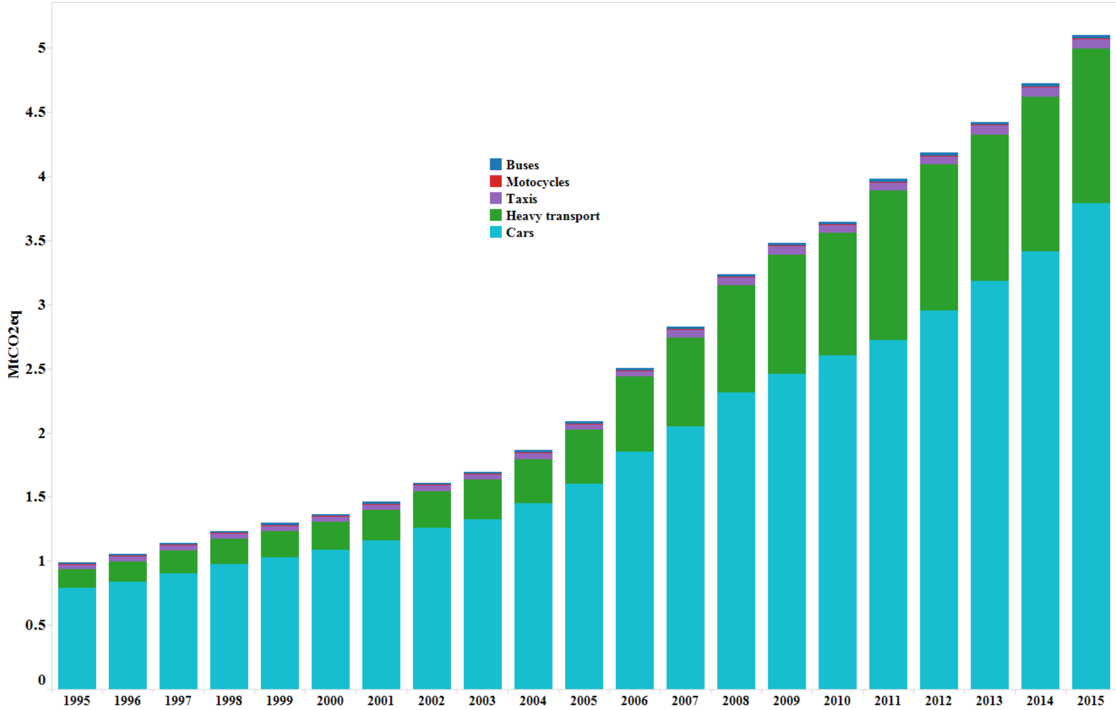


Figure 3.12 Emissions from road transport sector between 1995 and 2015

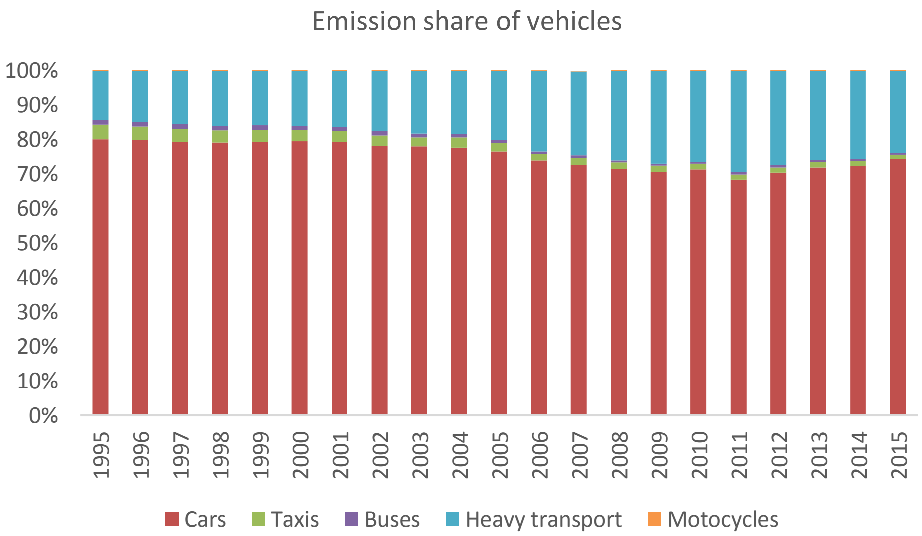


Figure 3.13 Emission shares of vehicle categories. Note the declining share of passenger vehicles from 2004

3.3 OIL AND GAS SECTOR

In this section, I estimated emissions from the oil and natural gas sector. In 2015, the total emissions from the oil and gas sector alone contributed 58.86 million tonnes CO_2equivalent, which represents 54 percent of the total greenhouse emissions of Qatar. Between 1995 and 2015, the O&G sector experienced the fastest emission growth among all other sectors; the average annual growth rate was 20 percent. The emission growth rate was higher in the first decade (28 percent against 12 percent in the latter decade). The staggering growth of emissions from the natural gas sector is because of the steady growth of LNG production trains and new GTL facilities. In the last three years of the study period, the oil and gas emissions are saturated because the LNG and GTL production will remain constant and existing moratorium. The slight decline in emissions from 2014 is because of falling oil production. If the production remained constant, emissions will decline further because of implementation of new emission reduction initiatives.

It is widely acknowledged that calculating emissions from the oil and gas sector is often riddled with uncertainties because of various technical challenges. Oil and gas systems are very complex and diverse. There is no standard procedure because of different procedures involved in crude oil and natural gas extraction, production, and processing. Additionally, the oil and gas sector is generally very protective of their technologies and processes, making it extremely difficult to estimate reliable emissions. Oil and natural (O&G) gas is an energy and emission intensive sector. Exploration, extraction, production, storage, and distribution involve a wide range of processes and emit different kinds of emissions at different stages. None of the companies have reported emissions during the extraction of natural gas from the offshore fields. O&G sector is the major source of GHG and non-GHG emissions. Of which, CO_2 gets more attention from the policymakers and companies. However, short-lived emissions like black carbon, methane, and non-GHG emissions like NMVOC, carbon monoxide, and particulate matter are discussed less. In the case of Qatar, it is far more challenging because very limited information is published for public use. Careful observation of sustainability reports of the major oil and gas sectors show that very few companies report emissions at a disaggregated level.

I estimated emissions from the exploration, oil/gas production and refining process as shown in figure 3.14.

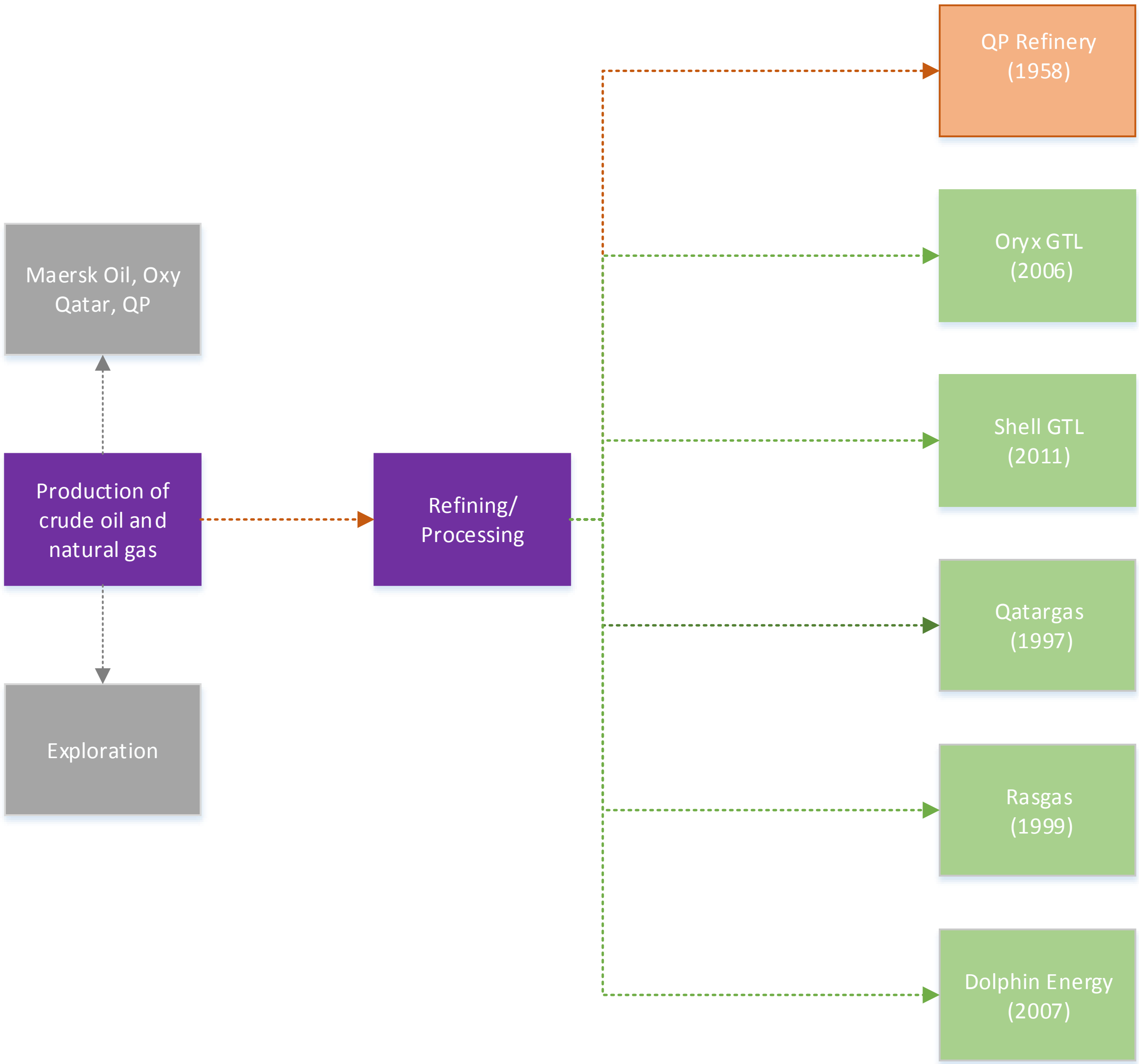


Figure 3.14 Oil and gas companies in Qatar

3.3.1 OIL SECTOR

In 2013, the total emissions from the oil sector, including exploration and drilling were 2.9 million tonnes CO_2equivalent. The CO_2 emission increased 86% between 1995 and 2013. In 2013, 2.63% of the total CO_2 emission was from the crude oil production process; whereas, CH_4 accounted for 52.02% of total methane emission. I excluded emissions from domestic oil transport and storage because very limited information is available and sparse information is provided in the OPEC reports. The total pipeline length for oil transportation is 843 km (OPEC, 2015).

I would like to inform the reader that emission data from the oil sector is far from complete, because key oil producers like Qatar Petroleum, Oxy Qatar refrained from providing detailed information about their production processes and its associated emissions. The production data is taken from the Annual Statistics Bulletin, annual reports of Maersk Oil Qatar, Qatar Petroleum and cross-checked with the international databases for data consistency. I tried to obtain data from internal sources, but I could not ascertain sufficient cooperation from respectable companies. Often the companies use “security concerns” and “internal policy” as reasons to avoid sharing information. Even in the sparse information published, the emission reporting is limited to CO_2 emissions that are aggregated into GHG emissions (CO_2eq). Therefore, this lack of information makes it extremely difficult to make reliable estimates of disaggregated emissions. Therefore, I take no responsibility for overestimating or underestimating emissions.

Qatar’s flaring reduction initiative came very late compared to many O&G production countries. For instance, Norway began regulating flaring during exploration and production in the 1970s. The Petroleum Act prohibits flaring except for safety reasons. In 1991, the Norwegian government introduced a CO_2 tax providing incentives for the O&G companies to reduce flaring. Since then, flaring in Norway reduced significantly. Qatar engaged in a World Bank’s initiative called Global Gas Flaring Reduction Partnership (GGFR). This initiative aims to achieve a target of zero-flaring. The Ministry of Environment (Qatar) has imposed new regulations - flaring volume should not exceed 0.3% of total sweet gas production. With the exception of flaring, there are no strict regulations to reduce emissions. Often companies report CO_2 emissions in their annual sustainability reports, very limited information is published about methane and black carbon emissions. I believe in the forthcoming inventories, given the cooperation from all companies, I would be able to provide reliable estimates of emissions of GHG and non-GHG.

As outlined before, the oil and gas sector is the most emission-intensive sector in the country contributing x% of overall emissions. The GHG emissions in the oil and natural gas industry occur from following sources (not necessary in order or intensity):

a. Combustion Sources
b. Process Emissions and Vented Sources
c. Fugitive Sources
d. Indirect Sources

The GHG emission from **combustion sources** is primarily the burning of fuel in stationary equipment such as engines, burners, heaters, boilers, flares, and incinerators. It includes emissions from mobile combustion devices such as vessels, barges, and so on. CO_2 is the major emission due to oxidation of carbon-containing fuels. Incomplete combustion results in methane emissions and an insignificant quantity of N_2O emission is released during the process.

Vented sources of emissions occur in normal (or routine) or emergency (non-routine) process. Primary sources of vented and process emissions are during the chemical transformation or processing step. Examples include dehydration, gas sweetening, naphtha reformers, catalytic cracking units, etc. It also includes compressor turn-arounds, pipeline pigging operations, etc. During emergency shutdowns, emissions are released from emergency safety blowdowns, pressure relief values and breakout/surge tanks.

Fugitive emissions are “unintentional releases from piping components and equipment links and also from underground pipeline leaks.” Emission releases from specific sources such as valves, flanges, pump seals, etc.

Indirect emissions are emissions from other sources that do not directly result from its production boundary such as electricity, heat, steam consumption imported from the third party.

There are several methods for estimating GHG emissions from the oil and gas industry, ranging from the very simple method of using published emission factors to using sophisticated continuous emission monitoring devices. In the case of Qatar, the latter is only applicable for the last few years, where most of the companies deployed advanced emission monitoring units and reported accurate emissions. However, detailed information is not available for public use, except the aggregated emissions. I estimated emissions using the published emission factors (provided by the companies) by Maersk for all other companies. Since I lack detailed data for each production process, it was **impossible** to use detailed engineering calculations. Wherever I found the required detailed data, I used such measures appropriately.

3.3.1 EXPLORATION AND PRODUCTION

Oil exploration began in 1935 in the Dukhan field, and commercial production started in 1940. Since the mid-1990s, the dynamics of the oil and gas sector changed considerably. The government partnered with international oil and gas companies to increase oil and gas production by developing a policy of exploration/production-sharing agreement (E/PSA). In 2013, there were five companies and seven (PSAs) involved in the production of offshore fields as shown in the table below. The total production from the PSA/EPSA operators was 63%, and QP takes a share of 37%, respectively.

In 1971, huge gas deposits were discovered on the northeast shore of the Qatari peninsula with total proven reserves of 900 trillion standard cubic feet (tscf), which is considered to be the largest single non-associated gas reservoir in the world covering an area of 6000 sq.km. The first commercial exploration of the North Field started in late 1991, which is dubbed the North Field Alpha (NFA). In 2013, the total NFA production achieved was 283 billion standard cubic feet (bscf) of gas and 8.24 million standard cubic feet of stabilized condensate. The Al-Khaleej Gas Project (AKG) operated by Rasgas utilizes the North Field’s reserves to supply gas to domestic consumers. In 2013, the AKG’s total 28.1 million barrels of condensate. The Dolphin Project entails the development of North Field reserves for the production of wellhead gas. The Barzan Gas project is expected to supply 1.3bscf/d of gas by the end of 2014. The gas is sent to the natural gas liquid plants and refineries located in the Messaeid and Ras Laffan Industrial City. The refinery products are sold to domestic consumers and exports via subsea pipelines and liquefied products via cargo ships. In the mid-1990s the crude oil production was

400,000 barrels per day and reached up to 840,000 barrels per day in 2010, since then, the crude oil production has declined gradually. Qatar oil export is significantly less compared to natural gas production, exports and its market share in the global market. In 2015, Qatar exported 497,000 barrels per day of crude oil; while Saudi Arabia exported 7,163,000 barrels per day.

Field	Operator	Total Drilling Wells	Total Production, Million barrels
Al Shaheen	Maersk Oil Qatar	15	110
Al Rayyan	Occidental Qatar Energy Company	7	78.4
Al Khalij	Total E&P Qatar	30	184.3
Idd El Shargi North Dome	Occidental Petroleum of Qatar	-	-
Idd El Shargi South Dome	Occidental Petroleum of Qatar	-	-
Al Karkara and A-Structures	Qatar Petroleum Development Company	-	-
El Bunduq	Bunduq Company Ltd.	-	-

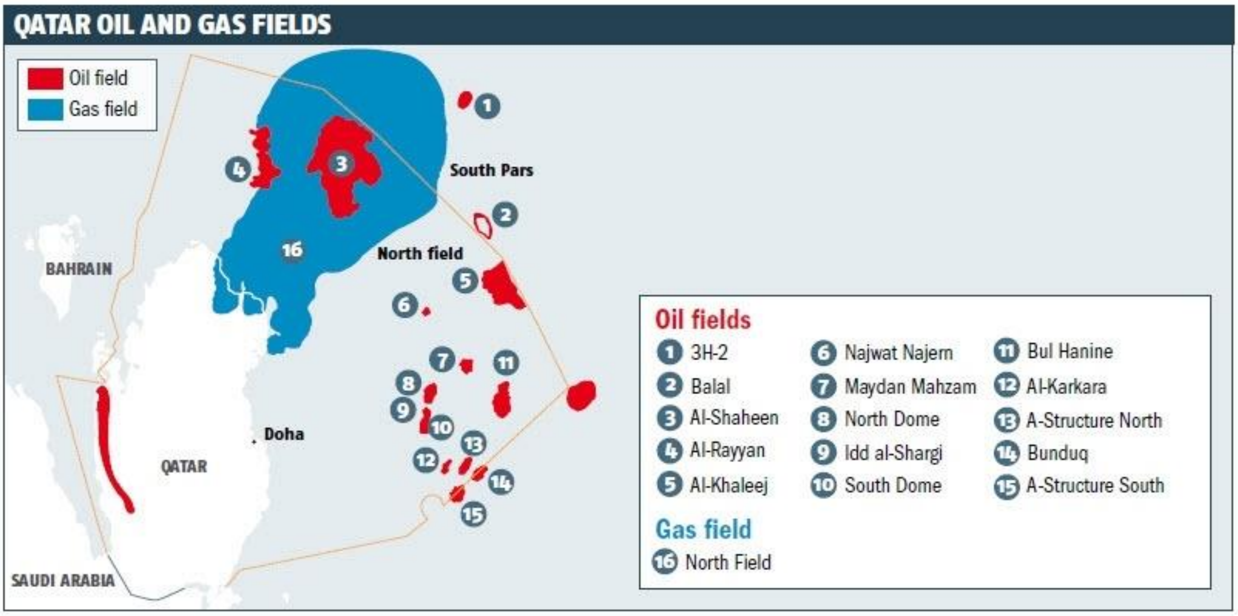


Figure 3.15 Qatar oil and gas fields (Source: EIU)

Methodological Issues

After the exploration and identification of potential oil and gas reserves using geophysical surveys and testing wells, the extraction process begins from the underground reservoirs. The possible sources of emission are from combustion from drilling operations, venting and flaring of gas during well testing and completions. Because of a lack of detailed data, I report emissions only from the combustion sources; emission from venting and fugitive sources is ignored. The possible sources of combustion are stationary, mobile and indirect (see figure 3.16). Chief among the stationary sources is – boilers/steam generators, turbine electric generators, combustion engines, flares, etc. CO_2, CH_4, and N_2O are the most common greenhouse gases emitted during oil exploration and testing as shown in the figure below. During production, CO_2 is the major source of emission, CH_4 and N_2O emission result during incomplete combustion. Nonetheless, CH_4 and N_2O are insignificant during the combustion process compared to CO_2. Besides, NMVOC, CO, SO_2, NOx, black carbon are also emitted. Some companies report oxides of nitrogen and sulphur emissions; whereas, other short-lived emissions are not reported.

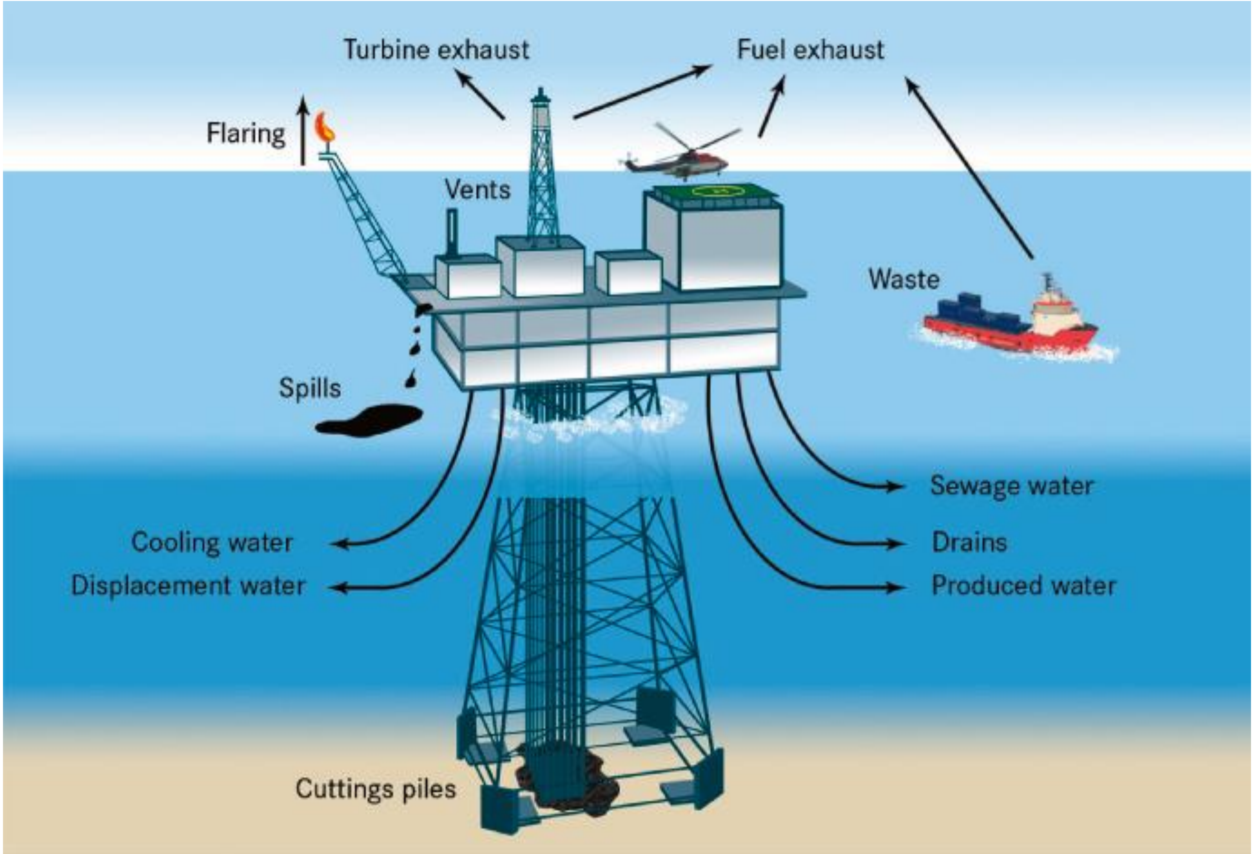


Figure 3.16. Emission released from a range of sources (Source: OSPAR) http://qsr2010.ospar.org/en/ch07_01.html, accessed 20th November 2015

Activity Data

This section is extremely challenging compared to the other sections because of a lack of data availability. Except Maersk Oil Qatar (MOQ), other companies did not provide any relevant information about production quantity, emissions resulting from combustion, venting, flaring and others. I used MOQ's averaged emission factor to estimate emissions from the oil sector to avoid overestimation of emissions. In the last few years, the GHG emission intensity per unit of oil production declined significantly, especially in the case of Oxy Qatar and Maersk Oil Qatar (see section 9). Based on the two company's track record of flaring emissions, 12.5% of overall emissions have resulted from venting and flaring alone. I used the same factor to estimate overall flaring emission from oil production.

The data for active drilling and testing wells were taken from the OPEC database. The OPEC database is one of the reliable sources of information regarding oil and gas production data. I assumed the number of wells drilled and tested was the same.

I obtained the number of active wells and production data from the OPEC database as shown in the figures 3.16-3.17. Emissions are calculated by multiplying the amount of activity data (such as active drilling wells) by respective emission factors.

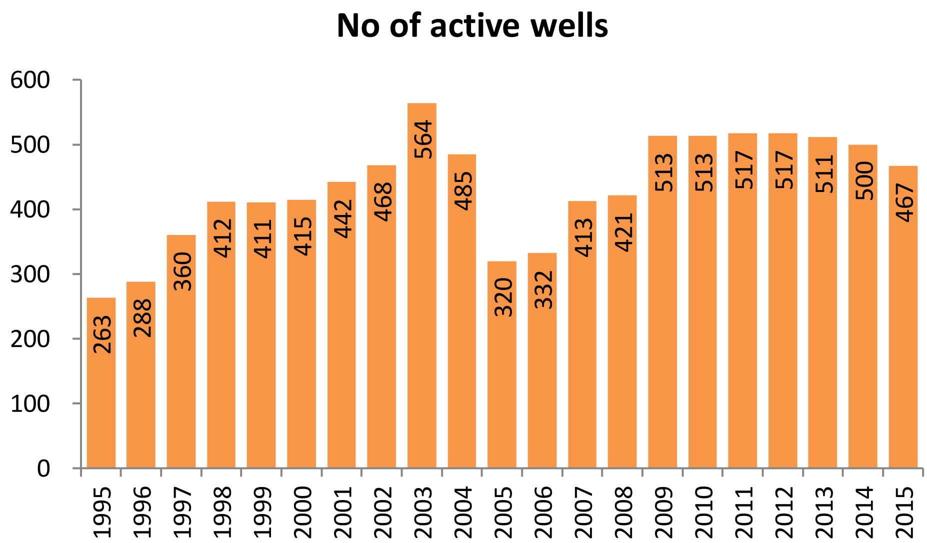


Figure 3.16 Number of active oil producing wells.

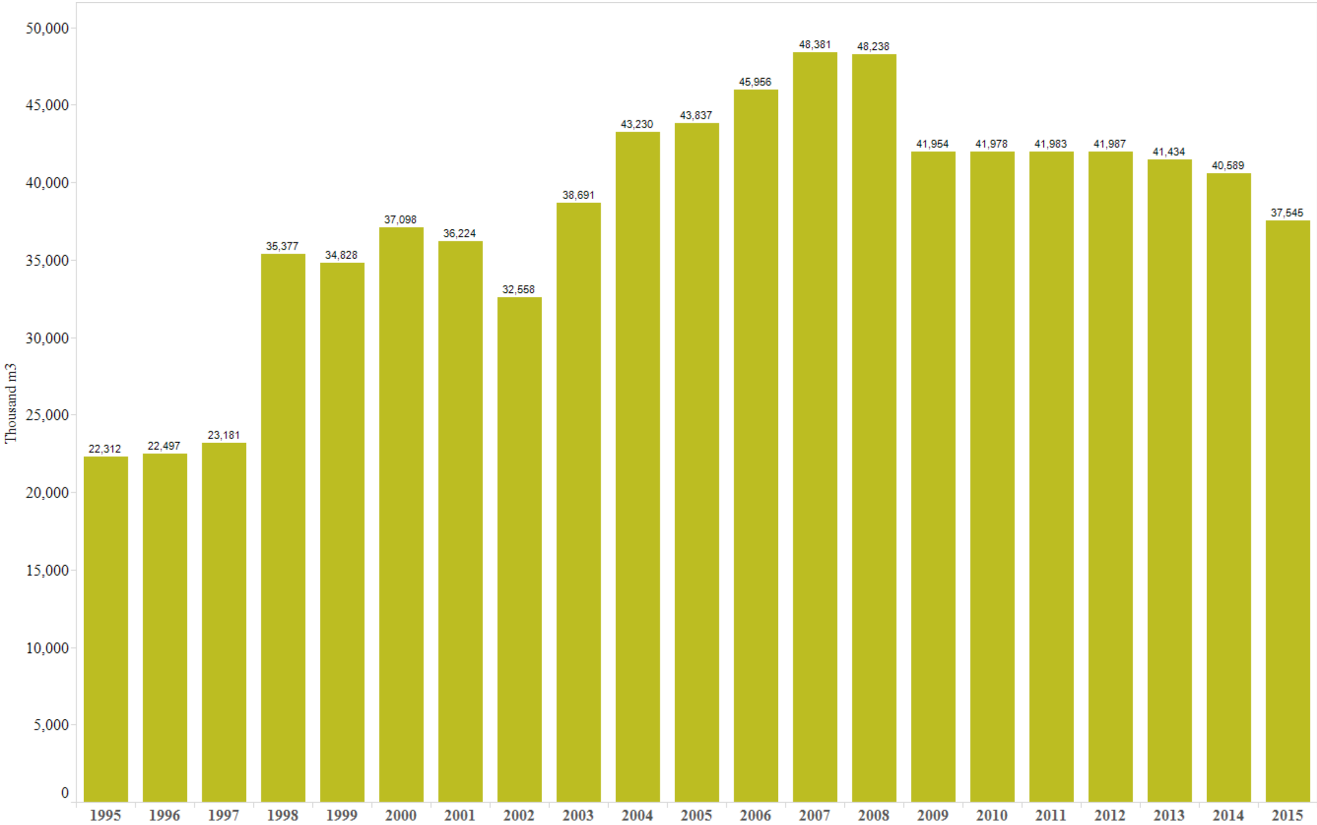


Figure 3.17 Oil production from 1995 to 2015

Emission Factors

All emission factors for exploration of oil were the default values from the IPCC Report (2-6, page 112). The default value for conventional crude oil given in the GPG (2000) was used for the emission factor instead of the facility data given in the individual company's sustainability report. In future inventories, I hope to use the Tier-3 method of obtaining facility data from all the companies.

	CO_2	CH_4	N_2O
Drilling	0.1	0.033	0
Testing	9	0.051	0.000068

Emission factors for exploration, drilling and testing wells (All emission factors are in Tonnes/10^3 m^3)

Emission factors for oil production is taken from the Maersk sustainability report and used to estimate the overall production in Qatar. Emissions declined gradually in last few years. This is mainly because of two reasons. First, oil production has declined and the wells are matured despite enhanced oil recovery methods in the offshore fields. Second, the emission factor declined from 138 tonnes CO2eq per thousand m^3 (Tonnes/10^3 m^3) of oil production in 2009 to 91.13 t/10^3 m^3 in 2014. I used the 2009 emission factor to estimate emissions for earlier years.

Figure 3.18 shows the total emission from oil production, including exploration and testing. In the last few years, the emission was constant because of stable oil production.

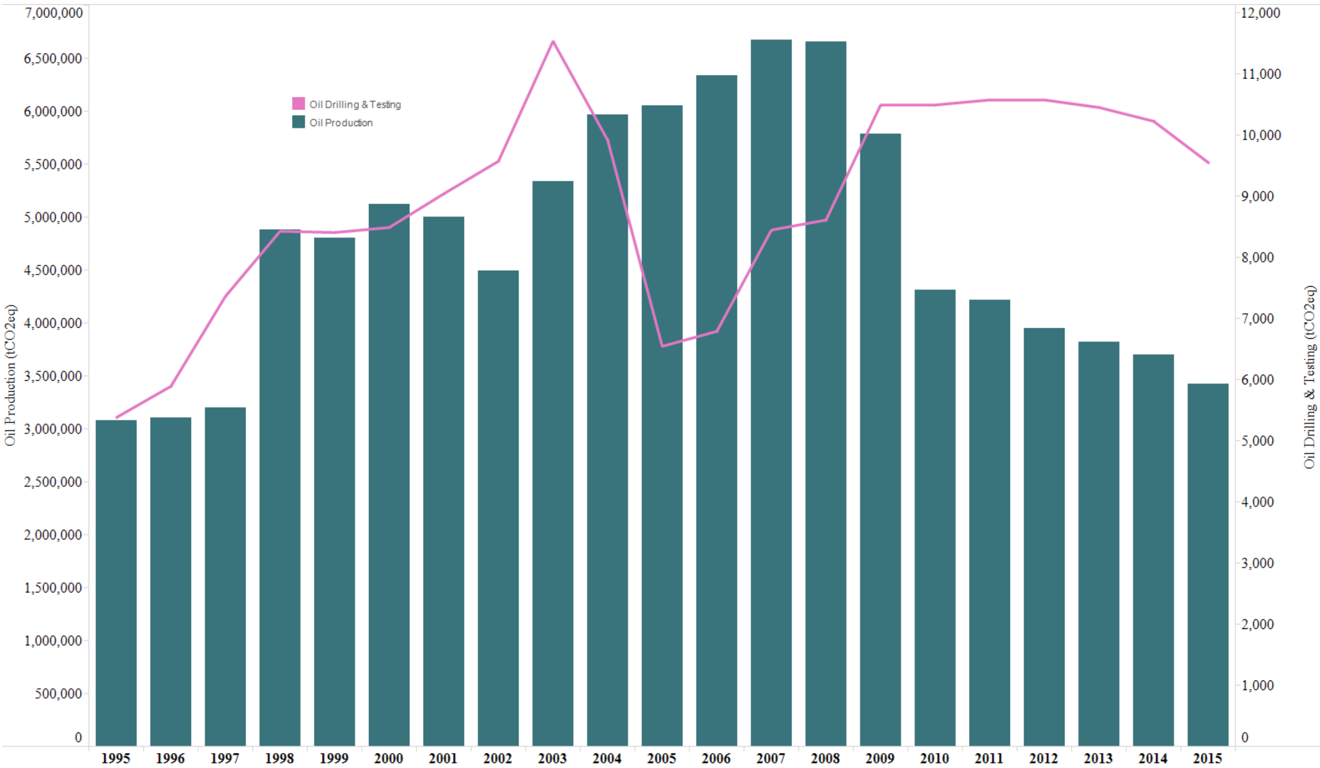


Figure 3.18 Emission from oil production between 1995 and 2015

3.3.2 REFINING

The crude oil and natural gas extracted from onshore and offshore fields is transported to the refineries through pipelines based in Dukhan, Mesaieed and Ras Laffan Industrial City. The main activity of the refinery is to process crude oil and condensate into various marketable products which can be easily transported in liquid forms. The main finished products are liquefied petroleum gas (LPG), naphtha, premium and super gasoline, jet fuel, diesel, decant oil and fuel oil. There are conflicting reports about the total output of the refineries. The authoritarian source, Joint Oil Data Initiatives – JODI- reports the total output of 23.89 million tonnes of refinery products. In the refining category, I used only QP Refinery located in Messaied and Dukhan.

The main source of direct emission is from the combustion sources including, boilers, gas turbines, incinerators (sulfur recovery unit, tail gas treatment unit) and flaring. Very few companies report disaggregated emissions and based on the reports, over 75% of emission is from the combustion process, with an average of 10-15% from flaring and the rest from sulphur recovery units and process emissions. However, these numbers vary from one facility to another. For the sake of this report, I consider the above figures.

The first **QP Refinery plant** started operation in 1958 as a small toppling plant and grew into a massive complex refinery plant over time. Since 1983, the refinery capacity has remained constant until 2001, producing an average of 63,000 b/d. With the growing demand for oil products in the country, Qatar Petroleum expanded the refinery facility in early 2000. The refinery capacity increased to 137,000 b/d. Qatar Petroleum has gas refineries too, producing lean gas, condensates, propane, butane and other hydrocarbon products. Unfortunately, the data is inconsistent in all the authoritarian data sources. Therefore, emissions were excluded from the gas operations.

In addition to crude oil refineries, Qatar built one of the largest condensate refineries in the world with a total production capacity of 146,000 b/d. The Laffan refinery has a production capacity of 61,000 b/d of naphtha, 52,000 b/d of kerojet, 24,000 b/d of gasoil, and 9,000 b/d of liquefied petroleum gas. Laffan Refinery 2 is under construction and expected to be fully operational by 2016, which will be able to process an additional 146,000 b/d. The total processing capacity would increase up to 292,000 b/d. However, these are managed by other companies, not included in the refinery sector.

Complex distillation is used to distil and separate valuable distillates such as naphtha, kerosene, petrol, diesel from the crude feedstock. After the preheating and dehydration process, the crude is flashed in different temperatures in the atmospheric distillation column as shown in the figure below. Various products are drawn from different layers of the column as shown in figure 3.16. Catalytic cracking, reforming, hydrocracking and hydrotreating are the most common methods used in the extraction of oil products.

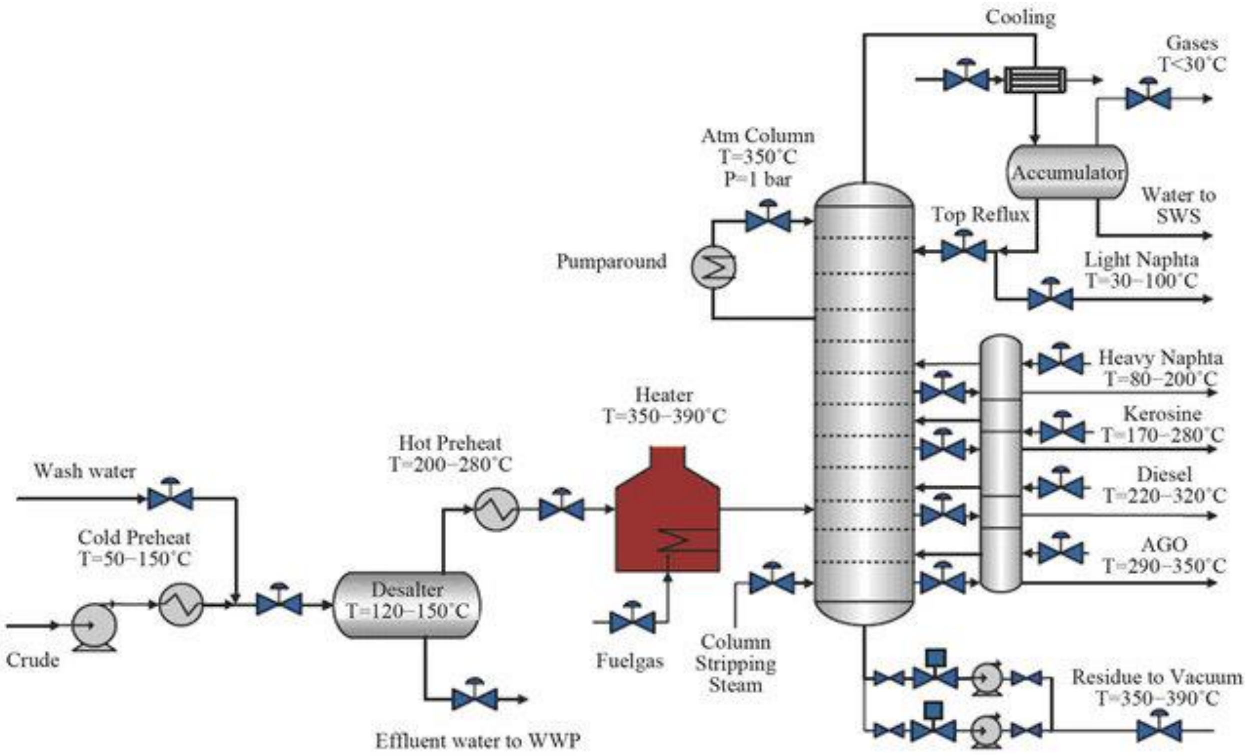


Figure 3.19 Crude oil distillation unit (http://file.scirp.org/Html/7-3700155_30523.htm)

Activity Data

The refinery output is highly contradictory. Different databases reported different values. The ASB reported refinery output until 2010 and from 2011-2015, I used QP annual reports and verified the information with the international databases such as JODI and OPEC. The disaggregated output of the refinery is shown in figure 3.20. As outlined before, I estimated only for oil refinery output. There is no consistent reporting of the volume of condensates and other hydrocarbon products.

Emission Factor

As discussed earlier, the oil sector is the least transparent of all the sectors. So far, there is only one sustainability report published by Qatar Petroleum in 2015. The report contains very limited information. The report contains GHG emissions of 2014 from the QP refineries. I used 0.188 tonne of CO_2eq for every ton of refinery output for the period 1995-2015. It is clearly evident, in the earlier years that the emission factor would be much higher because only in last few years were many new initiatives put in place to minimize GHG emissions. The emission from the oil sector, in general, is highly unreliable compared to other sectors. Emission was relatively stable until 2001 and increased since then because of an increase in refinery capacity.

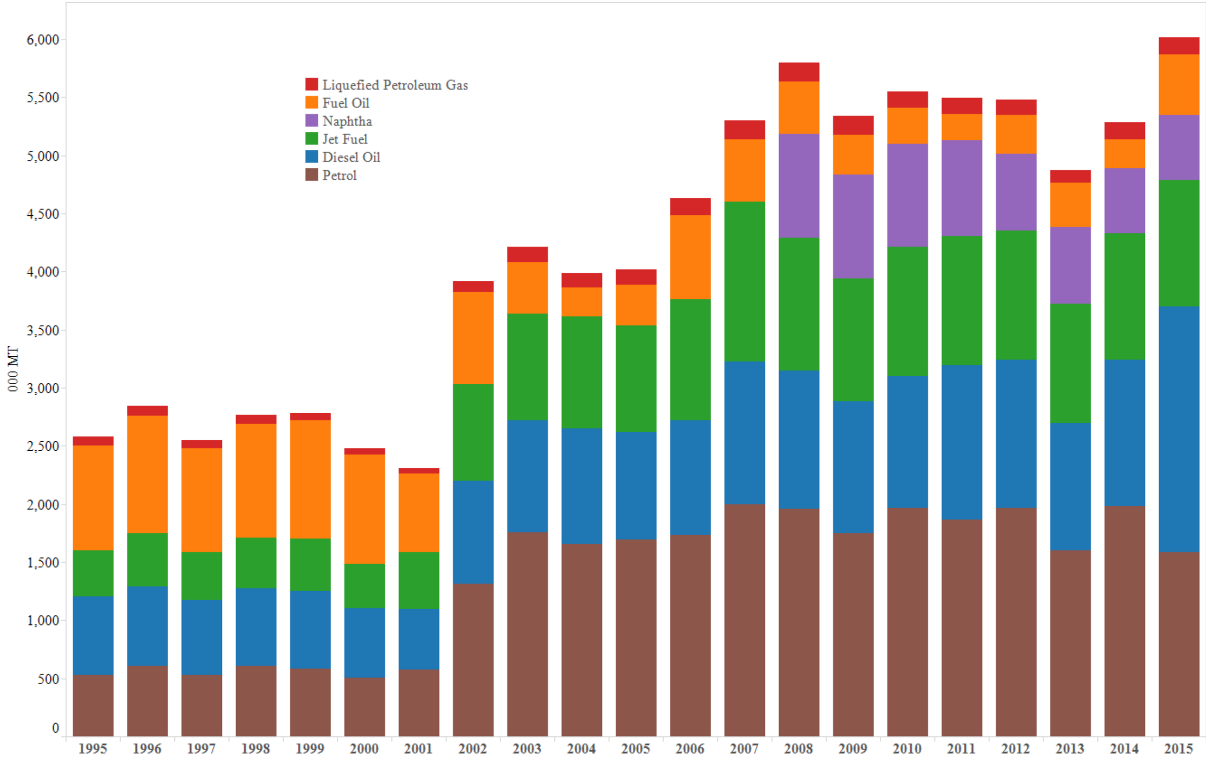


Figure 3.20 Refinery output from QP (Source: Author, data collected from the ASB, QP Annual Reports; cross checked with JODI and OPEC)

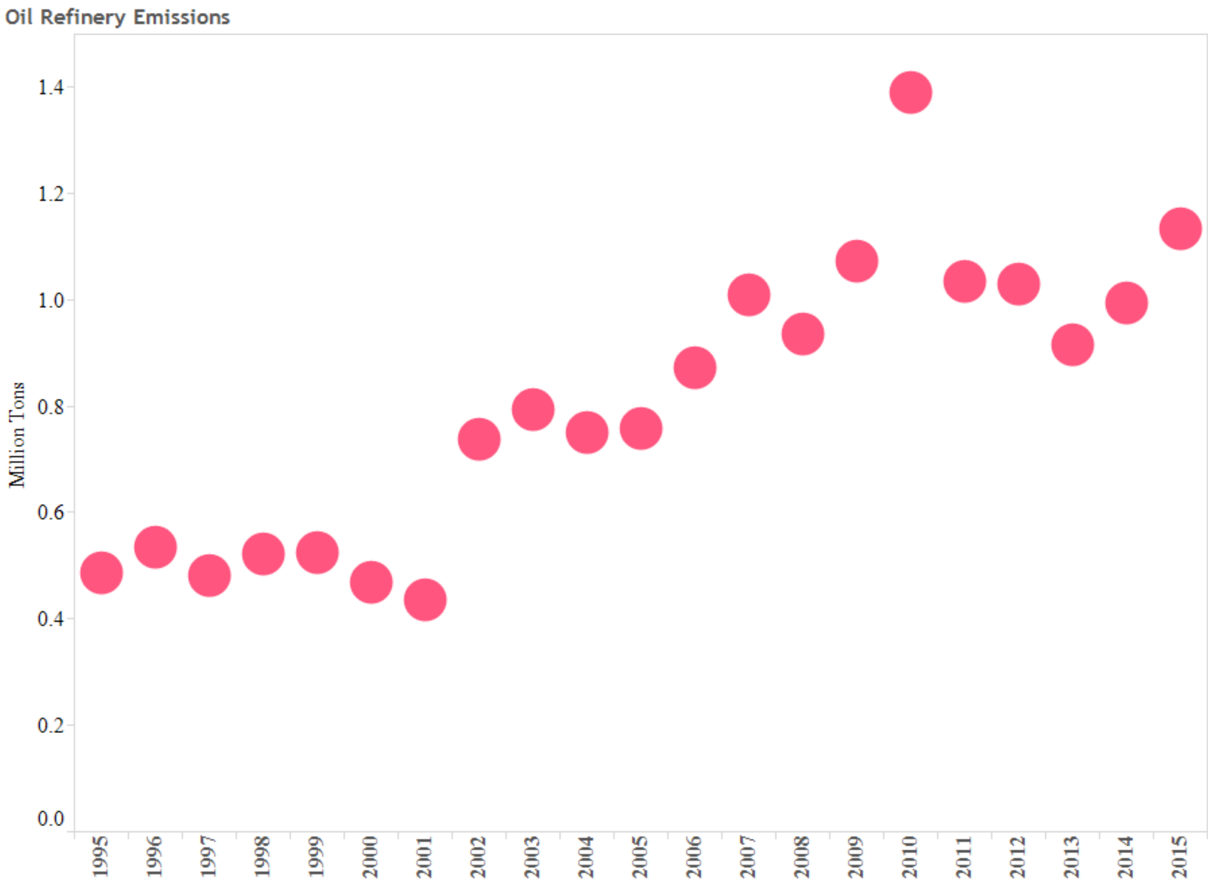


Figure 3.21 Emissions from oil refinery between 1995 and 2015

3.4 NATURAL GAS

In 2015, the natural gas sector alone contributed 55.43 million tonnes CO_2equivalents, which is half of the total national emissions. Emissions from this sector contributed 71 percent to the total energy sector and 52 percent of total national GHG in 2015. Over the last two decades, emissions from the natural gas sector increased significantly because of the rapid development & expansion of LNG trains and construction of new GTL and gas processing facilities. Between 1996 and 2015, the emission from this sector increased by 892 percent. The highest recorded growth of emissions was between 2009 and 2012, with an annual average of 28 percent, compared to average annual growth of 14 percent during the period 1996-2015. This is mainly due to two reasons: first, Rasgas and Qatargas successfully completed the construction of mega trains and these came into full operation in successive years between 2009 and 2011. Second, Shell GTL started its first phase of its new plant in 2011 and the second phase in 2012. The major investment in flaring reduction resulted in the decline of emissions by 2.8 percent in 2014 against 2013. Emissions will slightly decline in coming years when the current initiatives are in force. In 2015, the LNG sector alone contributed 78 percent (45 % and 33% by Qatargas and Rasgas, respectively) of total natural gas sector emissions, followed by the GTL sector with 17 percent.

Methodological Issues

Description

Qatar has the third-largest natural gas reserves in the world and is the second largest exporter of natural gas. For the tenth year in a row, Qatar is the largest exporter of LNG in the world. From 2012, Qatar also became one of the largest producers and exporters of GTL products.

There are five companies; two companies produce LNG and GTL products each, and there is a gas processing facility. Unlike the conventional reporting procedure, I differed in my approach in reporting the emissions. I combined combustion and fugitive emissions, the latter include flaring and venting. On average, 75-80% of emissions result from fuel gas combustion, heaters, and incinerators; and 20-25% from flaring and venting. I reported CO_{2eq} emissions because of a lack of disaggregated data from all companies. Except for Rasgas, no other companies have reported CH_4 and N_2O emissions. Based on the Rasgas data, nearly 99 percent of emissions are CO_2, and 0.098 and 0.002 percent is CH_4 and N_2O emissions. Additionally, none of the companies made any serious attempt to report NMVOC emissions. To maintain consistency, I report CO2eq emissions for the entire natural gas sector.

LNG Production

Currently, there are two LNG producers in Qatar – Qatargas and RasGas. Each has seven trains built during different periods. By the end of 2010, the total LNG capacity reached 77 million tonnes per annum (MTPA). Qatargas was established in 1983 and its first cargo shipment was in 1996. Emissions increase sharply from one year to another as the number of trains came into operation. Over the last five years, the LNG producers have reported annual emissions in their sustainability report.

Liquefied natural gas (LNG) is produced by turning the gas into a liquid state by refrigerating it to a temperature of about -162°C at atmospheric pressure, thereby, reducing the volume by a factor of more than 600 making it easier to ship long distances. The LNG composition is typically 95% methane, and 5% other hydrocarbons (ethane, propane, and butane) and nitrogen). The liquefaction process happens in following steps:

a. Natural gas is extracted from the 85 wellheads in the North Field, transporting 7,300 MMScf from nine offshore platforms to the seven onshore LNG trains via subsea pipelines.
b. The feed gas is received in a common reception, operated and maintained by Qatar Petroleum or other entities distributing to all companies
c. The raw natural gas is treated to remove all non-hydrocarbon components such as carbon dioxide, mercury, sulfur compounds and water.
d. The processed gas is passed through a series of liquefaction stages such as pre-cooking, liquefaction and sub-cooling until it reaches the required temperature. The chilling process happens through refrigerants.
e. The LNG is stored, loaded and distributed through LNG terminals and ships.
f. The by-products such as sulphur and condensate are supplied to other companies in the Messaeid or Ras Laffan Industrial City or shipped to the global market.

This process continues for each train as shown in figure 3.22. This process is similar to Rasgas. The emission results are mostly from:

a. Fuel gas combustion to power refrigeration compressors
b. Fired heaters, flares, incinerators
c. Venting of low pressure carbon dioxide
d. Fugitive losses of natural gas from the process due to leakage
e. Controlled and uncontrolled flaring

The emissions reported in this section are not only limited to the LNG production from Qatargas and RasGas, but also includes Laffan Refinery (operated by Qatargas) and Al-Khaleej Gas Project (operated by RasGas). Besides LNG, many other hydrocarbon products are produced by these companies as shown in figure 3.23. So, I limit the emission from the onshore process and loading.

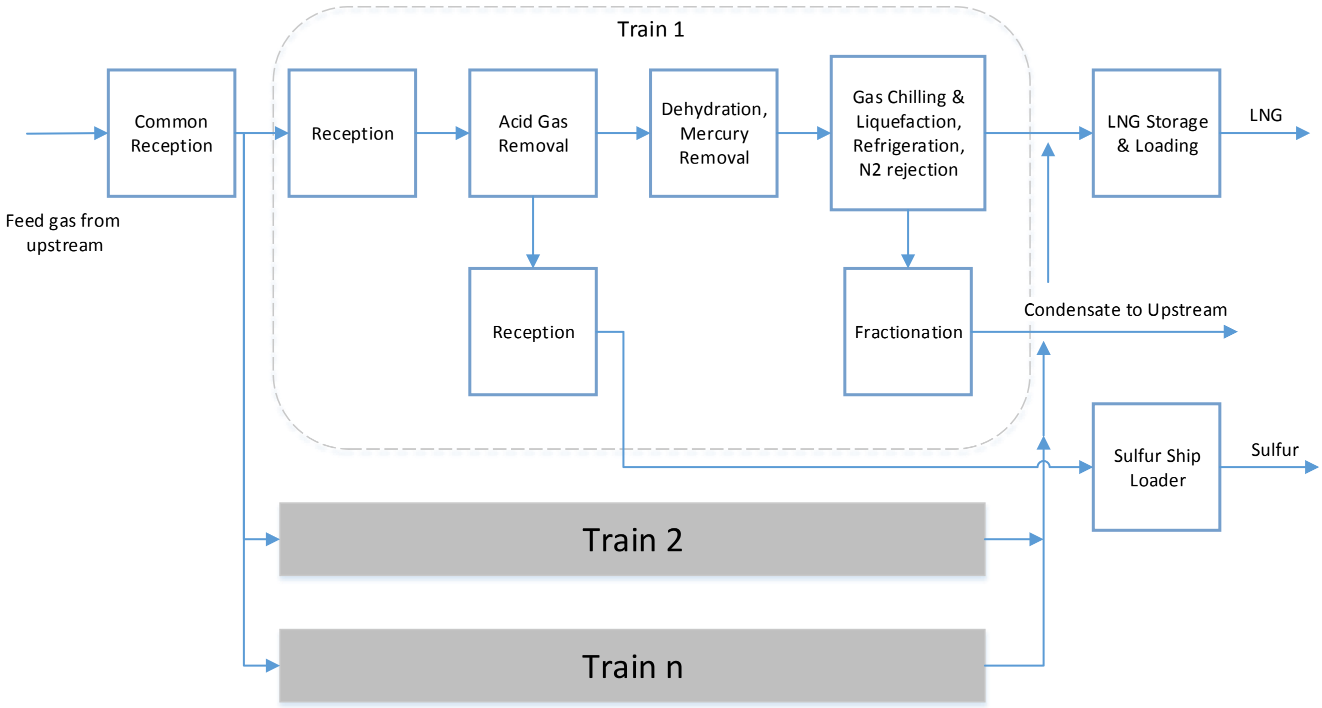


Figure 3.22 Block Diagram of Qatargas' LNG Process

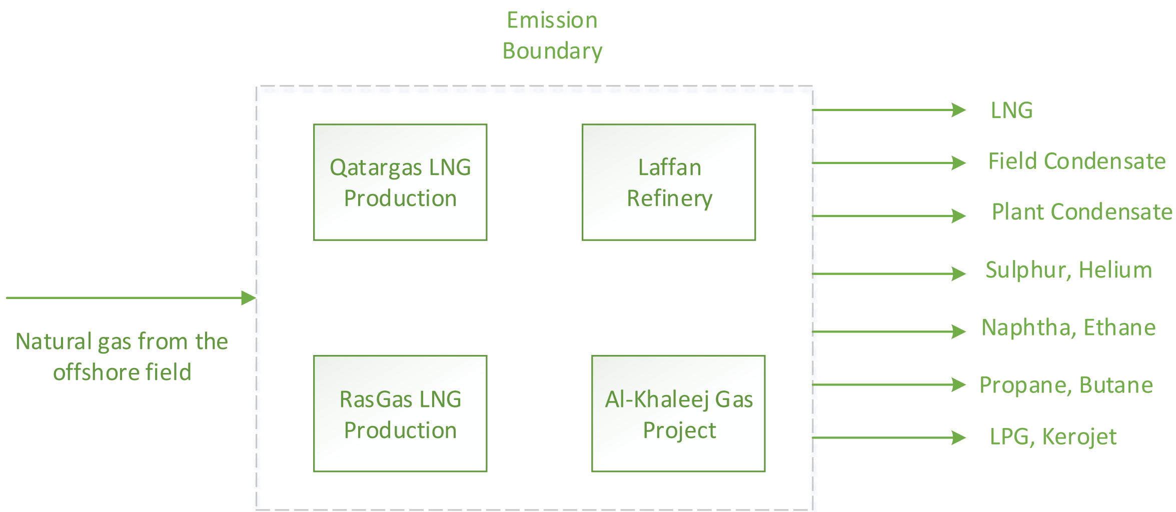
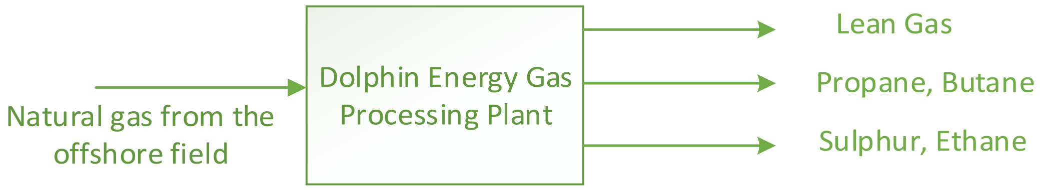


Figure 3.23 Emission boundary of Qatargas and Rasgas

Lean Gas Production

Dolphin Energy uses 2.36 bscf of raw (wet) natural gas per day from the North Field transporting it via subsea pipelines to the onshore gas processing facility. The plant produces 730 bscf lean gas per annum and other by-products including propane, butane, ethane, sulphur and condensate. The lean gas is compressed to reduce volume and exported via subsea pipeline to Abu Dhabi. Other hydrocarbon products were sold locally to the companies as a petrochemical feedstock or exported to other countries. The company started its operation in 2007 and full production in 2008.



GTL Production

Oryx GTL was established in January 2003 and came into full operation in 2007 and it is Qatar's first gas-to-liquids (GTL) plant. The Plant converts Qatar's North Field natural gas into high quality GTL products, including diesel, naphtha, and liquefied petroleum gas (LPG). The ORYX GTL production facility has two trains in operation, with a production capacity of 32,441 barrels per day (bbl/d) as shown in figure 3.20.

The production process is as follows:

a) Raw natural gas feedstock is extracted from the North Field and transmitted to the LNG facilities in Ras Laffan (Al-Khaleej).
b) After desulphrization, natural gas is fed to the GTL plant, 96% of the gas is used as feedstock for syngas production, and the rest is used as fuel
c) Synthesis gas is produced through reforming the oxygen and methane in an autothermal reforming unit.
d) The produced syngas is fed to the *Fischer-Tropsch (F-T)* unit.
e) The long -chain paraffin hydrocarbons produced are cooled and separated into tail gas, wax, hydrocarbon condensate and reaction water. Tail gas is sent for further hydrocarbon recovery; whereas, hydrocarbon condensate and wax are sent to the hydrocracking unit (which uses Chevron catalysts).
f) Product from hydrocracking is routed to a series of flash vessels to separate liquid and vapour phases. Vapour is recycled and liquid is fractionated and treated into final products (naphtha, diesel, LPG, etc.).

Pearl GTL

In 2006, the Qatar government decided to advance its GTL facilities by awarding a contract to Shell. The Pearl GTL project started its production in 2011, the output from the first train was 70 thousand b/d and the second train came on stream in 2012 yielding 140 thousand b/d of GTL with an additional 120 thousand b/d of condensate and dry gas. Pearl GTL uses natural gas to convert products like LPG, naphtha, jet fuel, diesel and heavy oils. This plant is similar to the Bintulu GTL plant in Malaysia as shown in figure 3.25.

The production process is almost similar to the ORYX GTL process, except for the kind of catalysts used and the production process for syngas is different.

a. The production of synthesis gas (syngas) – Shell Gasification Process
b. The conversion of syngas into heavy paraffins – Heavy Paraffin Synthesis
c. The conversion of paraffins into middle distillates – Heavy Paraffin Conversion

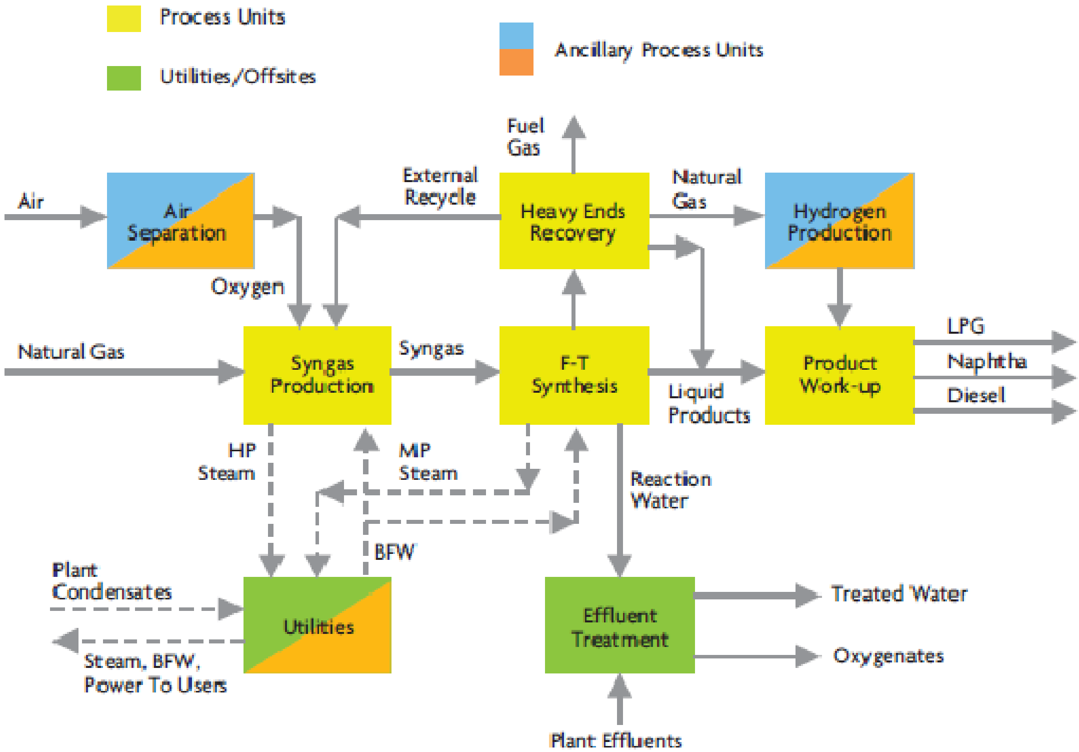


Figure 3.24: Oryx GTL production process

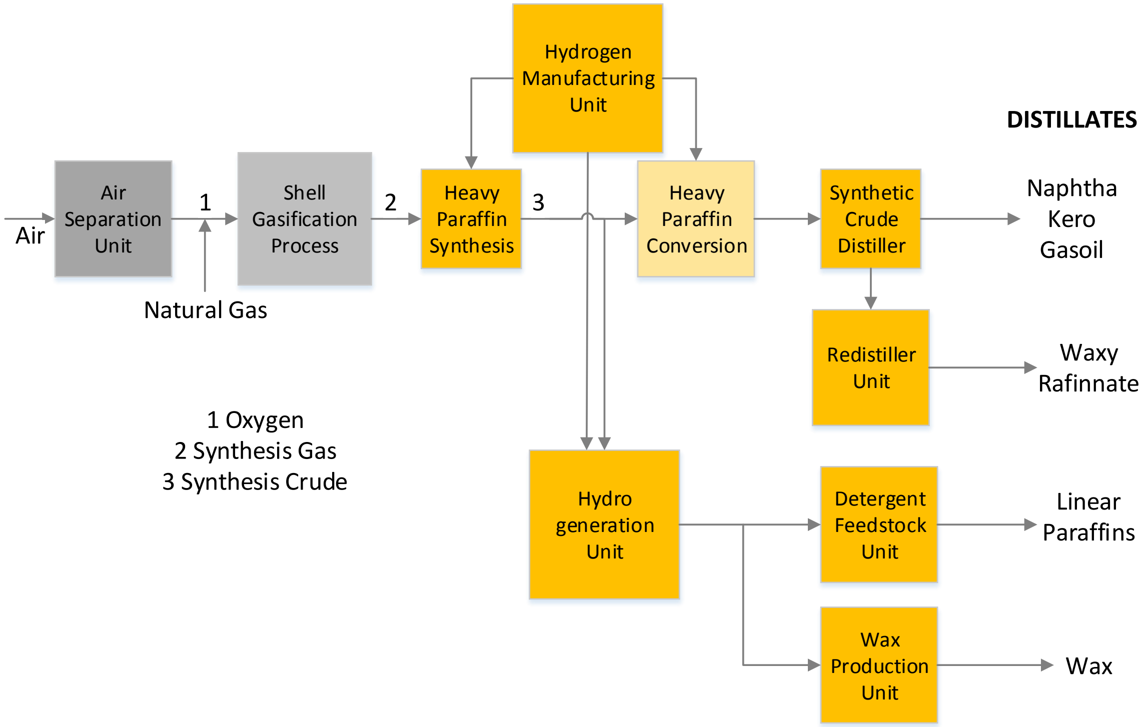


Figure 3.25. Complete block scheme of Shell GTL project in Bintulu (the same process is used in Pearl GTL Qatar)

Activity Data

I have taken production data from the Annual Statistics Bulletin, sustainability reports and directly from the companies. LNG production has changed significantly from 9.9 to 77 mtpa between 1996 and 2011, and since then LNG production has remained constant. Similarly, after the completion of the GTL facilities, production remained constant. There was no major expansion in last five years. Production from the four companies increased from merely 10 million tonnes to 140 million tonnes as shown in figure 3.26

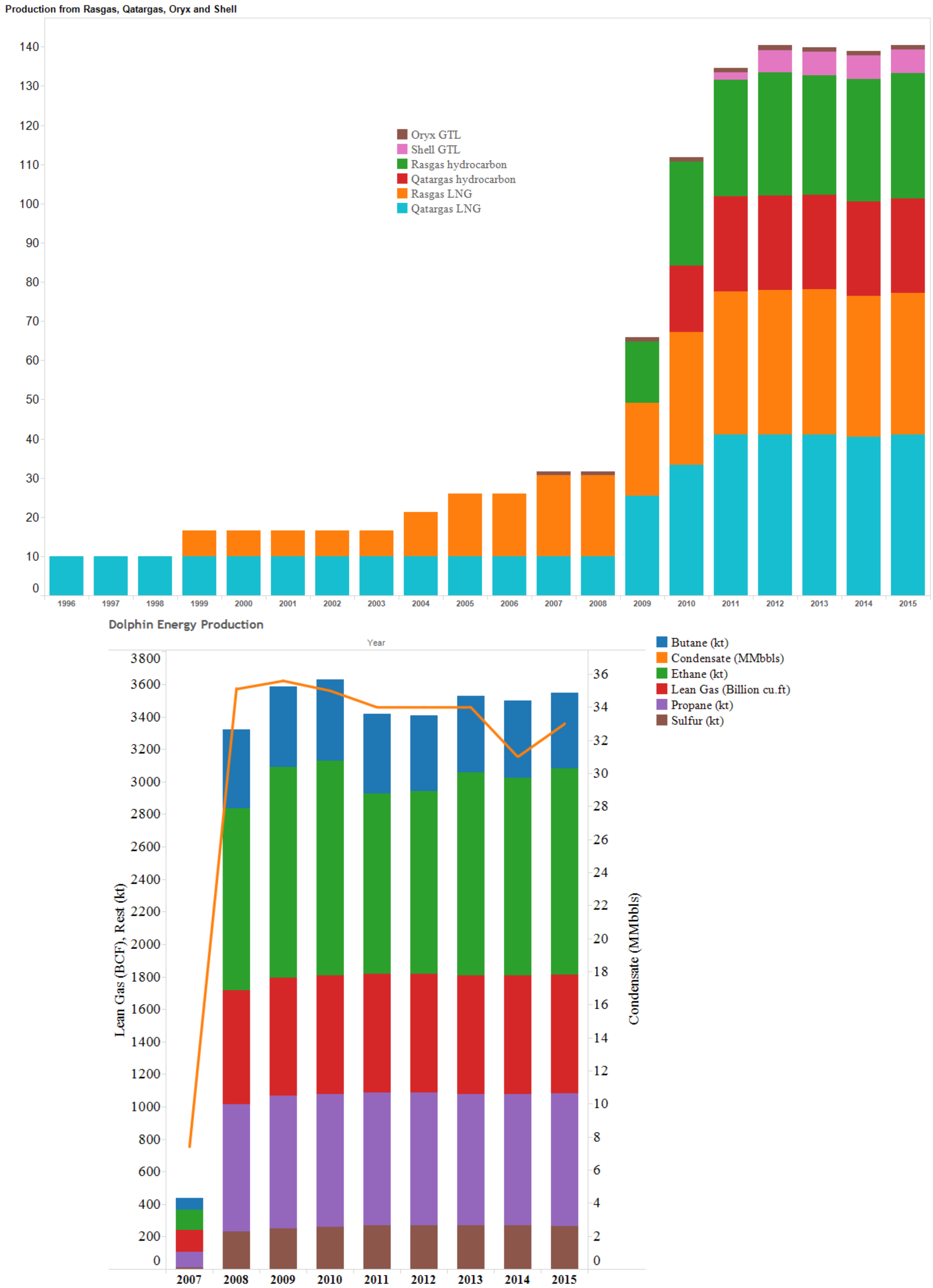


Figure 3.26 Production data from various natural gas processing facilities (BCF – Billion cubic foot; MMbbls –Million Barrels; kt – KiloTonnes)

Emission Factor

It is impractical to use the Tier-3 method to estimate emissions because of the lack of detailed data. Instead, I used the Tier-2 method or the Emission Factor (EF) method to estimate emissions for the natural gas sector. For the years 2007-2015 the data used in the inventory are emissions reported directly by the field operators in their annual sustainability reports. The CO2eq emission factor used for all years leading up to 2007 and for all fields was the earliest emission factor. For instance, I used the 2010 emission factor of Qatargas to estimate emissions from 1996 to 2009 because, it is only in recent years that new emission reduction initiatives were implemented, most notably, flaring reduction. The reader must keep in mind that all of these plants were built in the last two decades; they are very efficient and implemented advanced equipment and process systems.

$$CO2eq = \Sigma \text{Actvity data} * \text{Emission Factor}$$

GHG Emission Intensity	Unit	Previous Years	2011	2012	2013	2014
Qatargas	tonnes CO2e/tonne of LNG Produced	0.56	0.49	0.46	0.47	0.43
Rasgas	tonnes CO2e/tonne hydrocarbon produced	0.29	0.29	0.28	0.27	0.27
Dolphin Energy	kT of CO2e/mmBOE	-	13.90	13.20	12.80	13.40
Oryx GTL	tCO2e/ barrel	-	0.23	0.16	0.15	0.15
Shell GTL	tCO2e/barrel	-	-	1.32	1.32	1.32

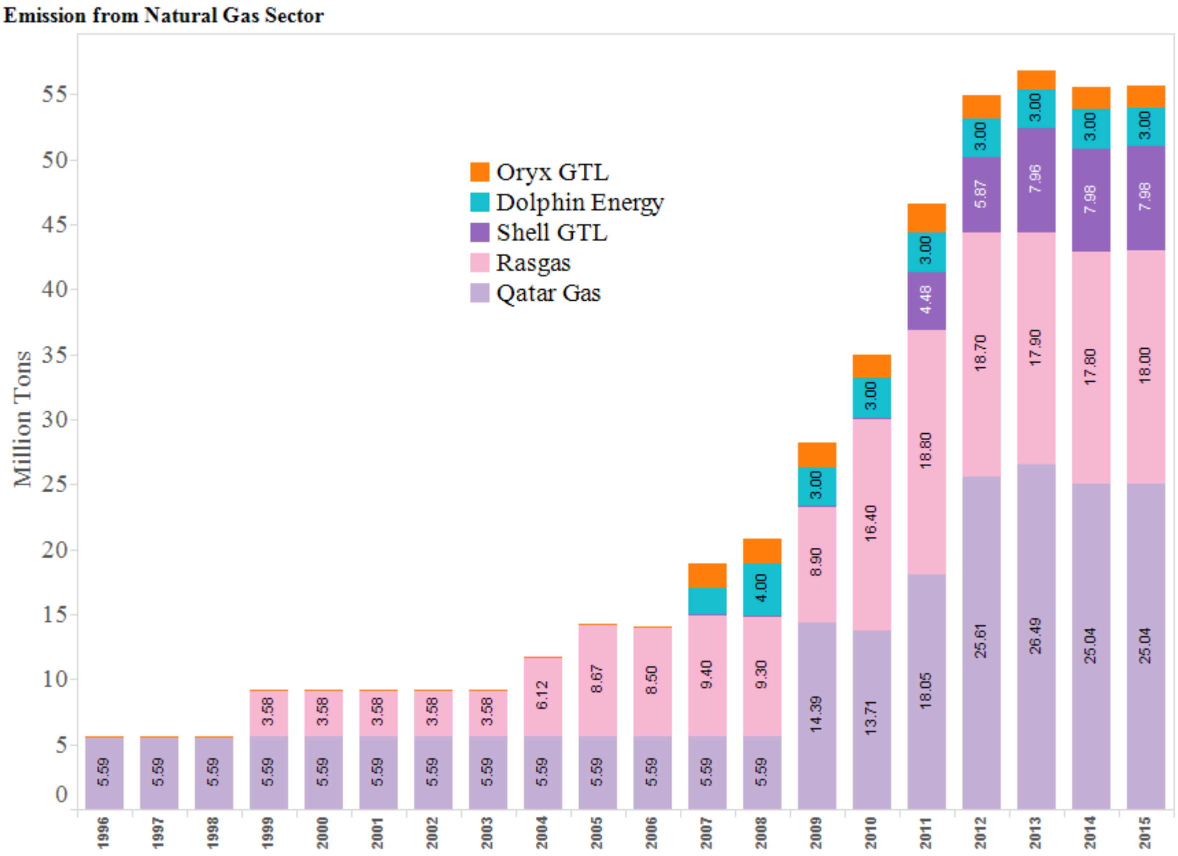


Figure 3.27 Emission trend of natural gas sector from 1995 to 2015

Uncertainties and time series consistency

The uncertainty for the activity data is less than 5 percent for all companies, except Shell GTL. The activity data in terms of production was attained directly from the companies. Based on judgment, the uncertainty for activity data of Shell GTL is l0 percent.

In the case of the emission factors for CO_2, the uncertainty is ±3 percent of the mean for Qatargas, ±2 percent of the mean for Rasgas, ±3 percent of the mean for Dolphin Energy and ±8 percent for Oryx GTL.

The production data for all the companies were reported in the annual reports of individual companies. It is thus assumed that time-series consistency is not seriously affected and that the emission trend is reliable.

4. INDUSTRIAL PROCESSES

Overview

In 2015, the total industrial sector contributed 30.53 million tonnes CO_2equivalent, which is 28 percent of the national emission inventory. In 2015, the petrochemical sector contributed 37 percent of the total industrial sector, followed by metal (30%) and mining (20%) and 14 percent from halocarbons. In last two decades, emissions increased from 4.4 million to 30.5 million tonnes. The average annual growth in emissions in the period 1995-2015 was 10 percent. A notable increase in emission happened in 2008 (21% compared to previous year) and 2011 (26%). The highest average annual growth was experienced in the mining subsector (16%) followed by metal (13%) and petrochemical (8.5%) respectively. This reflects the rapid growth and expansion of the industrial sector. On several occasions, I observed a significant jump in emissions from one year to another; this is due to expansion of existing production facilities and the establishment of new production units.

Since the late 1960s, the government has pursued economic diversification policies to reduce economic dependence on the oil and gas sector and develop a vibrant manufacturing sector. Despite substantial support from the government, the manufacturing sector remained weak for the next two decades. In the mid-1990s, along with development in the natural gas sector, the manufacturing sector was revived. The existing plants were expanded, and new industrial plants were built meeting the global demand for petrochemical products. With the availability of cheap feedstock and strong leadership, the manufacturing sector continues to gain a growing share of the national GDP. Between 1995 and 2014, the manufacturing sector grew over five times. In 2014, nearly 10 percent of the national GDP was from the manufacturing sector, and it has remained relatively constant for the last seven years.

y

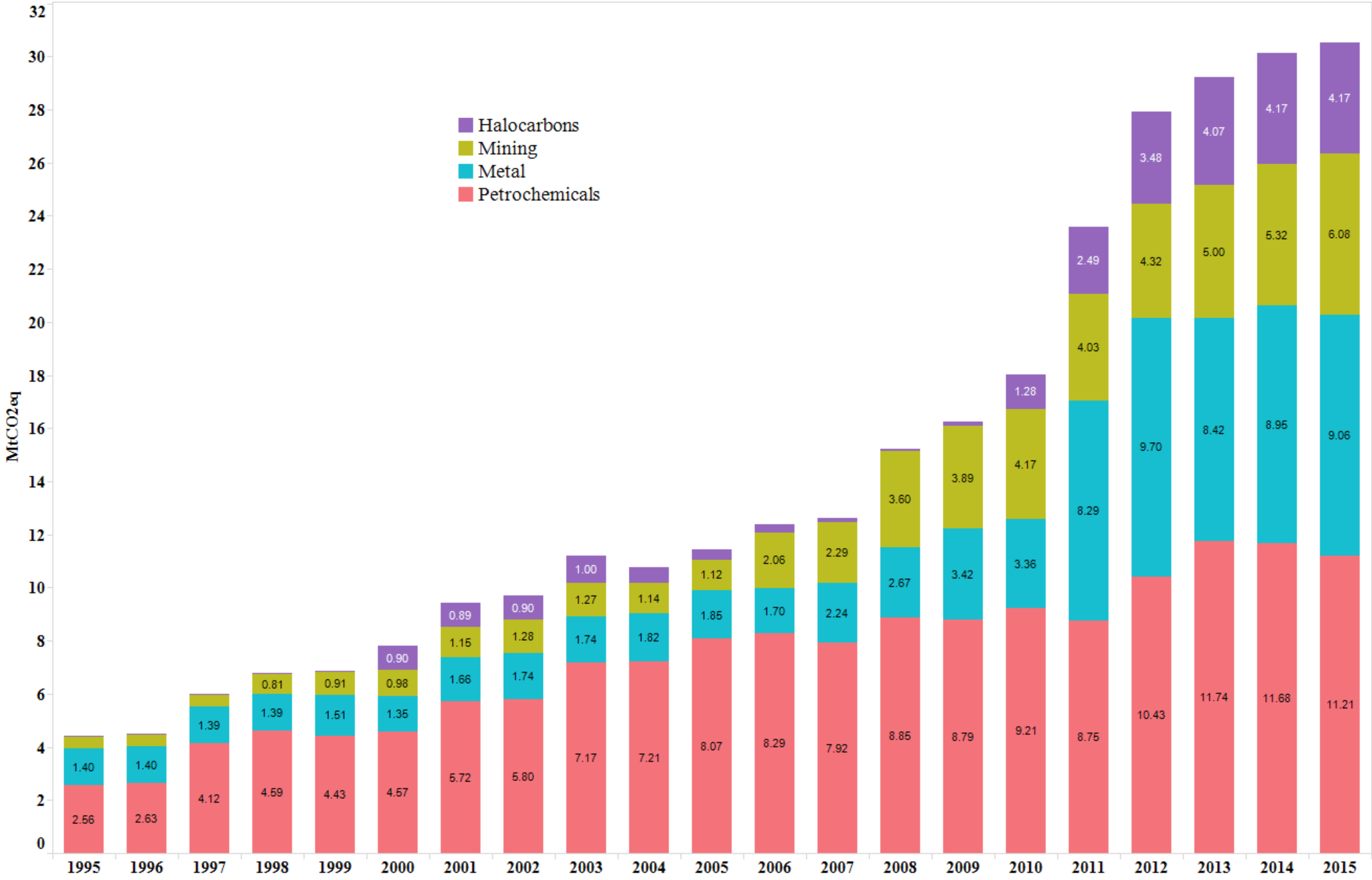


Figure 4.1 Emission trend from industrial sector between 1995 and 2015

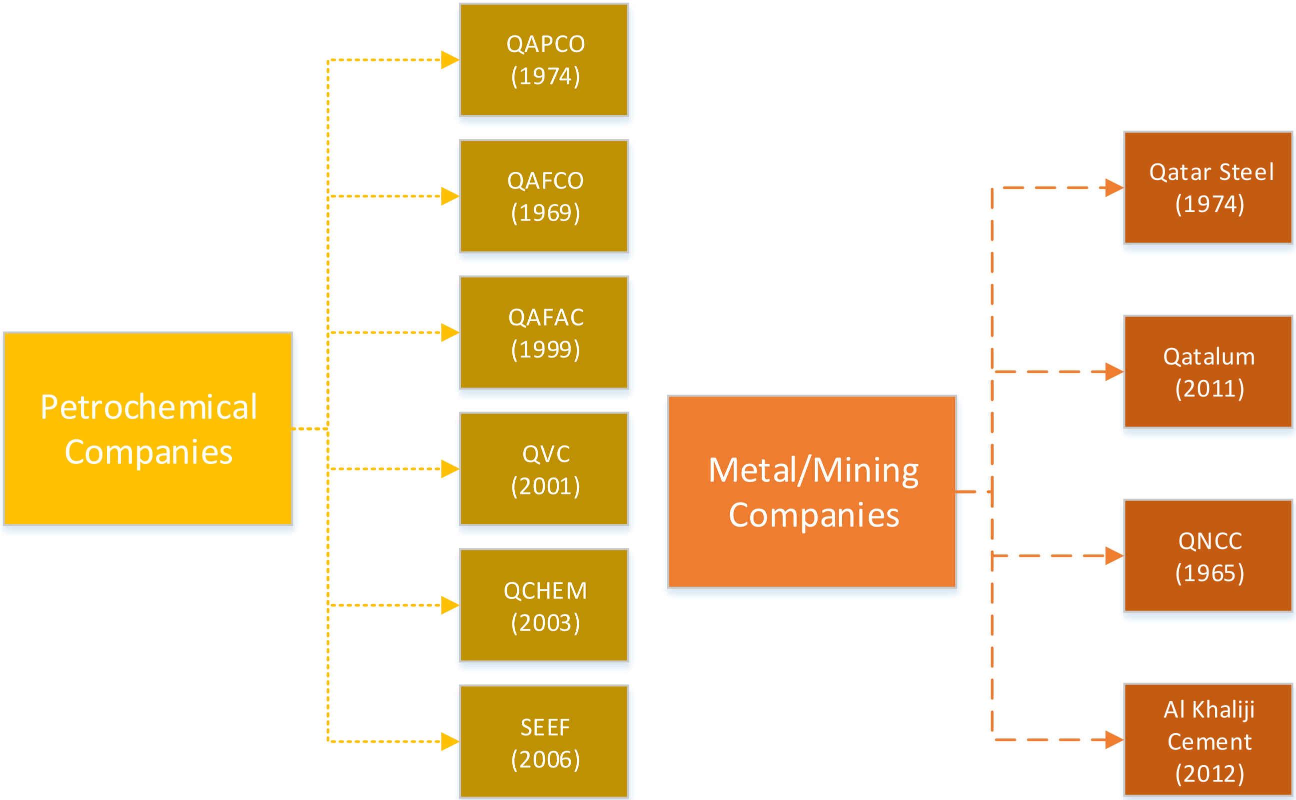


Figure 4.2 Companies involved from the petrochemical, metal and mining sector

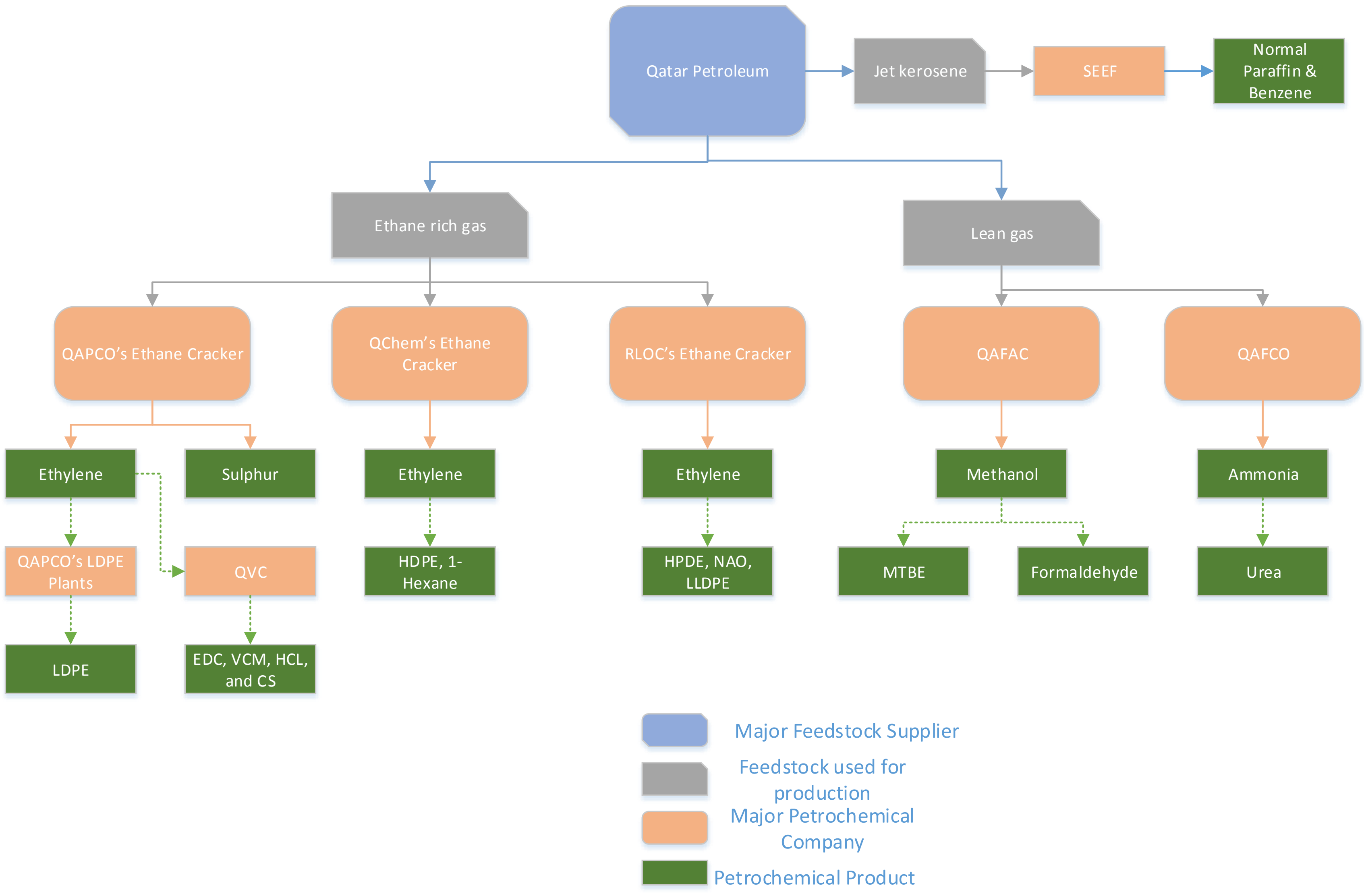


Figure 4.3 Feedstock for different companies and associated products

This section reports emissions from all industrial processes, which includes emissions from the process itself and energy (electricity, fuel) consumption. Contrary to the usual reporting methodology (IPCC guidelines), the industries lack data of disaggregated emissions resulting from the processes and energy consumption (electricity/fuel) (see figure 4.4). I used annual reports from all of the major companies in estimating emissions. In many cases, the emission factors reported is far higher than the IPCCs default emission factors. This is due to the methodological difference – combination of process and fuel/electricity combustion. In fact, many companies are far more efficient compared to global standards because of the implementation of advanced technologies. In future inventories, I aim to estimate emission based on the process and energy consumption. It is worth highlighting again, to avoid double counting I estimated emission including fuel and electricity used in the process.

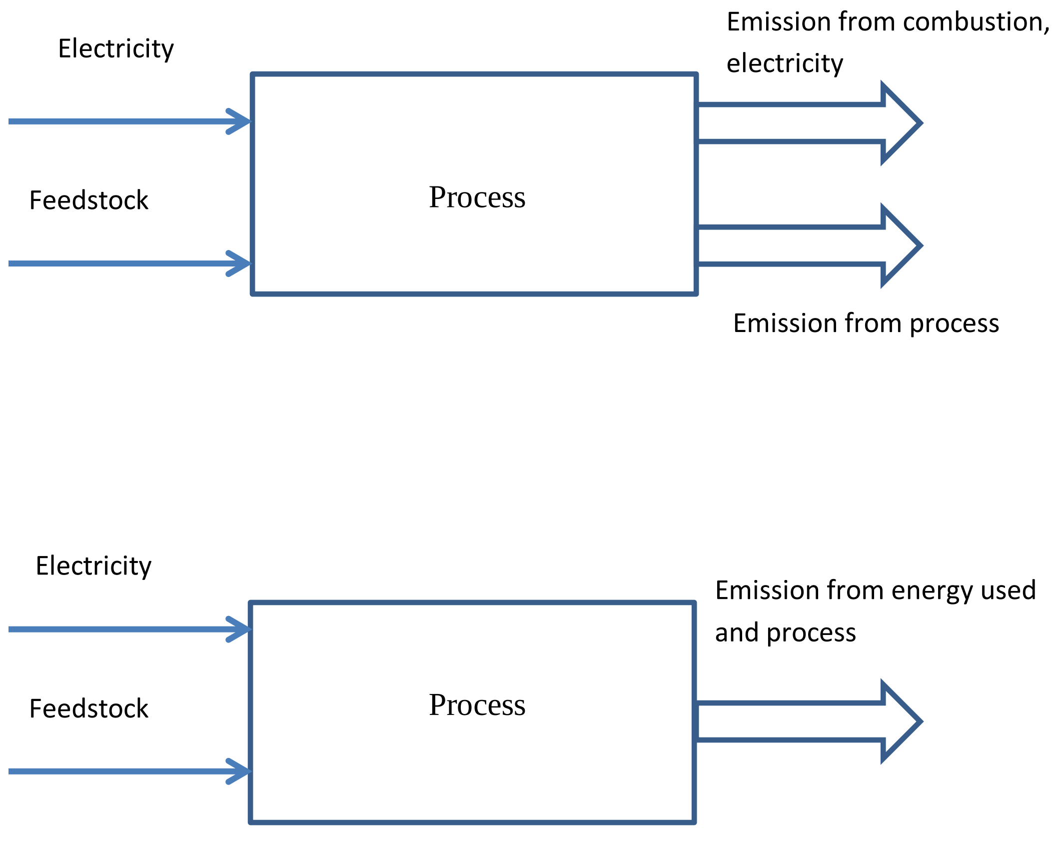


Figure 4.4 Emission calculation based on two methods. Preferred (top) and adopted method (below)

4.1 MINERAL INDUSTRY EMISSIONS

This sector covers emission from:

a. Cement production
b. Lime production

In 2015, the mineral sector contributed 5.5 percent of overall industrial emissions, of which cement alone contributed 99.6 percent and 0.4 percent of lime production. Emissions from cement production increased from 0.45 to 6.08 MtCO_2eq during the period 1995-2015. Emission grew at an average rate of 16 percent, which is highest of all sectors. Between 1995-2005 and 2005-2015 the annual average growth rates were 11 and 19 percent, respectively. Emission during the study period increased 1,247 percent.

	CO_2	CH_4	N_2O	PFCs/SF_6	Tier	Key Category
Cement	Y	NA	NA	NA	Tier-3	Yes
Lime	Y	NA	NA	NA	Tier-1	No

4.1.1 CEMENT PRODUCTION

Description

Cement production is one of the oldest industries in Qatar. The Qatar National Cement Company (QNCC) was established in 1965 and began full production in 1969 with a capacity of 100,000 tonnes annually to meet its domestic demand. This demand continued to grow, and the cement production facilities were expanded in following years. Currently, there are two companies producing over 6.43 million tonnes in 2015. National cement production has increased 1,253% in last two decades. Despite a significant increase in domestic production, the local consumption surpassed demand and needed to be met by imports. Until 2010, QNCC was the sole producer and distributor of cement in the domestic market. New players emerged because of the growing demand. The Al-Khaliji Cement Company (part of Qatar Investors) started production in 2010 and quickly reached full capacity. Currently, the Al-Khaliji Cement Company supplies 40% of the total domestic production. According to a survey by the Al-Khaliji Cement Company (AKCC), the demand for ordinary portland cement (OPC) is 23,000 metric Tonnes/day. The local production capacity within the country is 16,530 Tonnes/day, and the rest is imported.

Cement production generates combustion and non-combustion emissions of CO_2. The combustion emission is mostly related to energy consumption required for heating/electricity; whereas, the non-combustion emission originates from the raw material calcium carbonate

($CaCO_3$). The end product (calcium oxide) is heated to form clinker and then crushed to form cement.

$CaCO_3$ + heat → *$CaO + CO_2$*

CO_2 emission from cement production is a key category because of its contribution to total GHG emission.

Activity Data

The cement production data for the QNCC is directly received from the company; whereas, the data for AKCC is taken from their annual financial reports. Despite several attempts, AKCC refused to share any information. Cement production from the two companies is reported in figure 4.5. The increasing demand is met through import from neighbouring countries and is therefore excluded in the calculation according to the guidelines.

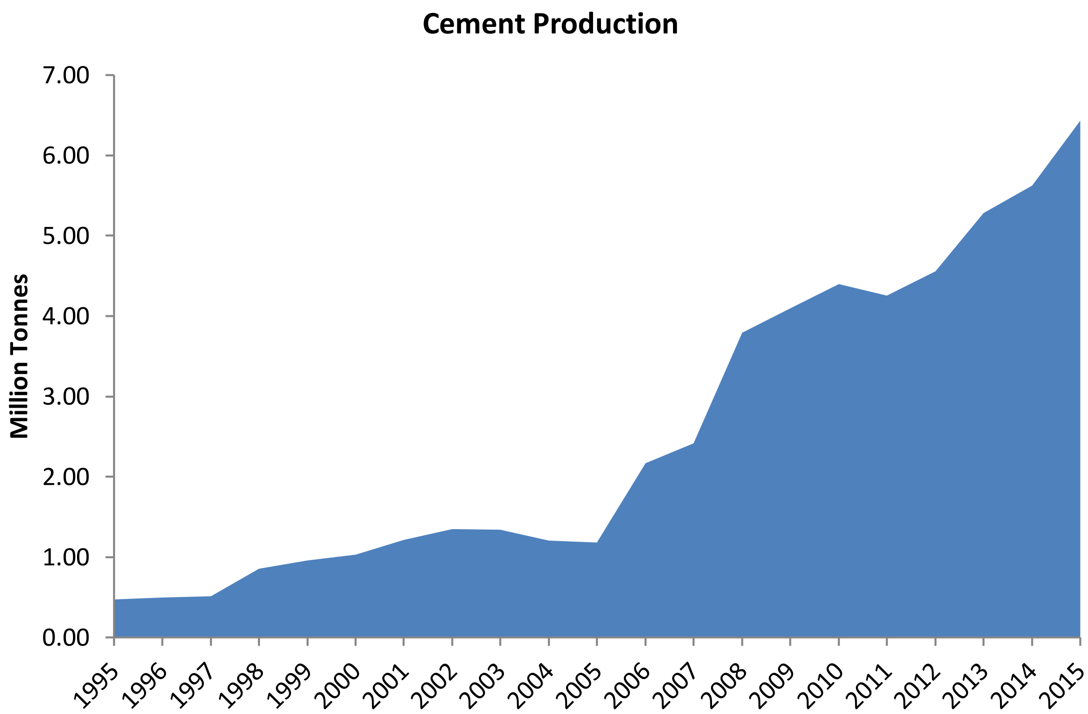


Figure 4.5 Total cement production in Qatar from 1995 and 2015

Emission

Cement production is an emission-intensive process because it requires a huge amount of energy. According to the facility data shared by QNCC, the emission factors did not vary much and tended to be around 0.95 tonne CO_2 per tonne clinker. Since AKCC did not share their emission data, I estimated with the same emission factor despite the fact that they have deployed one of the most advanced technologies in cement production. The IPCC default emission factor is 0.5071 tonne CO2/tonne clinker. In upcoming reports, I expect to report disaggregated emissions from the two companies to have an accurate estimation of emissions.

From the 2006 IPCC report, we used the equation;

CO_2 Emissions = [(Mci x Ccli) − Im + Ex] x EFclc

Where

CO_2 Emission = emission of CO_2 from cement production, tonnes

M_{ci} = weight (mass) of cement produced of type i, tonnes

C_{cli} = clinker fraction of cement of type *i*, fraction (0.95, assuming the total production is Portland cement)

I_m = Imports for consumption of clinker, tonnes

Ex = exports of clinker, tonnes (assumed zero)

EF_{clc} = emission factor for clinker in the particular cement, 0.95 tonnes CO_2/tonne clinker

Emission from the cement production is continuously increasing, and I noticed a dramatic rise from 2005. This reached a peak in 2009-10 and increased again with the new addition of AKCC production.

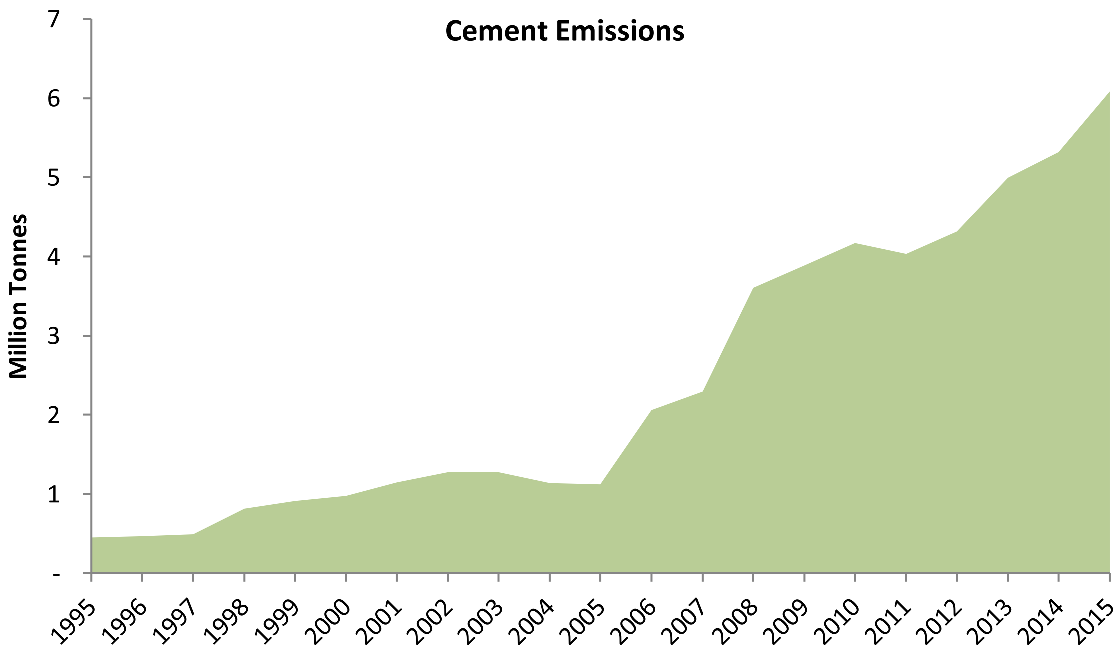


Figure 4.6 Emission from cement production between 1995 and 2015

Planned improvements

In following reports, I aim to obtain disaggregated data from both companies and report accurate emissions. I believe the emission data will be much less than current estimation.

4.1.2 LIME PRODUCTION

A very small quantity of quick lime is produced within the country. In 1995, lime production was 18,200 tonnes. This number peaked during the year 2001 and since then production has fallen continuously. I collected data about lime production from the national statistics bulletin. Data was reported till 2011. After this period, the Ministry did not publish the production data for lime. Because of the gradual decline in quicklime production, it is difficult to know whether the production has completely halted. To make any judgment without details, I decided to estimate emissions only till 2011. Notwithstanding, the total emission from the lime production was 10,350 tonnes CO_2eq, which is less than 0.1% of national GHG emissions.

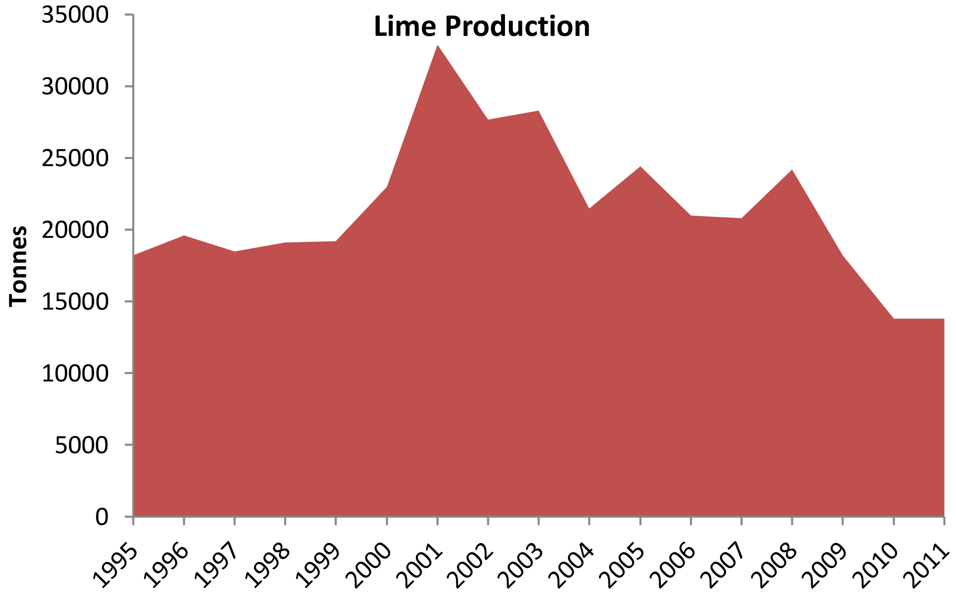


Figure 4.7 Lime production from 1995 to 2011

There is no plant-specific information available on lime production; I used the Tier-1 method described in the 2006 IPCC Subcategory 2A2 Lime Production section. I also assume that all lime production is a marketable good since it is harder to find the ratio of marketed to the non-marketed product. Figure 4.6 shows the emission trend for lime production

CO_2 Emissions = [(Mli)] x EFlime

Where,

CO_2 Emission = emission of CO_2 from lime production, tonnes

M_{li} = weight (mass) of cement produced of type i, tonnes (since I used the Tier-1 method, types or production is ignored)

EF_{clc} = emission factor for generic lime production, tonnes CO_2/tonne lime (I used the default emission factor - 0.75tonnes CO_2 / tonne lime produced)

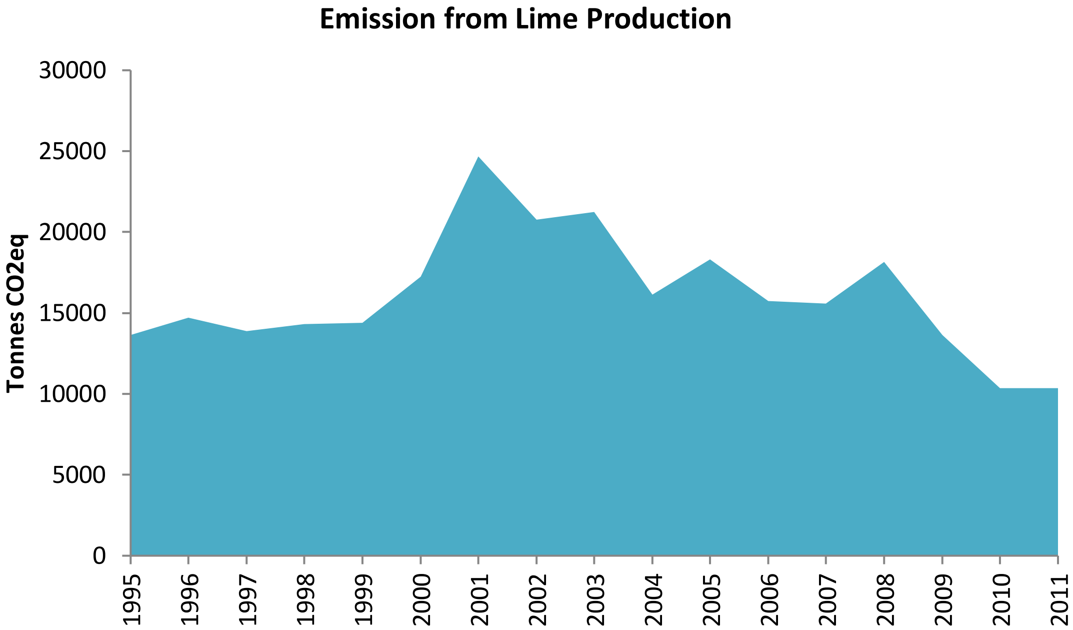


Figure 4.8 Emission from lime production between 1995 and 2011

Uncertainties and time-series consistency

There is higher uncertainty in emissions from lime production because of a lack of information. In the forthcoming inventories, I aim to report emissions from quicklime production.

4.2 METAL PRODUCTION

This sector covers emission from:

a. Steel production
b. Aluminium production

In 2015, total metal production contributed 9.06 million tonnes, that is, 30% of total industrial emissions and 8.3% of national GHG emissions. The annual average growth in CO2 emissions from metal subsector in the period 1995-2015 was 13 percent. Aluminium and steel production contributed 51 and 49 percent of total emissions from the metal subsector.

	CO_2	CH_4	PFCs	SF_6	Tier	Key Category
Steel	Y	NA	NA	NA	Tier-3	Yes
Aluminium	Y	NA	Y	Y	Tier-3	Yes

Y – Yes; NA- Not applicable

4.2.1 STEEL PRODUCTION

Qatar Steel was established in 1974, and is the only steel production company in Qatar. Rebar steel production has increased 180 percent between 1995 and 2014. Steel consumption is continuously increasing because of the rising demand for massive construction activities of large energy infrastructure (gas and petrochemical plants) and civil infrastructure. The upcoming FIFA infrastructure fuels the demand for steel and the company is planning for further expansion of production. Sales exceeded over 1.6 million Tonnes (mT) in 2014 compared to 0.6 mT. Qatar Steel supplies 98% of the reinforced steel bars to the market. Since the industry uses clean raw materials (DRI), unlike the scrap-based, the heavy metal, and dioxin emission is very negligible.

Qatar Steel's plant consists of four integrated primary units:

1. Direct Reduction Plants (DR1 & DR2)
2. Electric Arc Furnaces (EAF1, EAF2, EAF3, EAF4, EAF5)
3. Continuous Casting Plants (CC1, CC2, CC3 & CC4)
4. Rolling Mills (RM1 & RM2).

Direct Reduction is an iron making process for the new era. It is a process whereby iron ore pellets are converted at a high temperature into a highly pure form of iron. Qatar Steel has adopted the gas based Direct Reduction Process technology in its integrated complex for iron-making. The general production process is shown in figure x. In the case of fuel, Qatar uses natural gas throughout the process because of cheap availability. In 2014, it used 806 Mm^3 of natural gas bought under a long-term agreement with Qatar Petroleum. Additionally, Qatar imports 100 percent of iron ore from a handful of countries: Brazil, Sweden, Oman, and Norway. The total imported iron ore was 4.38 million tonnes in 2015.

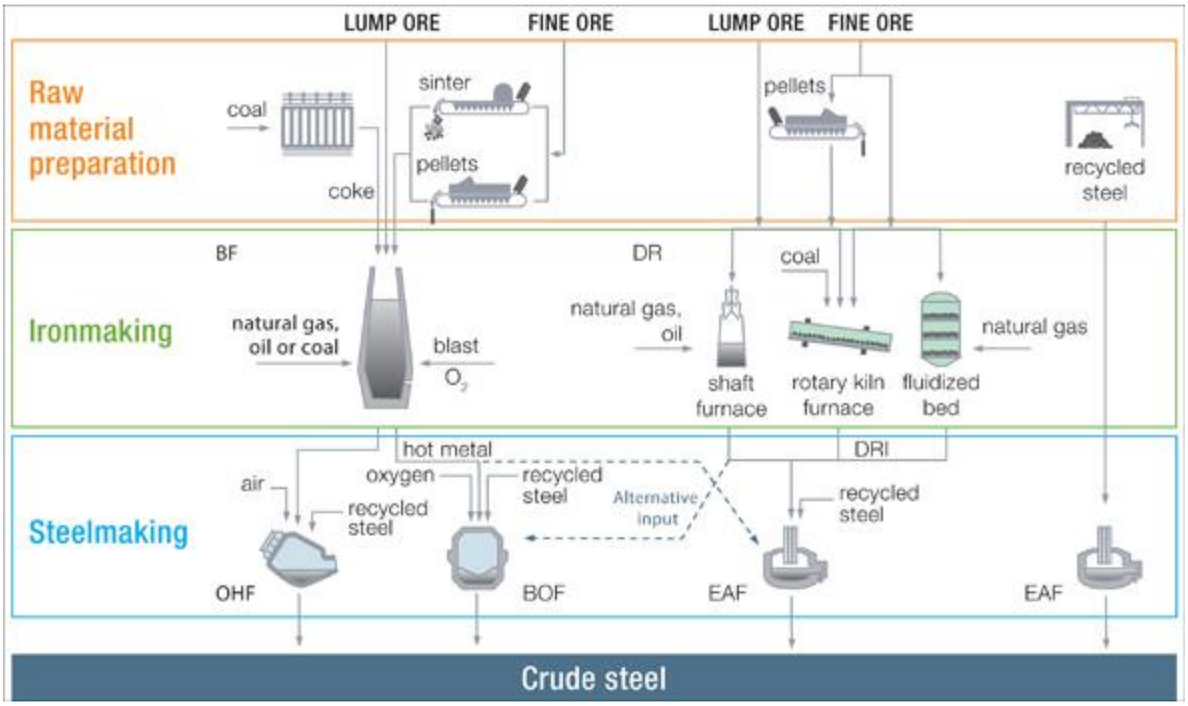


Figure 4.9 Steel production process in Qatar (Copied from http://worldsteel.org)

Activity Data

In 1995, the annual rebar steel production was 0.6 million tonnes (MT) and at the end of 2015, production rose to 1.7 MT. Major expansions were noticed in 2007 as shown in figure 4.7. Production increased 23% in 2007 compared to 2006. From 2009, Qatar Steel produced annual sustainability reports that record the annual emissions resulting from the steel production. The sustainability reports emission factor is only for the total steel sold not for the entire production. I estimated the emission factor based on the overall production. The emission factor varied between 2.24-2.36 and I used an averaged emission factor to estimate emission for previous years.

CO_2 Emissions = [(Msteel)] x EFsteel
Where,
CO_2 Emission = emission of CO_2 from steel production, tonnes
M = weight (mass) of steel produced by type i, tonnes
EF = emission factor for steel production, tonnes CO_2/tonne steel (I used a facility emission factor – 2.33 ton/ton between 1995 and 2009 and the rest given below in the table)

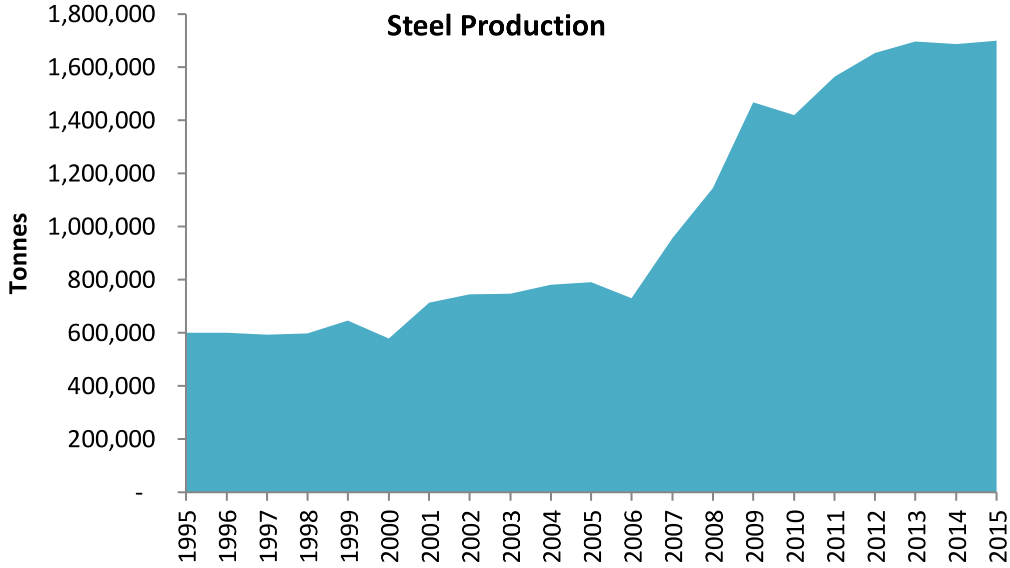


Figure 4.10 Total steel production in Qatar from 1995 to 2015

Emissions

The emission increased significantly from 2007 because of the continuous increase in steel production. Figure 4.11 shows the total emission from steel production. The total emission increased from 1.4 to 4.4 million Tonnes between 1995 and 2015. Because of efficiency gains from the replacement of advanced EAF and many other measures, the emission intensity has fallen for last two years.

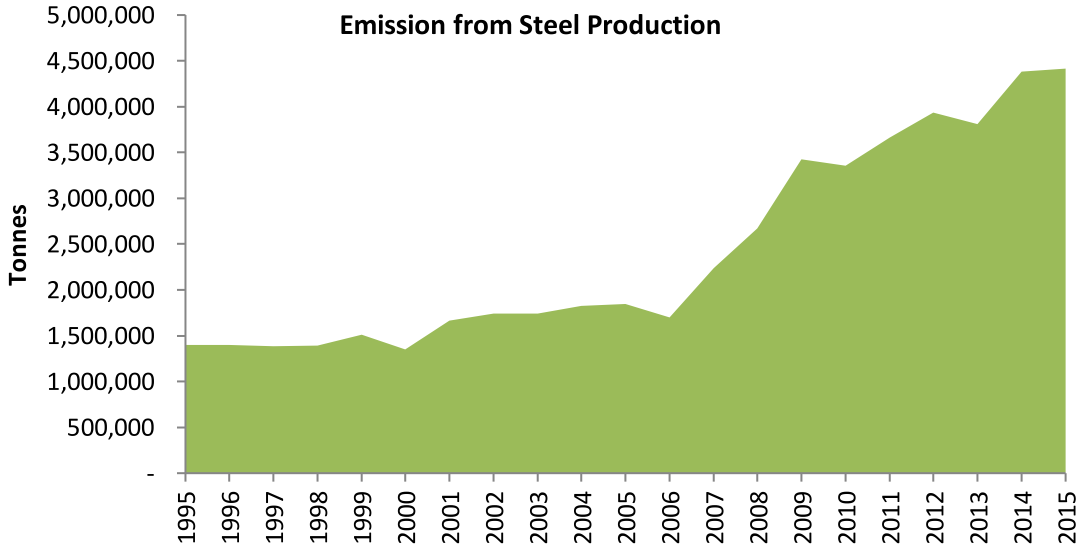


Figure 4.11 Emission trend of steel production between 1995 and 2015

Uncertainties and time-series consistency

The consumption data are of high quality, taken directly from the source. The uncertainty in the emission factors for CO_{2e} is 3 percent of the mean. There is no detailed record of CH_4 and N_2O estimation.

A general assessment of time series consistency has not revealed any time series inconsistencies in the emission estimates for this category.

4.2.2 ALUMINIUM PRODUCTION

Qatar is the thirteenth largest aluminium producer in the world with an annual capacity of 610 thousand tonnes per annum. Qatalum is the only aluminium producer in the country and is also one of the newest major industrial companies in Qatar. Production started in 2011 with 468,789 tonnes and reached approximately 640,000 tonnes in 2015. Qatalum produces extrusion ingots and foundry alloys. Most of the production is exported, and a small fraction is sold internally for a fledgling downstream aluminium industry.

Again, Qatar does not have any bauxite ores, and over 90 percent of its ore is imported from India. In 2015, 0.2 million tonnes of aluminium ore were imported, and 94% of it came from India. To produce 1 kg of aluminium, 4 kg of Bauxite is converted into 2 kg of Alumina oxide and then it requires 0.5 kg carbon and 13-15 kWh of electricity. Because of the huge energy requirement, Qatalum has its own electricity generation facility with a total capacity of 1,350 MW, which is approximately 15% of Qatar's total installed capacity. The general production process is shown in figure 4.12

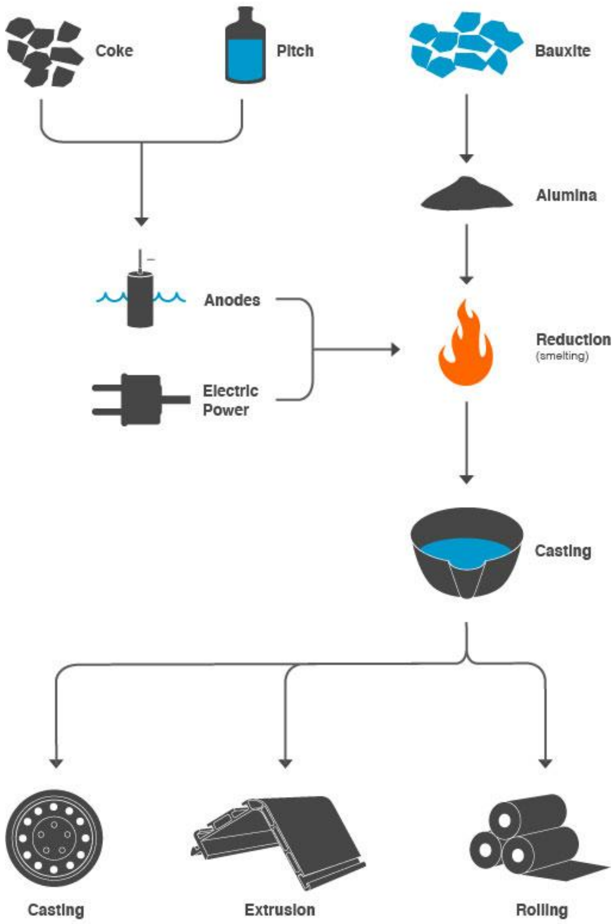


Figure 4.12. Aluminium production process (Source: http://www.hydro.com/en/About-aluminium/Aluminium-life-cycle/Primary-production/)

Methodological Issues

The inventory uses the emission figures reported in their annual sustainability reports. Qatalum consistently reports their emissions and other relevant parameters in their annual reports. The emission per unit of production is very small because it adopted the best available technologies in the market. Production of aluminium leads to the emission of various components of CO_2, SO_2, NOx, perfluorocarbons (PFCs) and heavy metals.

Activity Data

Aluminium production started in 2011 and reached its full production in 2012 and remained constant ever since. Figure 4.13 shows the total aluminium production in Qatar.

CO_2 Emissions = [(MAluminium)] x EFAluminium

Where,

CO_2 Emission = emission of CO_2 from aluminium production, tonnes

M = weight (mass) of aluminium produced, tonnes

EF = Based on the data, the averaged emission factor in 2013 is 7.26 ton/ton of aluminium production. The GHG emission factor in the last three years has declined 25% because of its advanced electricity production unit.

Also, the PFCs and SF_6 emission per unit of aluminium production are very low, as shown in the table below. These values are compared with the advanced Norwegian aluminium production technologies (both Soderberg and Prebaked).

	2011	2012
Total Fluorides (kg/mt Al)	0.1	0.13
PFC (both potlines (Kg/mt Al)	0.126	0.11

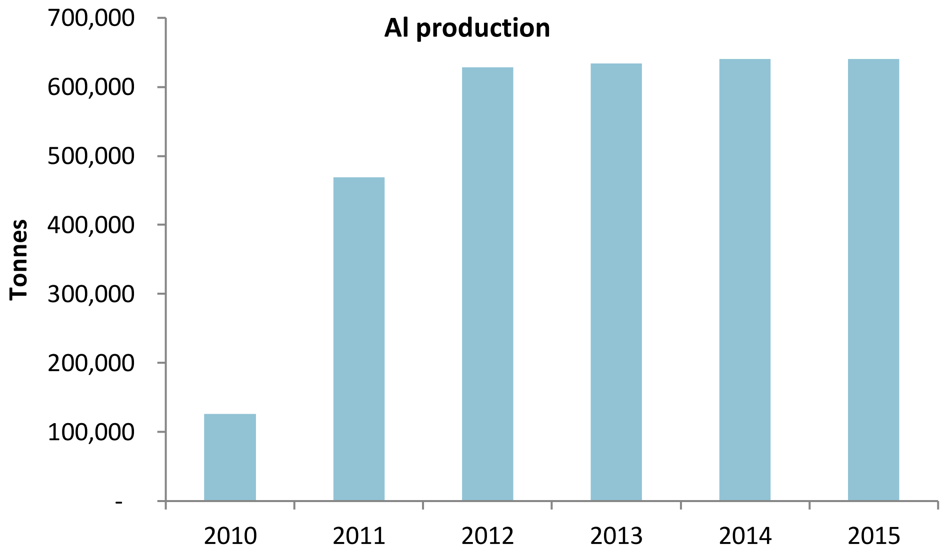


Figure 4.13 Total aluminium production between 2011 and 2013

Emissions

The total emissions reported in this inventory are based on the annual reports. Unfortunately, the methodology used in the calculation is not reported. In the forthcoming inventories, I plan to have a detailed methodology. In 2015, the total emission was 4.64 million tonnes, which is 2 % higher compared to 2015.

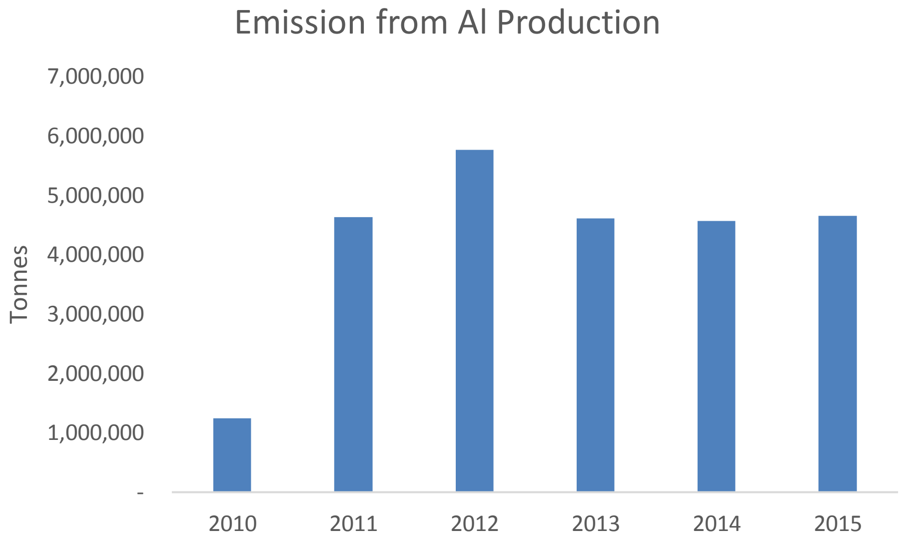


Figure 4.14 shows the total aluminium emission between 2011 and 2013

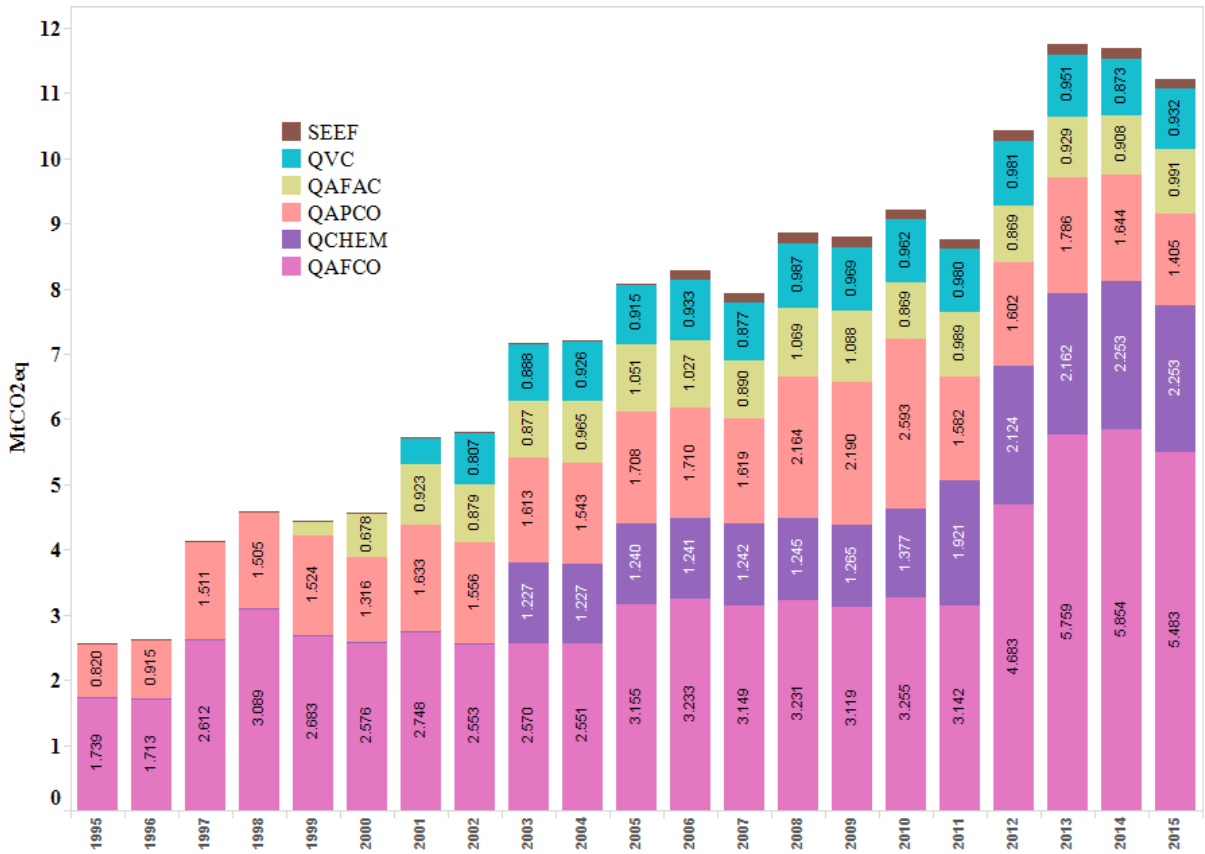
Uncertainties and time-series consistency

The production data are of high quality, taken directly from the source. The uncertainty in the emission factors for CO_{2e} is 7 percent of the mean. There is no detailed record of CH_4 and N_2O estimation. A general assessment of time series consistency has not revealed any time series inconsistencies in the emission estimates for this category.

4.3 CHEMICAL & PETROCHEMICAL SECTOR

In 2015, emission from the chemical and petrochemical sector was 11.2 MtCO$_2$eq, which is 37% and 10.2% of total manufacturing sector emissions and national GHG inventory. The emissions from the chemical and petrochemical sectors increased four times in last two decades. Fertilizers contributed 49%, ethylene and polyethylene production contributed 33%, Methanol, Ethylene Dichloride and others contributed 18 percent of the total emissions.

Some companies experienced a drastic reduction in emissions as a result of increasing investment in efficient technologies and flaring reduction initiatives. Also, because many companies established/expanded less than a decade ago that provided an advantage to build based on the most advanced technologies available on the market. For more details, please refer to chapter 9. The emission reported in this section involved energy-related and process-based emissions.



This sector covers emission from:

a. Ammonia/Urea (QAFCO)
b. Low-density polyethylene, ethylene, and sulphur (QAPCO)
c. Methyl tertiary-butyl ether, Methanol and Pentane (QAFAC)
d. Ethylene Dichloride, Vinyl Chloride Monomer (QVC)
e. Normal Paraffin, Alkylene Benzene, Benzene (SEEF)

	CO_2	CH_4	N_2O	PFCs/SF_6	Tier	Key Category
Ammonia/Urea	Y	Y	NA	NA	Tier-3	Yes
Methanol/Ethylene	Y	Y	Y	NA	Tier-3	Yes
Ethylene Dicholoride/Vinyl Chloride Monomer	Y	Y	Y	NA	Tier-3	Yes

Y – Yes; NA- Not applicable

Total Emissions = Emission from the combustion process while cracking of feedstock + Emission from electricity production (or used from the grid) + Emission from venting and flaring

There are six major petrochemical companies based in Messaied Industrial City. These companies are QAFCO, QChem, QAFAC, QAPCO, QVC, and SEEF. They produce urea, ethylene, polyethylene/low-density polyethylene (LDPE), methanol and benzene. Because of confidentiality agreements, I was not allowed to provide disaggregated data in terms of various products and companies. If the readers are interested in obtaining detailed product data, they can contact the respective companies. Most of the companies primarily use natural gas for cracking to make petrochemical products and also for electricity generation. Hence, in this section it is difficult to describe emissions from each petrochemical product. Consequently, I report collective emissions from all of the petrochemical products. All companies, except QVC, publish annual sustainability reports. I contacted QVC to provide relevant data to complete my study. Nearly all emission figures from this sector area based on plant-specific data published in the annual sustainability reports of the respective companies.

4.3.1 CHEMICAL SECTOR

Fertilizer Production

Qatar Fertilizers Company (QAFCO) was founded in 1969 and developed in several stages - Qafco-1 (1973), Qafco-II (1979), Qafco-III (1997) and Qafco-IV (2004) and Qafco V and VI (2010). Qafco is the sole producer of ammonia/urea in the Qatar and is marketed through Muntajat. With its fifth expansion, it became the world's largest single-site producer of urea. In 2015, urea production increased to 5.6 MT. Ammonia is produced through the HaberBosch process and over 85 percent is used locally for urea production and the rest is exported. QAFCO produces prilled, granular urea and melamine. Over 5 million tonnes of urea was exported in 2014. Natural gas is a common feedstock used in the process and is purchased under a long-term agreement with QP. QAFCO has its in-house co-generation power plant and partially its imported from the state utility provider.

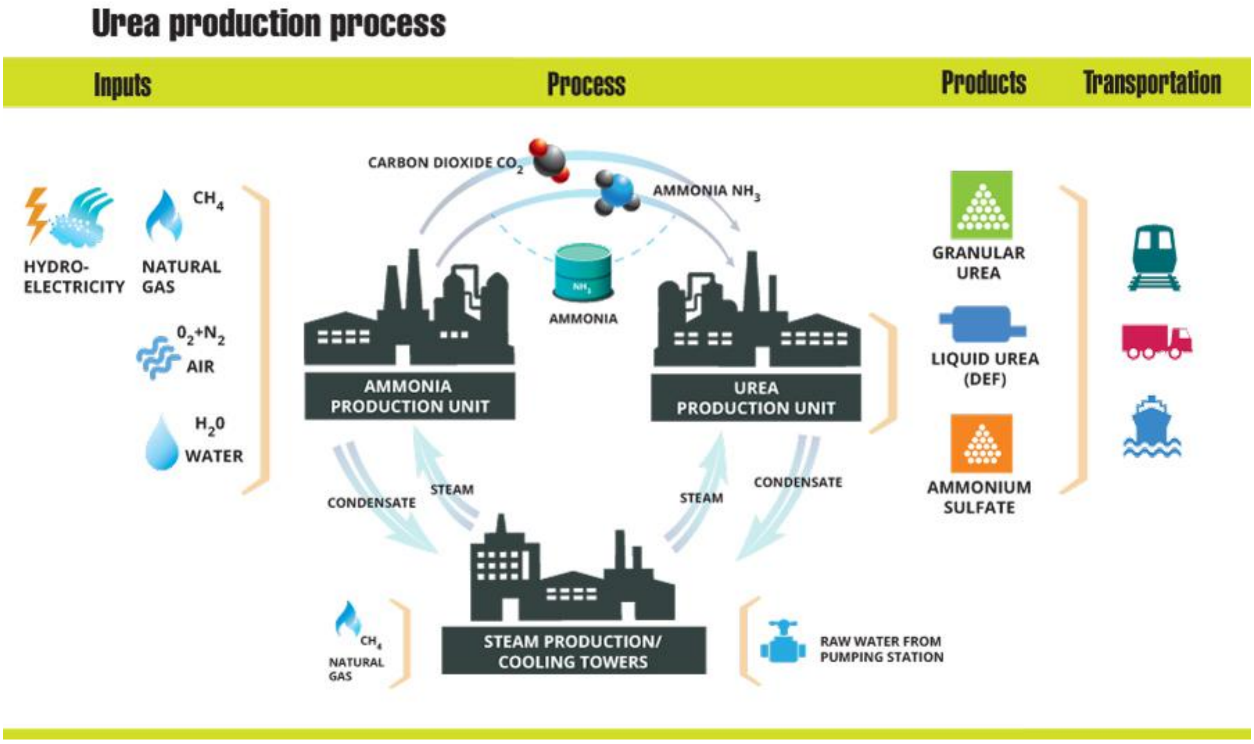


Figure 4.15 Urea production process (Source: http://iffcocan.com/?page_id=730&lang=en, accessed 18th November, 2015)

Methodological Issues

The CO_2 emission figures are reported in the annual sustainability reports and have been consistently reported since 2010.

Estimation Method

I use the Tier-3 method to estimate CO_2 emissions by multiplying the amount of ammonia/urea production by a greenhouse gas (GHG) emission factor.

Activity Data

I used annual production data from the QAFCO Company. In the last few years, the annual production of urea increased six fold. The production data is shown in figure 4.16. Most of the ammonia produced is used internally for urea production, and a very small amount of the remaining ammonia is exported. No data is available for ammonia exports; I assume nearly 90% of NH_3 is used within the facility. I received the total amount of natural gas consumed from 1999, and I used the averaged consumption to estimate the overall natural gas consumption for previous years.

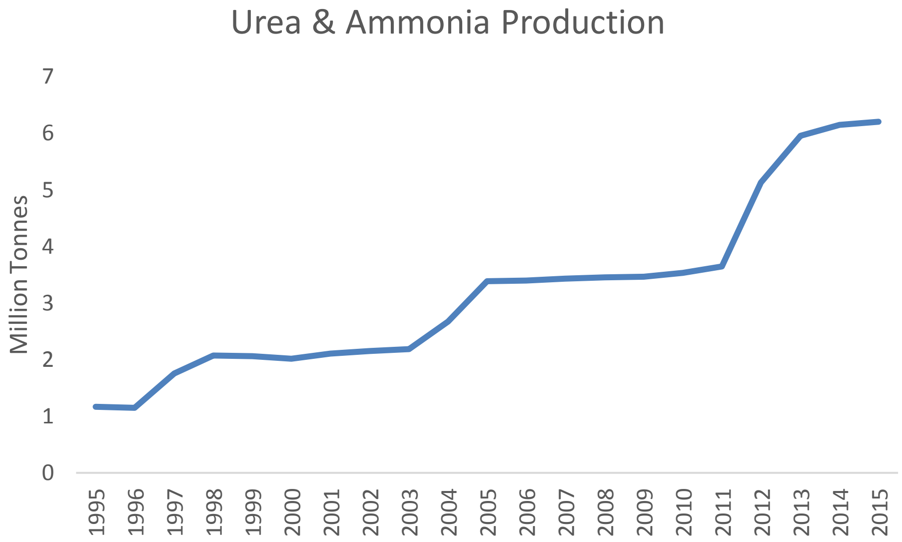


Figure 4.16 Total ammonia and urea production (in million Tonnes)

Emission Factor

The plant emission factors were calculated based on the composition of the gases consumed. On average, to produce one ton of ammonia, it requires 34 GJ of energy, which in this case natural gas. The emission factor declined to 0.96 ton/ton of urea in 2013 against 1.29 ton/ton in 1999. The uncertainty in the CO2e emission factors is ±4 percent. This significant decline is due to an increase in operational efficiency and replacement/adoption of new technologies in new facilities. With the new efficiency gains, QAFCO managed to reduce 1.8 million Tonnes in 2015.

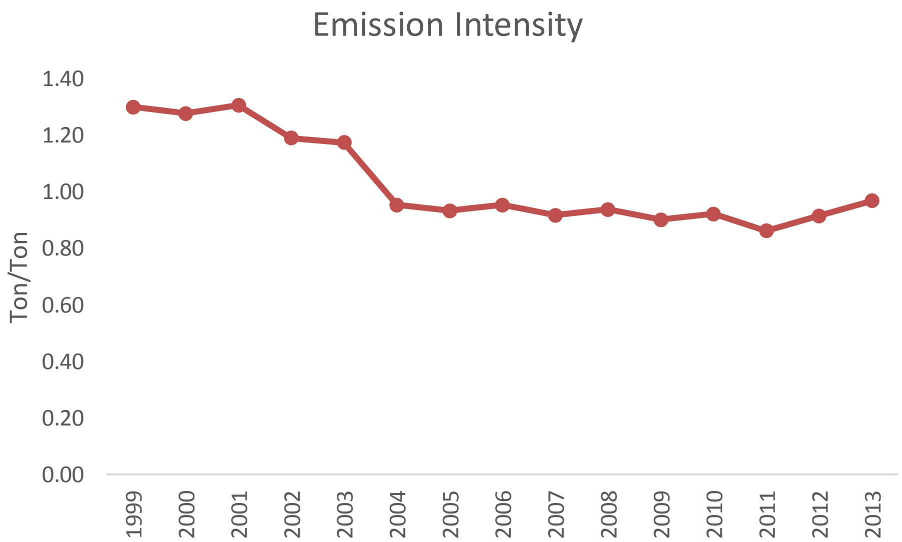


Figure 4.17 Greenhouse gas emission intensity of fertilizer production from 1999 to 2013

Emissions
The greenhouse gas emission from the ammonia/urea production is substantially high. In 2015, fertilizer production alone contributed 49% of total emissions resulting from the chemical (which includes petrochemicals) sector. Between 1995 and 2015, the emission increased 215%. The sudden increase of emission is due to an increase in production. Despite several measures to reduce GHG emissions, the overall trend is upward.

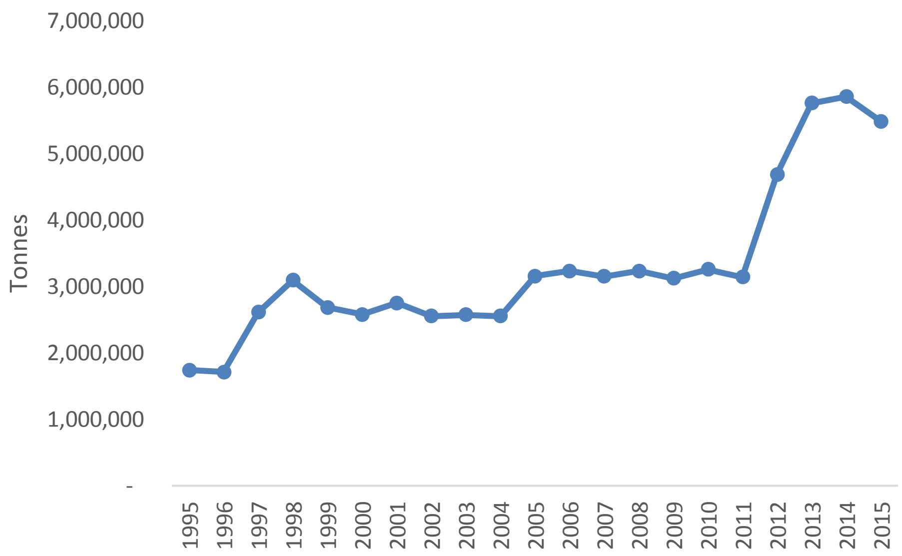


Figure 4.18 Emission from urea production between 1995 and 2015

4.3.2 PETROCHEMICAL SECTOR

Methodological issues

Ethylene Production (*this section is copied directly from the IPCC report, Ch3*)
Ethylene is produced by way of steam cracking of petrochemical feedstock (ethane/natural gas/naphtha).

The fundamental chemical equation for ethylene production is as follows

Ethane Dehydrogenation to Ethylene

$$C_2H_6 \rightarrow C_2H_4 + H_2$$

QAPCO and QChem are major producers of ethylene and its derivatives such as high-density polyethylene (HDPE), linear low-density, polyethylene (LLDPE), polypropylene, butadiene and py-gasoline. Ethane is used as a feedstock supplied by Qatar Petroleum.

Methanol Production (*this section is copied directly from the IPCC report*, *Ch3*)
Globally, methanol is primarily produced through steam reforming of natural gas. Qatar uses a similar process. Because of the cheap availability of natural gas, Qatar produces over one million ton of methanol annually. Steam reforming of natural gas produces methanol and by-product, CO_2, CO and H_2 from the synthesis gas. There are multiple methods of producing methanol from natural gas, namely: conventional reforming process, combined reforming, and partial oxidation process. Since Qatar produces through steam reforming process (figure 4.19), I explain the process below.

Conventional Reforming Process
The Conventional Reforming Process for methanol production involves steam reforming (which may include either a single reformer unit or both a primary reformer unit and a secondary reformer unit) and methanol synthesis. The overall equations for the Conventional Reforming Process are:

Steam Reforming

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

Shift Reaction

$$CO + H_2O \rightarrow CO_2 + H_2$$

Methanol Production

$$CO + 2H_2 \rightarrow CH_3OH$$
$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$$

Reforming/Shift Reaction

$$2CH_4 + 3H_2O \rightarrow CO + CO_2 + 7H_2$$

Methanol Production

$$CO + CO_2 + 7H_2 \rightarrow 2CH_3OH + 2H_2 + H_2O$$

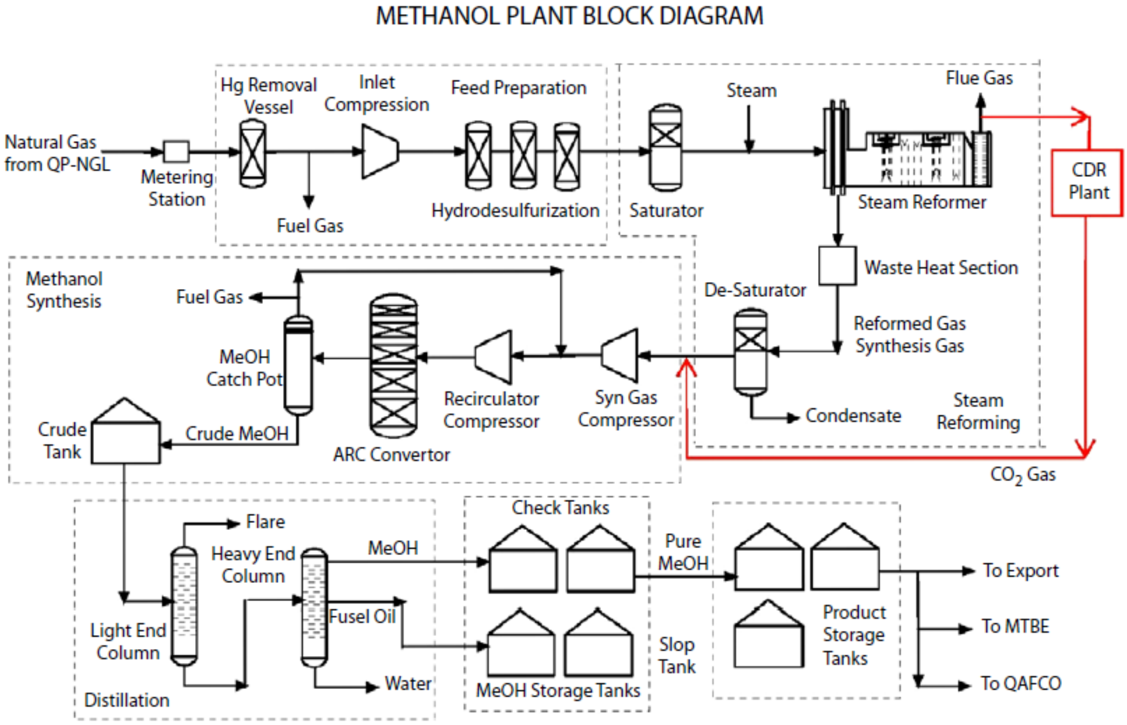


Figure 4.19 Methanol production process in Qatar (Al-Hitmi, 2012)

Ethylene Dichloride and Vinyl Chloride Monomer (*this section is copied directly from the IPCC report, Ch3*)

Ethylene dichloride is made by direct chlorination or oxychlorination of ethylene, or by a combination of the two processes (referred to the balanced process). Qatar produces 0.465 million tonnes of combined ethylene dichloride and vinyl chloride monomer.

Direct Chlorination and Oxychlorination Processes

The direct chlorination process involves the gas-phase reaction of ethylene with chlorine to produce ethylene dichloride. The oxychlorination process involves the gas-phase reaction of ethylene with hydrochloric acid and oxygen to produce ethylene dichloride and water. The ethylene dichloride is then cracked to produce vinyl chloride monomer and hydrochloric acid. The oxychlorination process produces a process off-gas containing by-product CO_2 produced from the direct oxidation of the ethylene feedstock. The process is shown in figure 4.18.

The fundamental chemical equations for the direct chlorination and oxychlorination processes are as follows:

Direct Chlorination

$$C_2H_2 + Cl_2 \rightarrow C_2H_4Cl_2$$

Oxychlorination reaction

$$C_2H_4 + \frac{1}{2}O_2 + 2HCl \rightarrow C_2H_4Cl_2 + H_2O$$

Ethylene dichloride >> Vinyl chloride

$$2C_2H_4Cl_2 \rightarrow 2CH_2CHCl + 2HCl$$

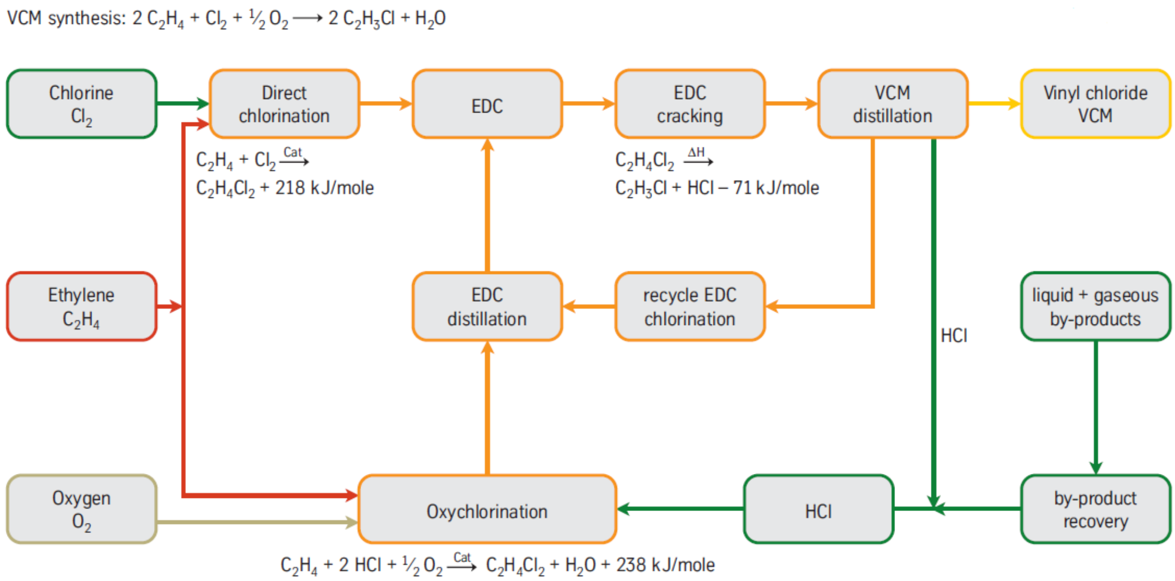


Figure 4.20 Direct Chlorination and Oxychlorination Processes (Thyssenkrupp-industrial-solutions.com)

Linear Alkyl Benzene (LAB) is the most common raw material used in the manufacturing of environmental friendly biodegradable household detergents. LAB is manufactured in two stages using two main raw materials namely, benzene and normal paraffin.

First Stage: Normal paraffin is produced in the N-Paraffin unit. Kerosene prefractionation is often used to tailor the kerosene feed to the desired carbon range. Kerosene is stripped of light ends and heavier components so that the heart cut, containing the desired n-paraffins for the production of LAB of a certain range of molecular weight, is produced.

Second Stage: In the Pacol process, the normal paraffins are dehydrogenated in a vapour phase reaction to corresponding mono-olefins over a highly selective and active catalyst. The DeFine process is a liquid phase, elective hydrogenation of diolefins in the Pacol reactor effluent to corresponding mono-olefins over a catalyst bed. The PEP process allows the selective removal of aromatics in the feed to the Detal or Detergent Alkylate unit. Detergent Alkylate is a process in which benzene is alkylated with mono-olefins produced in the Pacol unit to LAB using HF acid as a catalyst.

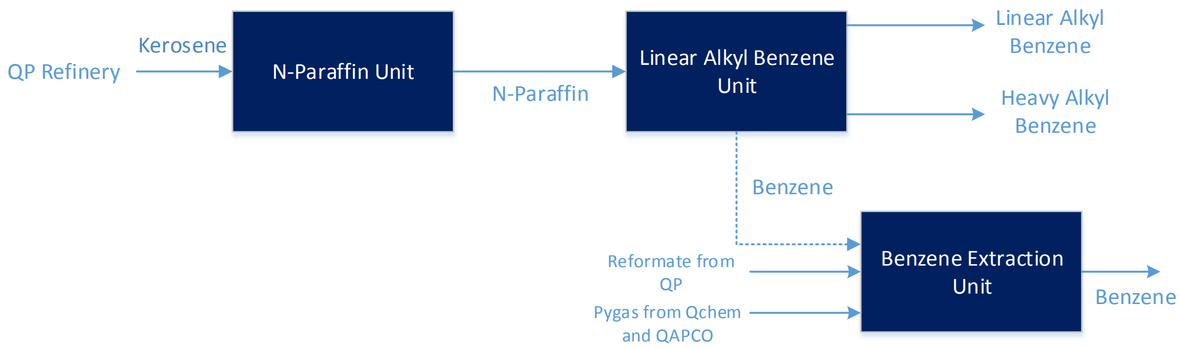


Figure 4.21 Linear Alkyl production process in Qatar

Activity Data

I contacted all of the companies to get disaggregated production data. I couldn't get the production and emission data from SEEF and QChem for 2015. I assumed the production and emission remained constant for both companies. Although QChem started several initiatives to minimize emissions, it is not reflected in this report because of a lack of data.

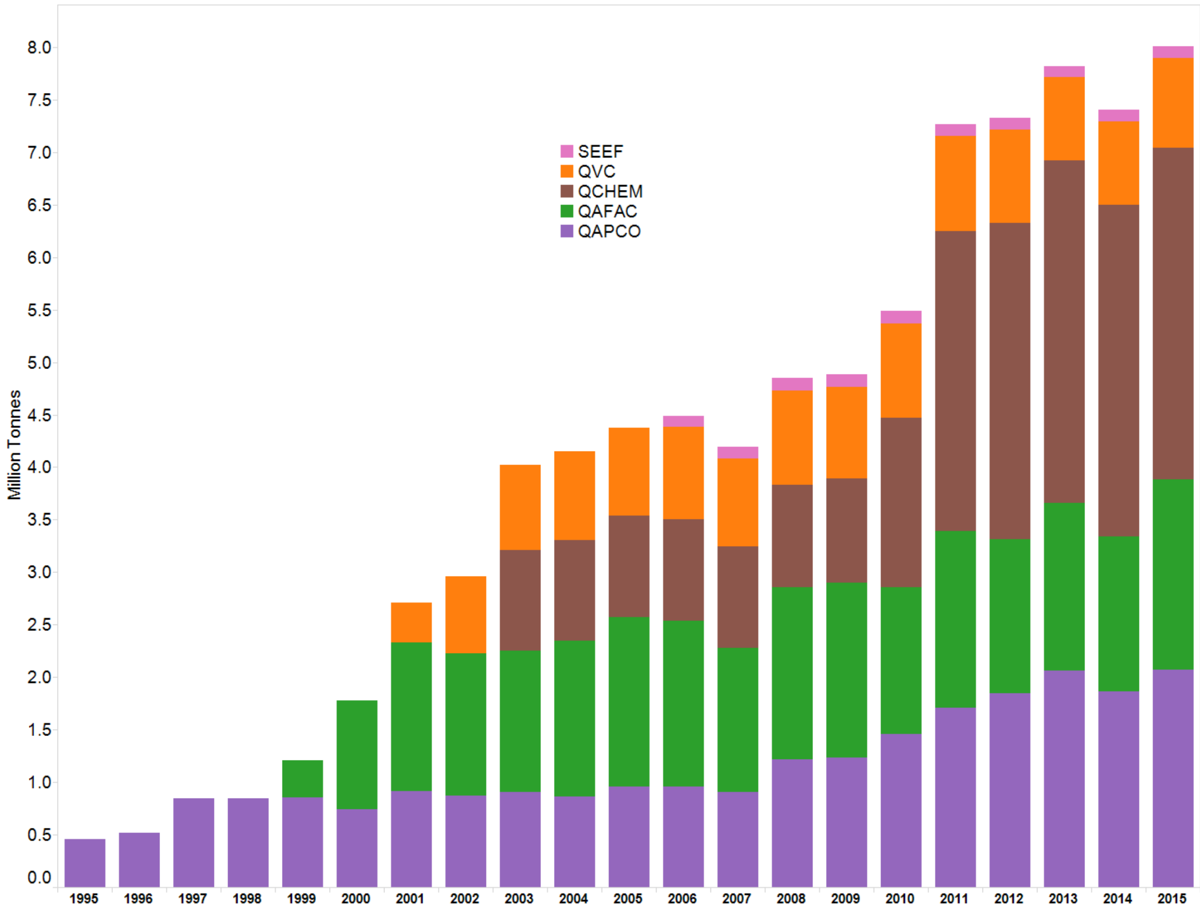


Figure 4.22 Chemical and petrochemical production from 1995 to 2015

Emission Factors

Each company has its refinery facilities. Some are operated in partnership with other companies. For instance, Qatofin is managed by QAPCO and the emissions are reported for both companies.

In last few years, all companies, excluding QVC, have published annual sustainability reports, which include total GHG emissions. I contacted all of the companies to get raw consumption of fuel/electricity data. I used each company's emission factor to estimate the emissions. The emission factors are given below for all the GHG emissions instead of CO_2, CH_4, N_2O, NMVOC, etc. I assumed 99% of the total emissions are CO_2. In future inventory reports, I expect to report emissions at a disaggregated level.

GHG ton/ton of production	2010	2011	2012	2013	2014
QAPCO	-	1.78	1.55	1.39	1.4
QCHEM	1.28	0.83	0.84	0.81	0.82
QAFAC	0.62	0.71	0.62	0.66	0.65
QVC	1.07	1.09	1.11	1.20	1.09
SEEF	0.712	0.635	0.781	0.719	-

Planned Improvements

In the upcoming inventories, I aim to report emissions at a disaggregated level based on the process and combustion sources.

4.4 HALOCARBONS and SF_6

In 2015, nearly 4.1 $MtCO_2eq$ of emissions, which is equivalent to 3.8 percent and 14 percent of national inventory and industrial sector were from the category Consumption of Halocarbons and SF_6/PFC. The emission rate remained constant for last two years.

This category covers emissions from different halocarbons or ozone-depleting compounds (ODCs) and PFC and SF_6. All ODC chemicals were imported and the database recorded consumption only from 2005. As a signatory to the Montreal Protocol, Qatar tracks the consumption of halocarbons (which includes HFCs, HCFCs, CFCs, etc.) and aims to minimize the consumption. To comply with the Protocol, since 2010, Qatar has stopped importing CFC-11 and CFC-12 and has slowly replaced it with HCFCs as shown in Table 4.1. Hydrofluorocarbons are innocuous (check references below) to the ozone layer, unlike CFCs. The consumption of HCFC 22 and HCFC 134A increased over time especially from 2009. Between 2000 and 2013, the emission from halocarbons reduced over 80 percent.

Activity Data and Estimation Method

Unfortunately, there is no clear record of consumption of halocarbons for various uses. In many developed countries, the Ministries and other agencies track the consumption for different applications. For instance, Japan's emission inventory recorded very detailed consumption of halocarbons like refrigeration and air conditioning equipment, number of devices contain HFCs, and the number of devices disposed of and the quantity of HFC in each device. Such detailed information provides an accurate estimation of emissions resulting from halocarbons and SF_6. Unfortunately, Qatar has no such detailed records of halocarbon consumption, except the aggregated consumption on a national scale as shown in figure 4.23. By the time of this writing, 2015 data was not released. I assumed the consumption remained constant in 2015 same as 2014.

Halocarbon Emissions = Total hydrocarbon consumption x ozone depletion potential (ODP) x global warming potential (GWP)

	2008	2009	2010	2011	2012	2013	2014	2015
CFC-11	1.78	0	0	0	0	0	0	0
CFC-12	3.27	0	0	0	0	0	0	0
HCFC-22	604	1225	1446	1483	1479	1579	1019	1019
HFC-134a	0	150	580	581	581	0	319	319

Table 4.1 Breakdown of halocarbon consumption from 2005 to 2014

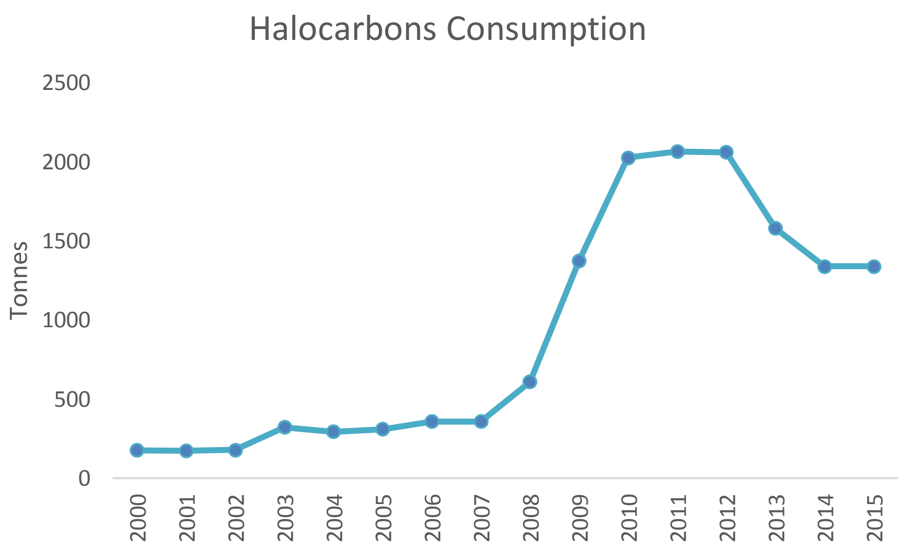


Figure 4.23 Total halocarbons consumption between 2000 and 2013

The global warming potential (GWP) is based on the Fourth Assessment Report.

Halocarbons	ODP	GWP
CFC-11	1	4750
CFC-12	1	10900
HCFC-22	0.055	1810
HFC-134a	0.055	1430

Emissions

The total halocarbon emission is reported in figure 4.24. There is a sharp decline in emissions because of phasing out potent halocarbons from 2004. Despite the growing consumption of HFC22 and HFC134a, the corresponding emissions are low compared to CFC-11 and CFC-12.

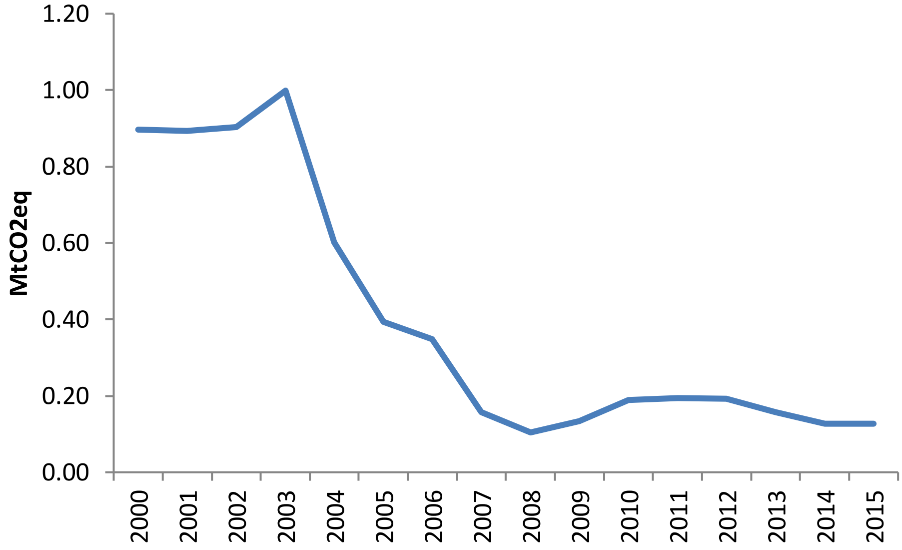
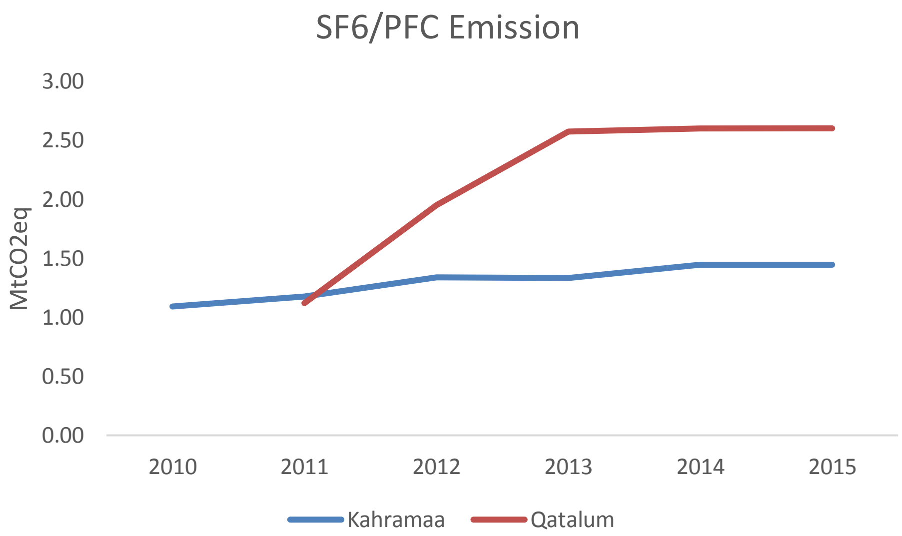


Figure 4.24 Total emissions from consumption of halocarbons

Emissions of SF6 from Products and Processes

SF6 is used as an insulation medium in high tension electrical equipment including gas insulated switchgear (GIS) and circuit breakers. SF6/PFC is used in aluminium production. There is no production of SF6/PFC in Qatar. There is no clear record of consumption of SF_6, except by Qatalum. Kahramaa reported the emissions from SF6/PFC under the indirect emission category. Based on the sparse data, I managed to report SF_6 emission only from 2010. The total emissions from SF6 in 2015 were 4.17 MtCO2eq, which is equivalent to 4 percent to total GHG emission inventory.


SF6/PFC Emission
3.00
2.50
2.00
1.50
1.00
0.50
0.00
MtCO2eq
2010
2011
2012
2013
2014
2015
Kahramaa
Qatalum

5. SOLVENT AND OTHER PRODUCT USE

This chapter describes emissions from solvents and other products. In general, solvents emit non-methane volatile organic compounds (NMVOC), which is regarded as indirect GHG emissions. Over a period, NMVOC oxidize to CO_2. Very limited information is available about the solvents used. I relied on the import-export database to obtain the activity data of lubricants, paraffin wax, and asphalt.

The total emission from the solvent use is insignificant. In 2015, the total emission was 74 tonnes.

	CO_2	CH_4	N_2O	NMVOC	Tier	Key Category
Lubricant	Y	NA	NA	NA	Tier-1	No
Paraffin Wax use	Y	NA	NA	NA	Tier-1	No
Asphalt	Y	NA	NA	Y	Tier-1	No

5.1 LUBRICANT USE

Lubricants are widely used in industrial and transport applications. Lubricants are the subsequent refining of crude oil. Though Qatar has large petrochemical facilities, it is uncertain about the quantity of domestic production and local sale as it is not reported in any of the national reports or statistical databases. In which case, I relied on the import-export trade database and calculated the total imports from 1998-2013. The values for 1995-1997 are same as 1998.

Methodological Issues

I used the Tier-1 method for estimating the emissions from the lubricants. The amount of lubricant (in tonnes) is converted into the energy unit TJ. The equation is given as

CO_2 Emissions = $LC * CC_{wax} * ODU_{wax} * 44/12$

Where:

CO_2 Emissions – CO_2 emissions from lubricants, tonne CO_2

LW = total wax consumption, TJ

CC_{wax} = carbon content of paraffin wax (default), tonne C/TJ (=kg/GJ), 20 tonne C/TJ

ODU_{wax} = ODU factor for paraffin wax, fraction = 0.2

44/12 = mass ratio of CO_2/C

Activity Data

The consumption of lubricants is taken from the import-export database. I ignored domestic production and local sales because of limited information. I assume the imported quantity is consumed within the same year. Also, the database recorded values only from 1998, and I used the 1998 data for the previous years from 1995 to 1997 as shown in figure 5.1. Emission from secondary fate (disposed or combusted) is ignored.

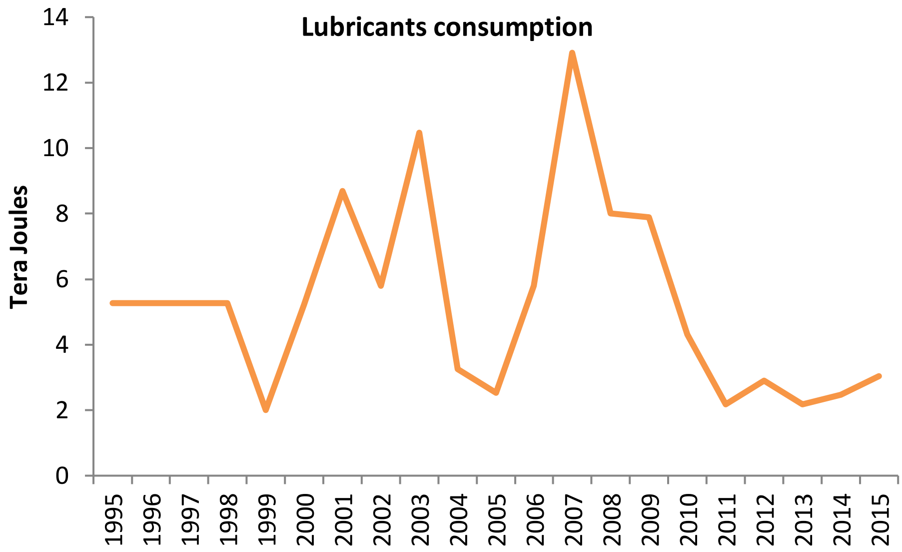


Figure 5.1 Total lubricants consumption between 1995 and 2015 (1995-1997 values are same as 1998)

Emissions

The emissions are calculated based on the above equation. Lubricants emission to the overall CO_2 emission is insignificant. Figure 5.2 shows the emission trend of lubricants.

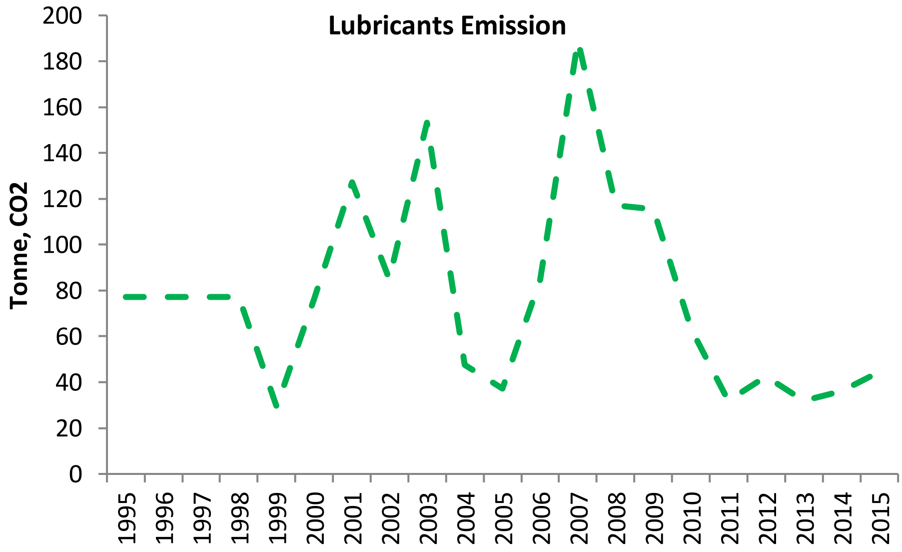


Figure 5.2 Total emissions from lubricants

5.2 PARAFFIN WAX USE

Paraffin wax is separated from crude oil during the production of lubricating oils. Al-Seef produces paraffin as an intermediary product. There is no data regarding how much of the paraffin produced is sold domestically. To avoid confusion, I used the imported paraffin wax data for calculation. Paraffin waxes are used in various applications ranging from candles, corrugated boxes, paper coating to food production and surfactants.

Methodological Issues

Even in the IPCC reports, very limited information is available regarding the solvents. I used the Tier1 method to estimate emissions from paraffin wax. The amount of paraffin wax (in tonnes) should be converted into energy units like TJ or GJ. The equation is described as

CO_2 Emissions = PW* CC_{wax}* ODU_{wax}*44/12

Where:

CO_2 Emissions – CO_2 emissions from waxes, tonne CO_2

PW = total wax consumption, TJ

CC_{wax} = carbon content of paraffin wax (default), tonne C/TJ (=kg/GJ), 20 tonne C/TJ

ODU_{wax} = ODU factor for paraffin wax, fraction = 0.2

44/12 = mass ratio of CO_2/C

Activity Data

As discussed above, the paraffin wax consumption is taken from the import-export database. Assuming all the values are consumed within the same year. Also, the database recorded values only from 1998, and I used the 1998 data for the previous years from 1995 to 1997 as shown in figure 5.3. There is no clear reason for the sudden peak in 2010.

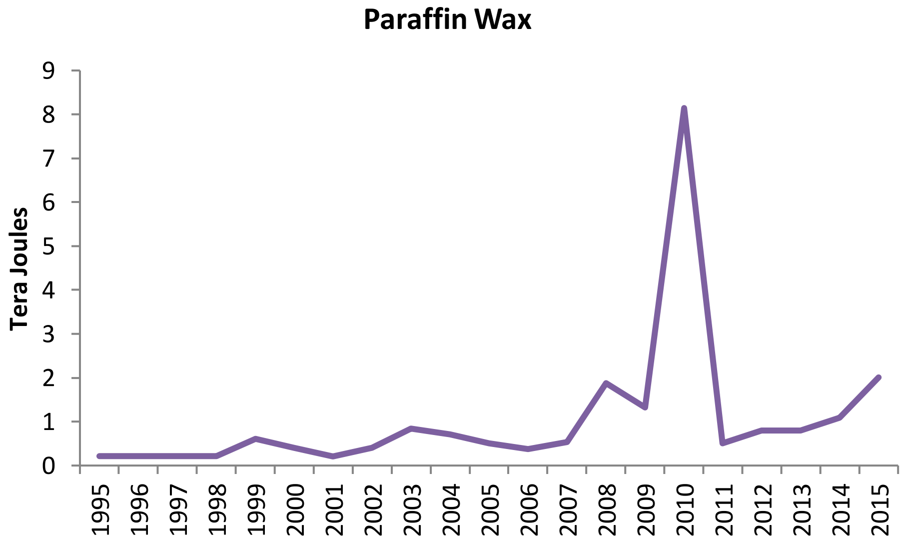


Figure 5.3 Total paraffin wax consumption between 1995 and 2015 (1995-1997 values are same as 1998)

Emissions

I estimated the emissions from paraffin wax based on the Tier-1 methodology. The total contribution of CO_2 emissions to the national inventory is insignificant. Figure 5.4 shows the emission trend of paraffin wax.

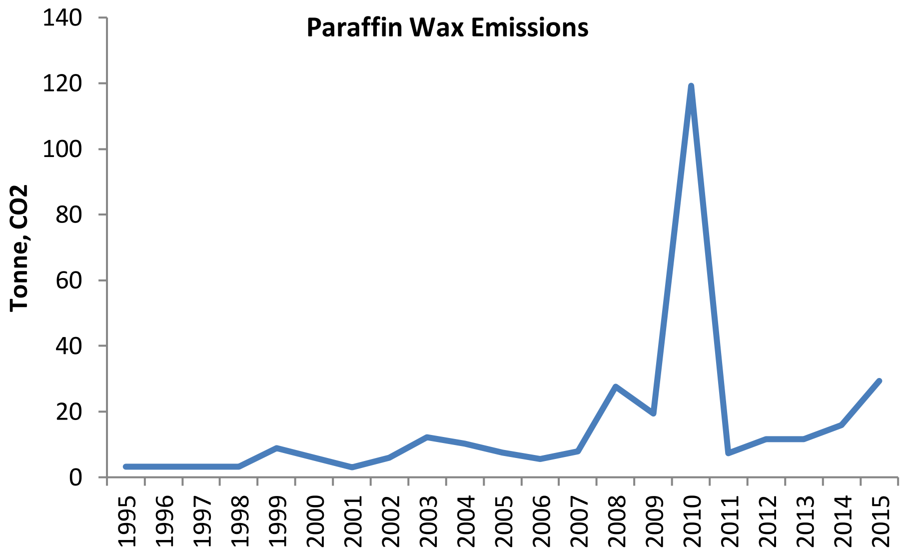


Figure 5.4 Total emissions from paraffin wax

5.3 ASPHALT CONSUMPTION

In this section, I report emissions from asphalt consumption in road paving. In the last few years, asphalt consumption has increased significantly because of the phenomenal growth of road construction projects. Asphalt is commonly known as bitumen; mainly produced in petroleum refineries. There are several asphalt production companies. There are 20 asphalt suppliers in the market. I sent emails to all of the companies, but I received responses only from 9 companies (refer to the Data Collection section above). The total asphalt consumption reported here is far from complete.

Methodological Issues

Asphalt is used for road paving and roofing products. I assume 99% of asphalt is used for road paving. Greenhouse gas emissions like CO_2, CH_4 are negligible compared to emissions such as NMVOC, CO, and particulate matter. I have consumption data only from 2002. Between 2002 and 2013, the asphalt consumption (given the incompleteness of data) increased 88%. I used averaged (2008-2013) annual growth rate of 11 percent to estimate the consumption of Asphalt for 2014 and 2015. I estimated only the process emission, the combustion emission related to asphalt production is known, and it is a by-product of the refinery process. I followed Tier-1 default approach to estimate emissions.

$E_{Polluntant} = AR_{Polluntant} \times EF_{Polluntant}$

$E_{Polluntant}$ = the emission of the specified pollutant

$AR_{Polluntant}$ = the activity rate for the road paving with asphalt, see figure 5.5

$EF_{Polluntant}$ = the emission factor for this pollutant (16 g/Mg asphalt)

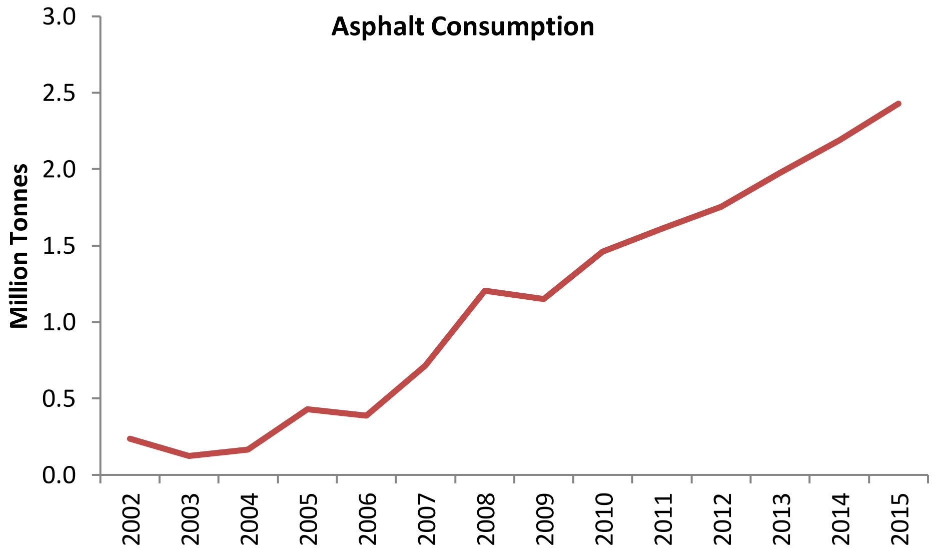


Figure 5.5 Asphalt production of 9 companies

Emissions

Asphalt in road paving emits NMVOC emissions, and the trend is upward because of the continuous increase in consumption. Figure 5.6 reports the NMVOC emission from 2002. I believe the number will significantly increase if all asphalt consumption is taken into account.

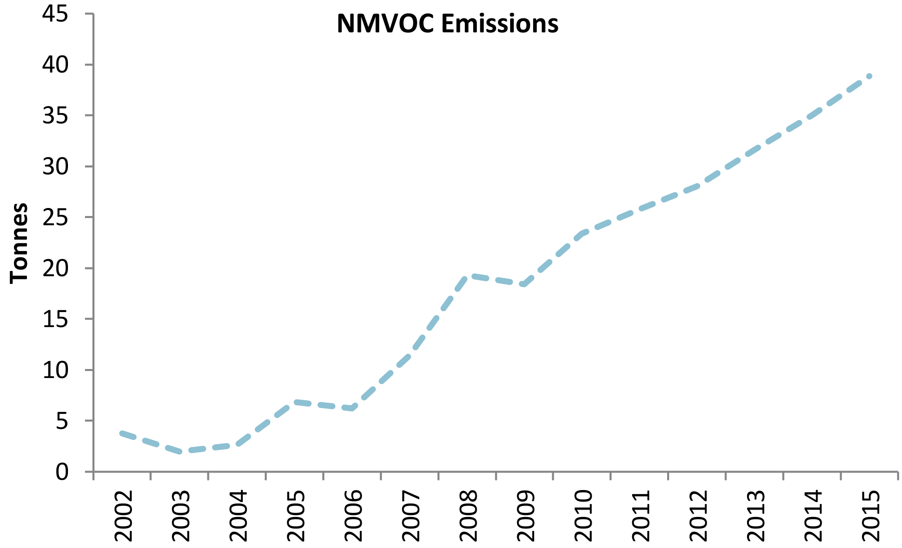


Figure 5.6 NMVOC emissions from asphalt road paving consumption

6. AGRICULTURE

In 2015, only 0.1 percent of total GHG emissions were from the agricultural sector. This corresponds to 0.844 million tonnes CO_2 equivalents. Emissions increased 260 percent between 1995 and 2015. The largest source of agricultural emissions is from fertilizers (N_2O) contributing nearly 60%, followed by enteric fermentation (CH_4) and manure management (N_2O) 20% each and less than 0.8% from manure management (CH_4).

As an arid nation with extremely scarce renewable freshwater resources and limited fertile land, agriculture is neither a primary economic activity nor a labour-intensive sector. The agricultural sector's contribution to the national economy is less than 0.2%, far below the comparison figure in 1995. Total cultivated land in 2014 was only 11,101 hectares, of which half of the land is allocated to fodder production, followed by dates and vegetables.

The self-sufficiency ratio is very small as shown in figure 6.1. Cereal production is nil, meat and poultry production is modest, reaching 10 percent in 2014. Citrus fruits, dates, and fodder are the main produce in Qatar. In last few years, there was a continuous push for increasing local production of perishable products such as vegetables and dairy. Despite growing investment in the agricultural sector, the local production is insufficient to cater to the domestic demand. Nearly 90 percent of the food in Qatar is imported. In 2015, 1.5 million tonnes of food was imported; whereas, the total domestic production (excluding fodder) was 0.2 million tonnes in 2014.

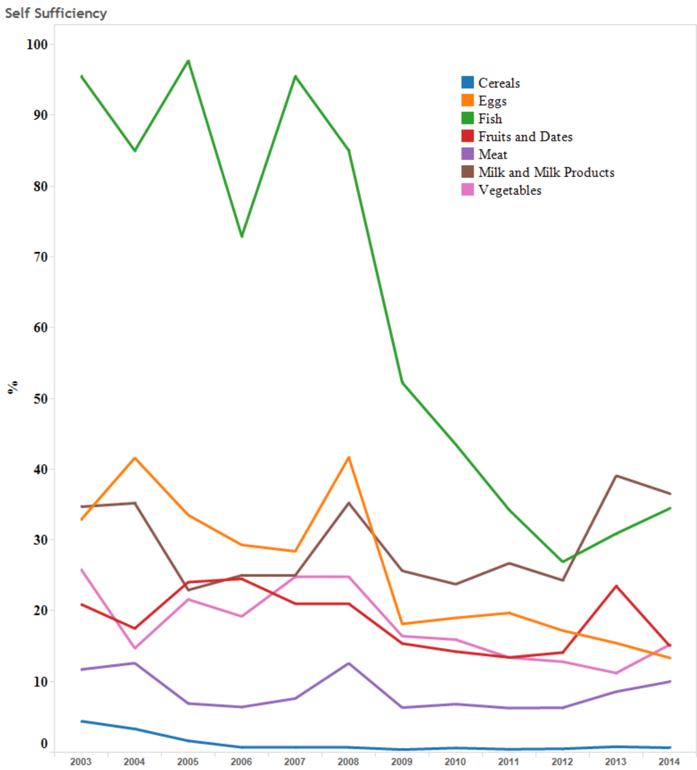


Figure 6.1 Self-sufficiency of various food categories from 2003-2014. (Note, there is a sharp decline in fish self-sufficiency as well, but the absolute production has increased slightly)

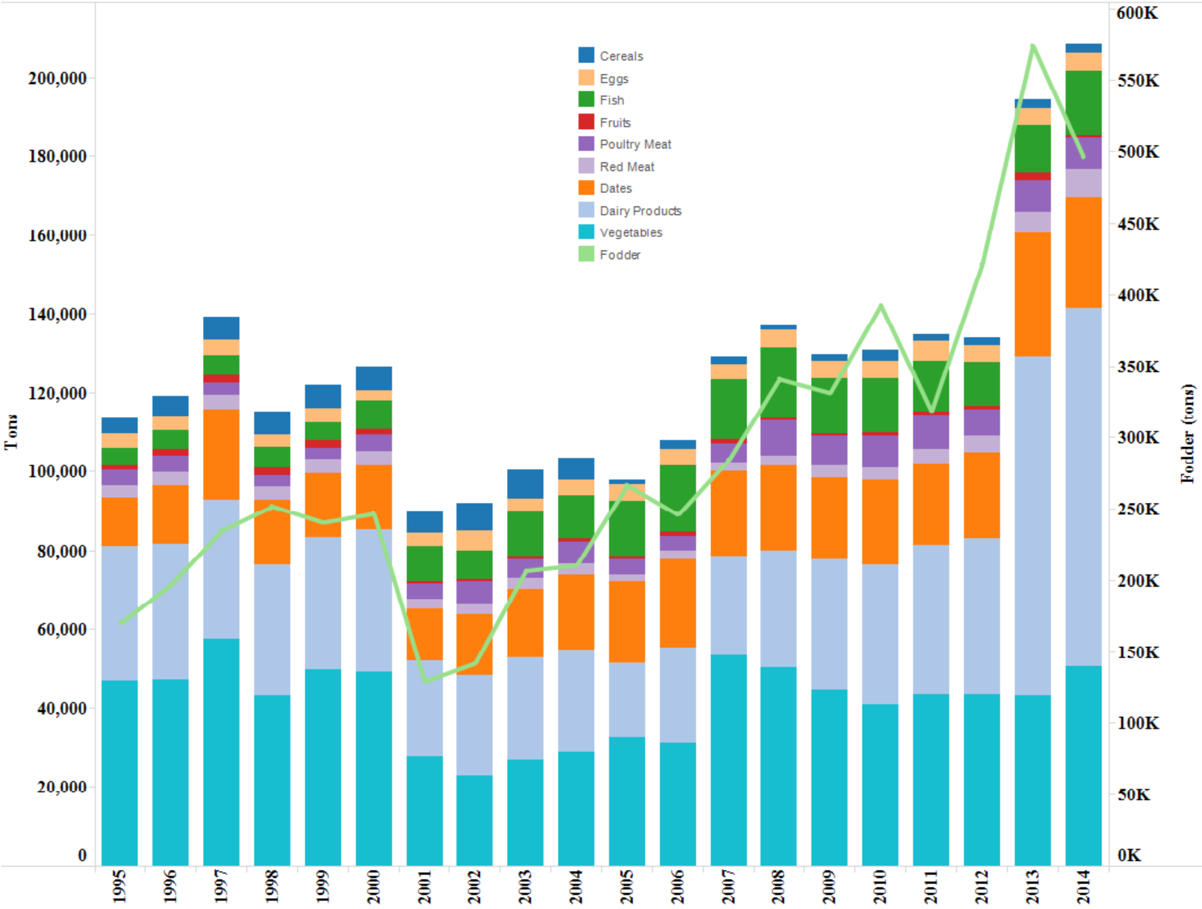


Figure 6.2 Agricultural productions in Qatar from 1995 to 2014

Agriculture contributes CH_4 and N_2O emissions. Greenhouse gas emission from the agriculture sector is calculated for three categories: Enteric Fermentation (1A), Manure Management (1B), and Emission from Soils (1C). Emission from rice cultivation (zero cultivation over the last three decades) and burning of Savannas is ignored.

Emission from selected livestock was taken into calculation (period in the bracket shows the livestock count availability)

- Cows, sheep, goats, camels and horses (1995-2015), deer (1995-2009)

The emission estimations are based on the Tier-1 method. At the time of writing the report, the 2015 agricultural and livestock data was not released. I assumed the agricultural production and livestock count remains the same as 2014.

The emission of greenhouse gases from agricultural activities includes:

- CH_4 emission from enteric fermentation and manure management.
- N_2O emission from manure management and agricultural soils.

Emissions not reported:

- Emissions from biomass burning. It is not a common practice to burn biomass
- Emissions from rice production, because the rice production is zero
- Emissions from swine (zero), poultry (insignificant number)
- NMVOC, particulate matter, heavy metals, and other non-GHG emissions were not estimated because of lack of detailed data

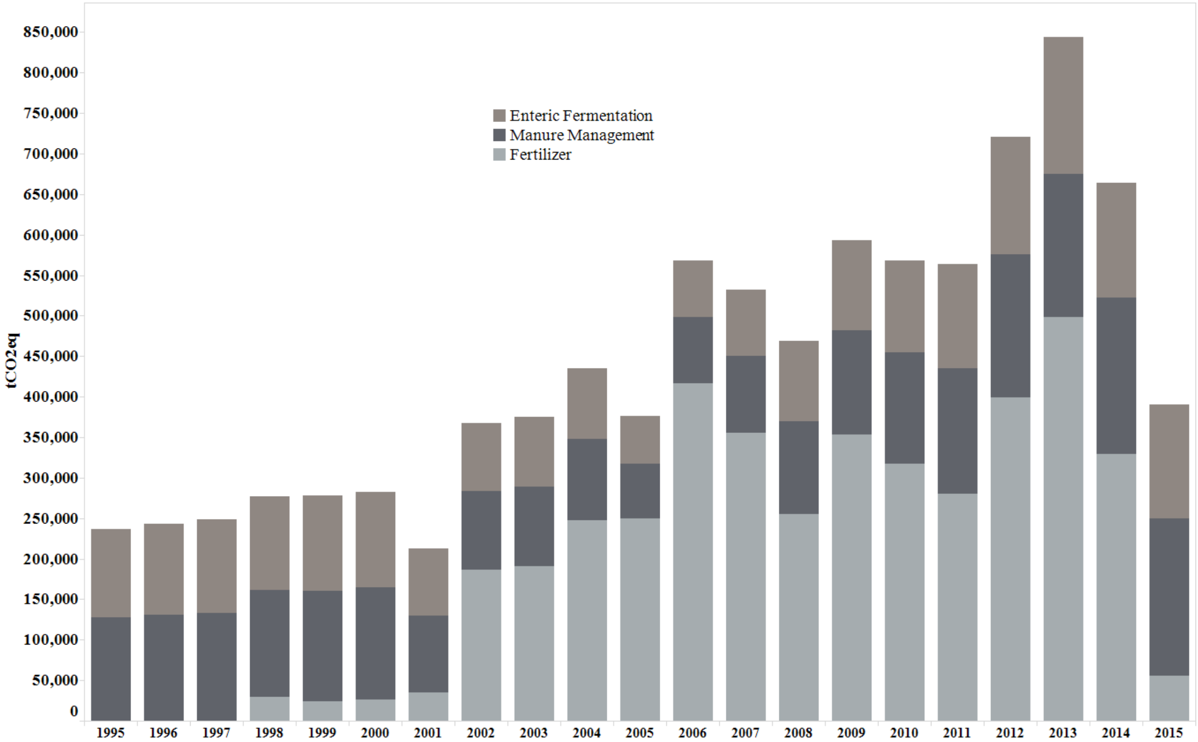


Figure 6.3 Emissions from the agricultural sector from 1995- 2015

	CO_2	CH_4	N_2O	PFCs/SF_6	Tier	Key Category
Enteric Fermentation	N	Y	N	NA	Tier-1	No
Manure Management	N	N	Y	NA	Tier-1	No
Emission from soils	N	N	Y	NA	Tier-1	Yes

6.1 ENTERIC FERMENTATION

Methane emissions from cattle, goats, sheep, camels and horses are estimated based on the default emission factors provided in the IPCC guidelines report. Lack of grazing land and green pastures limited the growth of the livestock industry in Qatar. Cattle are used for milk and meat production, and the feed is partially grown in Qatar and the rest is imported. To prevent desertification and overgrazing of lands, natural grazing was banned in selected Protected Areas. There is no publicly available information about the existing practices of natural grazing.

The major part of agricultural methane (CH_4) emission originates from enteric fermentation. The averaged emission during the period is 95.5%, and remaining 4.5% from manure management. The emission from camel production is the largest source (39%), followed by sheep (32%), goat (19%), cattle (8.7%) and the rest are from horses and deer.

Methodological issues

The methodology for estimating emissions from enteric fermentation is based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and the IPCC Good Practices Guidelines.

Data Collection

The total number of heads of various livestock is taken from the Annual Statistics Bulletin from 1995-2014.

Assumptions

a. There is a consistent reporting of livestock heads for all the years for the majority of the categories except horses since 2011.
b. All the livestock are mature, and 50 percent of cattle are for dairy production and 50 percent non-dairy cattle. Since the cattle livestock is very small, I used Tier-1 method.
c. Feed data is not available
d. 2015 livestock count is same as 2014
e. Poultry is insignificant, most of the domestic demand are met through imports

Emission Factors

The emission factor (EF) for CH_4 associated with enteric fermentation from all livestock based on the default emission factors given in the IPCC guidelines (2006) report. The values of emission factors for cattle are based on the Africa and Middle East region.

Category	***Emission Factor (Kg CH_4/head-yr)***
Dairy Cattle	46
Non-Dairy Cattle	31
Sheep/goat	6.5
Camel	46
Horse	18
Deer	20

Activity Data

The number of livestock of various categories is collected from the ASB reports published by QSA. Lack of sufficient grazing land is one of the prime reasons for having limited livestock. Lamb is the preferred meat in Qatar and majority of the meat is imported as shown in the self-sufficiency table. The sheep are used for meat production, not for wool rearing. There was a 60 percent decrease in camel heads in 2005, and gradually the number reached the 1995 levels in 2009 and has continued to increase since then. However, there is no clear evidence of why there was a major drop in the camel headcounts in that particular year.

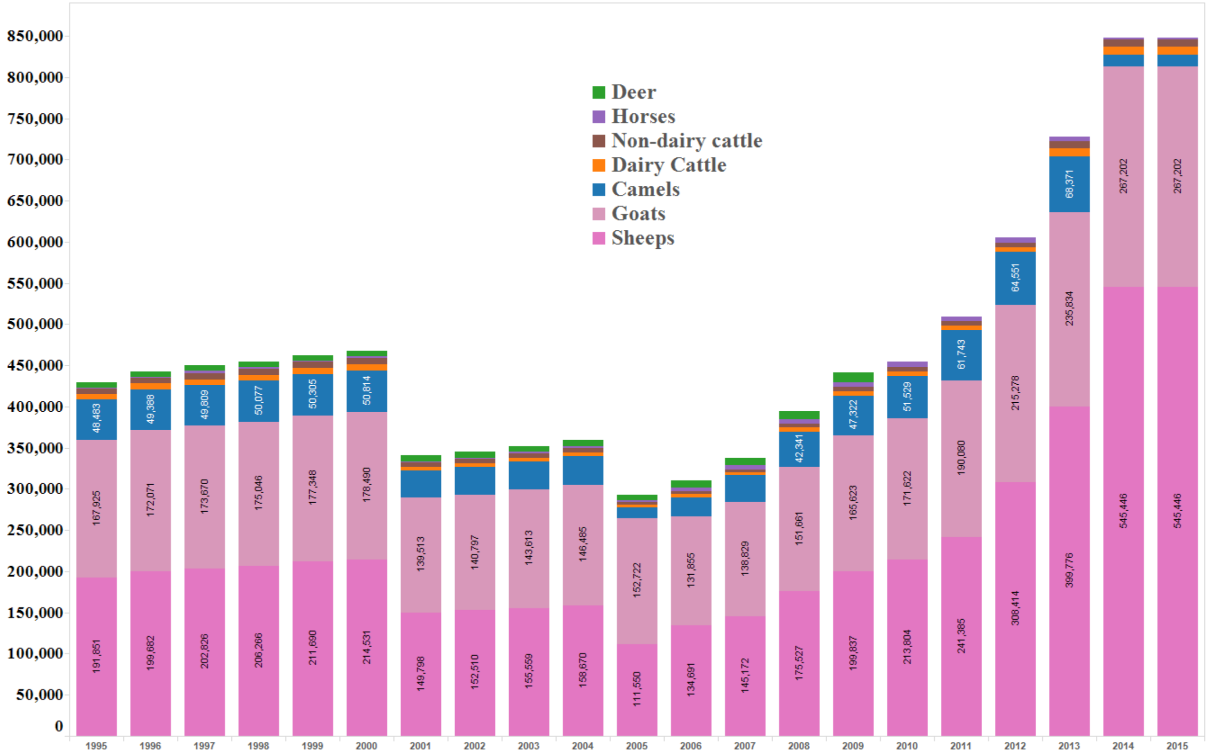


Figure 6.4 Livestock head counts from 1995 to 2015. Note: Headcount of deer is available only for 2009. 2015 data is equal to 2014.

Emissions = EF $_{(T)}$ * (N $_{(T)}$ /10^3)

Emissions = methane emissions from Enteric Fermentation, Tonnes CH_4 yr-1
EF (T) = emission factor for the defined livestock population, kg CH_4 head-1 yr-1
N (T) = the number of head of livestock species/category T in the country
T = species/category of livestock

Total Emissions from Livestock Enteric Fermentation

Total $CH_{4\,Enteric} = \sum_i E$i

The total emissions from the livestock enteric fermentation were estimated based on the Tier-1 method provided in the IPCC (2006) guidelines.

The CH_4 emission from enteric fermentation is given in figure 6.5 and table 6.1. From1990 to 2013, the emission has increased by 58%, which is primarily related to an increase in the number of goats and sheep. The number of sheep has increased from 0.19 million in 1995 to 0.39 million in 2013. A similar trend is observed in other livestock categories, too.

6.2 MANURE MANAGEMENT

Livestock manure generates CH_4 and breaks down into CH_4 gas through the fermentation process and is released aeration or agitation. Similarly, N_2O is produced via nitrification and denitrification processes. I applied the Tier-1 method because there was no detailed data available about local emission factors. Furthermore, the livestock sector contribution to national inventory is insignificant.

CH_4 emission from manure management is insignificant, whereas N_2O from manure management contributes 21% of the total GHG emissions from the agricultural sector in 2013, while the CH_4 emission is less than 1%. The primary sources of N_2O emission are from sheep (39%), camels (34%) and goats (19%).

Methane Emission from Manure Management is estimated from the equation

$CH_{4\,manure} = \sum_T N(T) * EF\ (T)$

CH_4Manure = CH_4 emissions from manure management, for a defined population, kg CH4 yr-1

EF(T) = emission factor for the defined livestock population, kg CH_4 head-1 yr-1

N(T) = the number of head of livestock species/category T in the country

T = species/category of livestock

Emission factors are influenced based on the temperature and the region. In my analysis, the emission factors are from the regional characteristics – Middle East – temperature above 28°C.

	kg CH_4/head/year
Dairy Cows	3
Sheep	0.2
Goats	0.26
Camels	2.56
Horses	2.19
Deer	0.22

Estimation Method

In my analysis, only the direct N_2O emission from manure management is utilized, while the indirect N_2O emission is neglected.

Direct N_2O Emission from Manure Management

$N_2O_{(mm)} = [\sum_S [\sum_T N(T) * Nex(T) * MS(T,S)] * EF(S)] * \frac{44}{28}$

$Nex_{(T)} = N_{rate(T)} * \frac{TAM}{1000} * 365$

N_2O $_{(mm)}$ = direct N_2O emissions from manure management in the country, kg N_2O yr^{-1}

N (T) = number of head of livestock species/category *T* in the country

Nex (T) = annual average N excretion per head of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1}

MS (T, S) = fraction of total annual nitrogen excretion of each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless

N rate (T) = default N excretion rate, kg, N (1000 kg animal mass) $^{-1}$ day^{-1}

TAM(T) = typical animal mass for livestock category *T*, kg $animal^{-1}$

EF3 (S) = emission factor for direct N2O emissions from manure management system *S* in the country, kg N2O-N/kg N in manure management system *S*

S = manure management system

T = species/category of livestock

44/28 = conversion of (N_2O-N) (mm) emissions to N_2O (mm) emissions

Activity Data

The number of livestock of various categories is collected from the ASB reports published by QSA. There is no detailed data about the usage of manure. I assume the manure is collected from the slaughtering house and major farms (cattle, sheep, goat, camel, and horses) and dried (the method of drying is unaware, assuming it's sun drying) and used as compost for agriculture and landscapes in public places.

The default values for the nitrogen excretion rate are taken from the IPCC report (Table 10.19) for the Middle East region:

	N_{rate} (kg N (1000 kg animal mass) $^{-1}$ day^{-1}	Annual Excretion Rate kg animal^{-1} yr^{-1}
Cows	0.7	79.97
Sheep	1.17	22.21
Goats	1.37	15.50
Camels	0.46	92.35
Horses	0.46	60.44

Unfortunately, very little information is available about manure management. I assumed the manure is managed as a dry lot. As the description says, dry lots are most typically found in dry climates. The default emission factors for direct N_2O emissions is taken from the IPCC (table 10.21) report,

EF_3= 0.02 [kg N_2O-N (kg Nitrogen excreted) $^{-1}$]

Figure 6.5-6.6 shows the CH_4 and N_2O emission from manure management from 1995 to 2015.

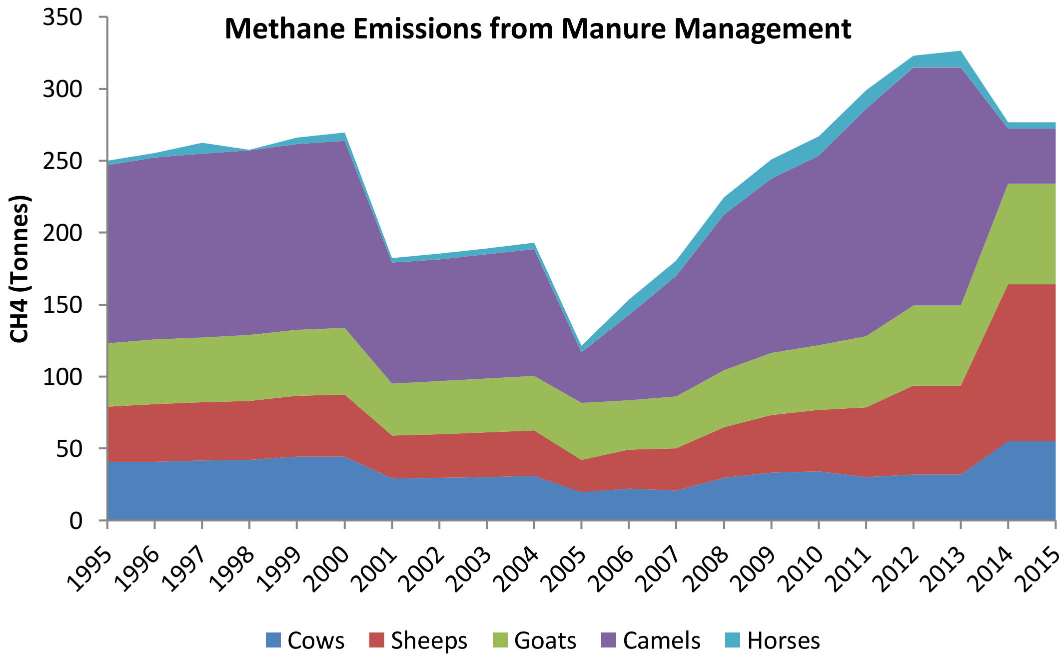


Figure 6.5 Methane emissions from manure management from 1995 to 2015

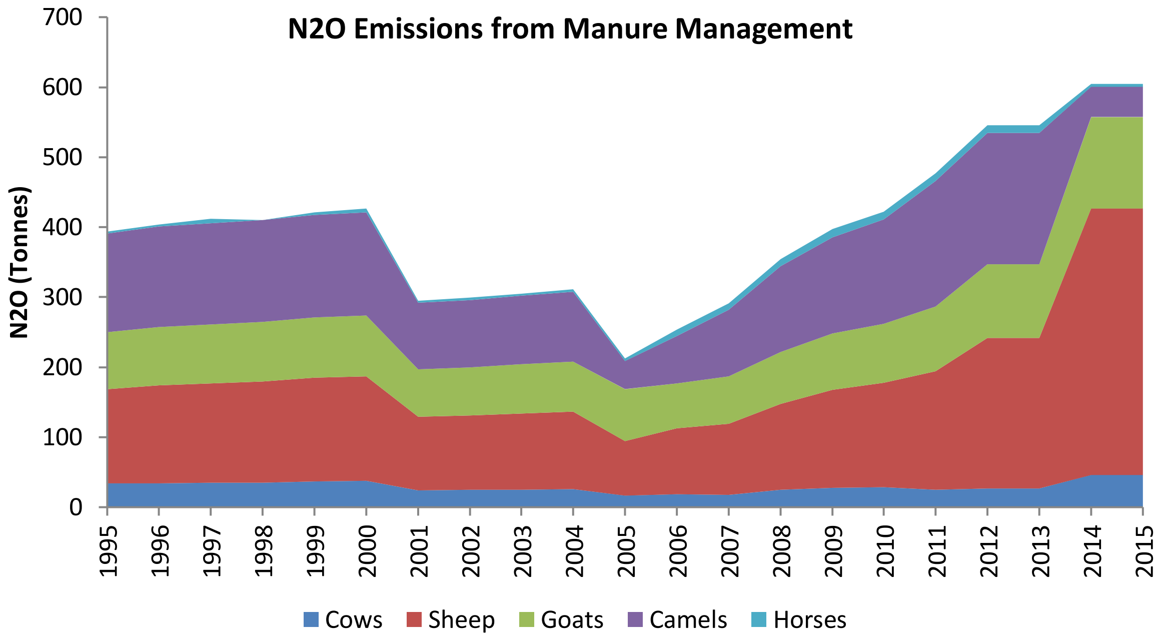


Figure 6.6 N_2O Emissions from Manure Management from 1995 to 2015.

There is considerable effort needed to understand the handling of manure. Also, the average weight of livestock categories is unreported in any of the reports published by the Ministry of Environment (Agriculture sector). The average TAM - typical animal mass- is taken from other countries that share relatively similar geographical features. Having a local TAM will provide an accurate nitrogen excretion rate. In further analysis, these inconsistencies will be addressed.

6.3 N_2O EMISSIONS FROM AGRICULTURAL SOILS

In 2015, the emissions from agriculture soil accounted for 14% of N_2O emissions from the agricultural sector. The emission estimated from agriculture soils are based on the Tier-1 method since detailed information is unavailable.

Description

Three sources of N_2O from agricultural soils are distinguished in the IPCC methodology, namely:

- Direct emissions from agricultural soils (from the use of synthetic fertilizers, animal excreta nitrogen used as fertilizer, biological nitrogen fixation, crop residues, industrial and urban wastes and the cultivation of soils with a high organic content);
- Direct soil emissions from animal production (emissions from droppings on pastures);
- N_2O emissions indirectly induced by agricultural activities (N losses by volatilization, leaching, and runoff).

In my analysis, I consider only the emissions from the usage of synthetic and organic fertilizers. The emissions from crop residues, biological nitrogen crops, and others are ignored because of negligible quantity. The quantity of sludge used as a fertilizer is unknown.

Activity Data

Very limited information is available on organic and synthetic fertilizer consumption. Nevertheless, from 2002 consumption of organic fertilizers is reported in the Annual Statistics Bulletin. However, this information is reported sporadically. The organic fertilizers are divided into three parts: fine and rough organic and poultry manure. From my estimation, the animal excreta are collected from the private/government-managed animal farms managed and converted into compost and used as soil enhancers. Qatar is one of the largest producers of synthetic fertilizers; it exports most of its production to Asia and Europe. There is accurate data about the export volume, but the domestic consumption of fertilizers purchased from the local production unit is unavailable. Based on the trade database, Qatar has imported various kinds of fertilizers and I assumed all of it’s used for food and forage production. In my analysis, I calculated the emissions based only on the imported fertilizer.

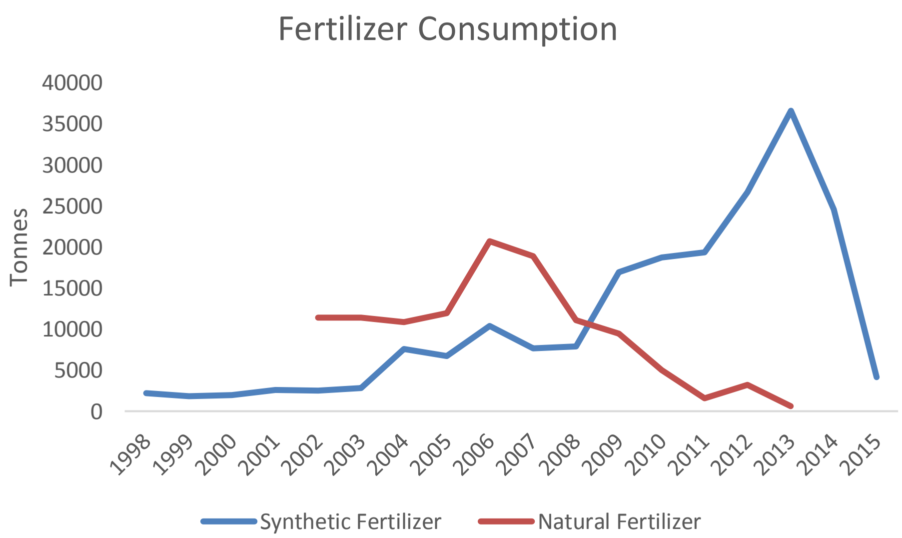


Figure 6.7 Fertilizer Consumption between 1998 and 2015

Emission factors

N_2O

The IPCC default emission factor for organic and synthetic fertilizer is 0.01 kg N_2O-N/kg N has been used for all sources of direct N_2O emissions from agricultural soils, and 0.01 kg N_2O-N/kg N, 0.0075 kg N_2O-N/kg N for indirect N_2O emissions (volatilization and leaching). (IPCC 2006).

$N_2O = (\sum_i Fi * EFi)*\frac{44}{28}$

Total N_2O emissions resulting from organic and synthetic fertilizers (tonnes)

Fi – Total amount of synthetic and organic fertilizers consumed (tonnes)

EF_i – Emission factor for synthetic and organic fertilizers kg N2O-N/kg N provided in the IPCC tables

44/28 – Conversion from kg N_2O-N to N_2O

The N_2O emissions from agricultural soils have increased by 1600% from 1997 to 2013. This value should be taken with considerable caution because the fertilizer consumption was not fully reported in the previous reports. It is highly unlikely to make an accurate estimation.

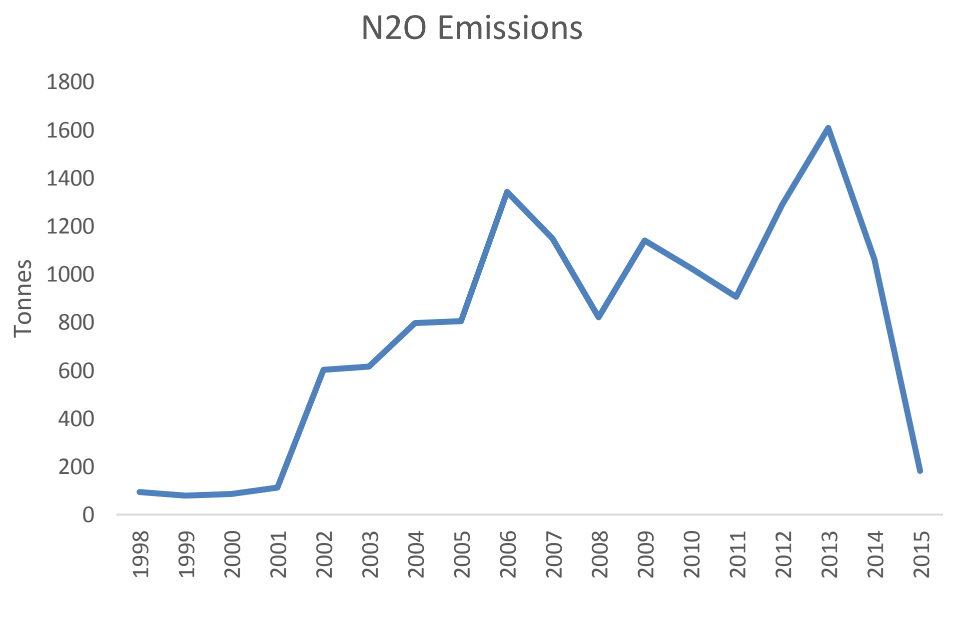


Figure 6.8 N_2O Emissions from Fertilizers Consumption between 1995 and 2015

7. WASTE

The waste sector consists of two categories: a) Solid waste disposal on land, and b) Wastewater handling. Two other major sub-categories are ignored: Waste incineration and Other waste because of a lack of detailed information. I believe in future inventories these sections will be discussed.

In 2015, the waste sector's contribution to the national GHG inventory was less than 1 percent. The total emission from the waste sector is 0.56 million tonnes CO_2 equivalents. In 2015, emissions from solid waste and wastewater accounted for 29 and 71 percent, respectively. The emissions from solid waste declined over 60 percent in 2015 compared to its peak in 2012. Last year, landfill emission showed an upward trend because of growing landfill waste and the treatment unit running at full capacity. Compared to 2012, the wastewater emission share had increased from 41 to 71 percent in 2015.

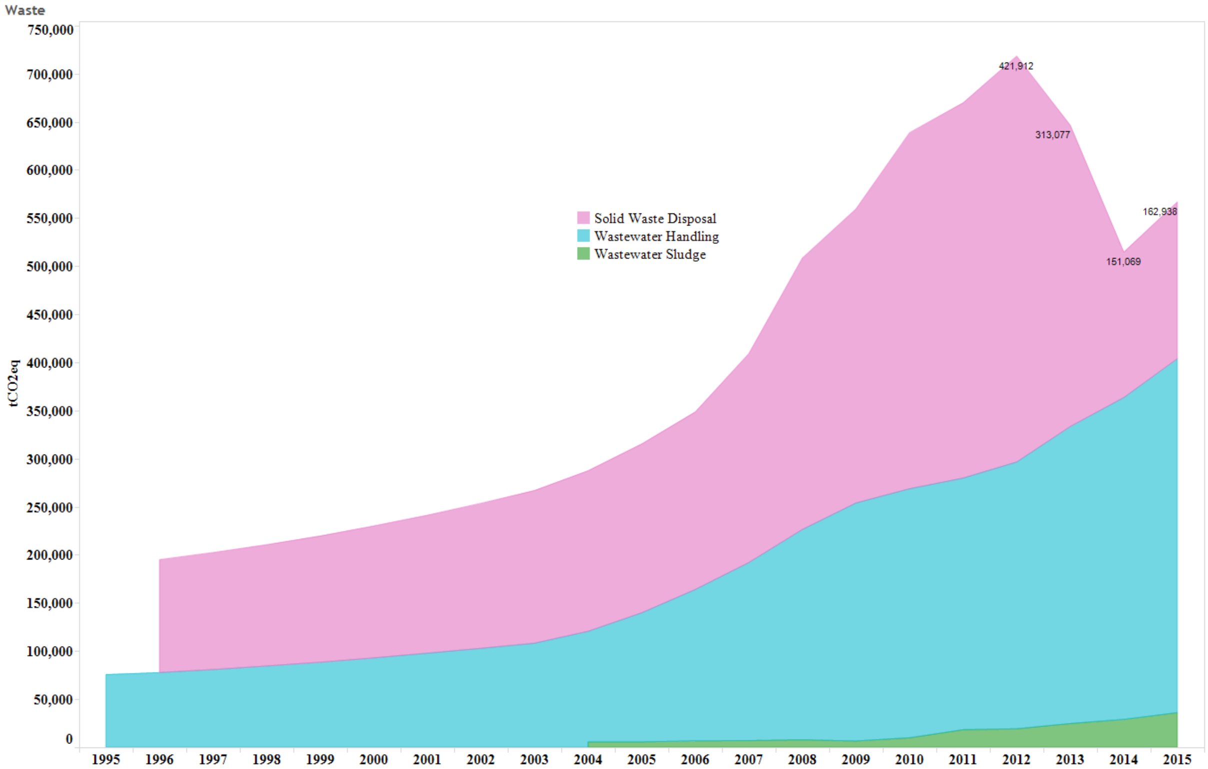


Figure 7.1 Total emissions from the waste sector between 1995 and 2015

7.1 MANAGED WASTE DISPOSAL ON LAND

Municipal solid waste (MSW) is growing gradually and is influenced by various factors, most notably, economic development, the degree of industrialization and urbanization, household income, and public behaviour. Over the last few years, Qatar's disposable income and living standards have increased remarkably, which in turn has increased municipal solid waste. In the last two decades, MSW had increased 350% from 0.24 million tonnes in 1995 to 1.1 million tonnes in 2015. However, per capita waste has declined from 1.49 kg/day in 2006 to 1.24 kg/day in 2015. This is mainly due to an increase in the low-income population contributing less waste compared to the high-income households. Besides household waste, commercial waste (not industrial waste) is increasing at an alarming rate. The recycling rate is very low. The organic waste from landscapes, slaughterhouses, food waste from hotels and sludge from wastewater treatment plants are converted into compost and sold to local farms as organic fertilizers.

Industrial waste and hazardous waste is managed separately, and there is no publicly available information. Despite multiple requests through several emails to the concerned authorities, I was unable to ascertain required the information. I believe the industrial waste managed by Messaied and Ras Laffan Industrial Cities. No further information is available in this regard. Therefore, I ignored the emissions from the industrial waste subsector. Since 2015, 56% of domestic waste has been treated in waste treatment units. Although the government built one of the largest solid waste treatment centres, the annual landfill waste continues to increase and the centre is unable to treat the entirety of the generated waste.

Domestic Solid Waste Management Centre - Because of a shortage of land and increasing complaints from neighbourhoods, the government built a sophisticated solid waste treatment plant in 2011. The plant became fully operational in 2012 which led to the closure of one of the landfill sites (Umm Al-Afai). The design capacity of the plant is 2,300 tonnes of mixed domestic solid waste per day. The plant is comprised of state-of-the-art waste sorting and recycling facilities, an anaerobic digestion composting plant, a 1,500 ton-per-day incineration plant, and a sanitary landfill (Keppel Seghers, 2014).

> The pre-processing aspect of the Center is especially important, because it enables materials suitable for recycling and energy recovery to be separated and transferred to the appropriate processing line. This is done through our proprietary ‘dano drum', which feeds into magnetic separators, eddy current separators, and infra-red and wind sifters. This entire process can help to recover 90 per cent of metals, and 50 percent of plastics for recycling.
>
> Organic waste is sent to the Anaerobic Digestion & Composting plant to produce soil enhancers for use in agriculture and landscaping as well as energy. The remaining waste which is not recycled or composted is then sent to an advanced and fully controlled incineration process, where energy will be recovered to generate steam and electricity. The facility has three separate lines with a combined capacity of 1,500 Tonnes per day.

Around 30 MW of electricity is generated by the energy recovery unit which is exported to the national grid after meeting plant requirements. In 2015, 245 GWh of electricity was generated, which is equivalent to 70 percent of electricity consumed by the large hotels in Qatar.

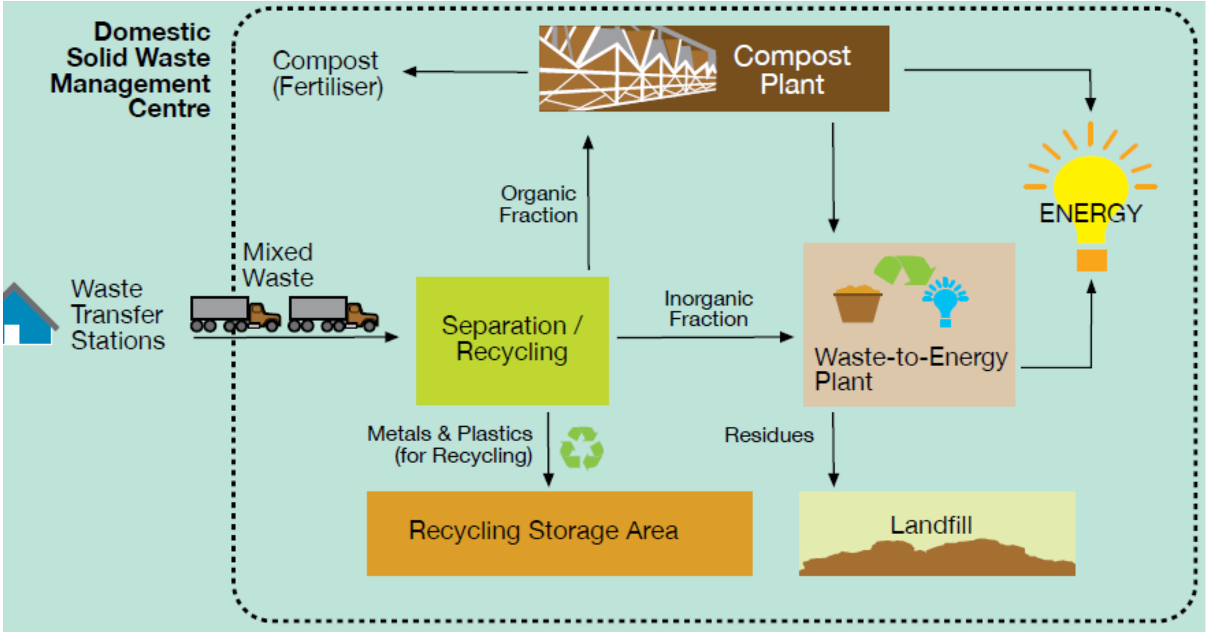


Figure 7.2 Domestic waste management process (Source: MME)

Methane and other gases are emitted during the biological decomposition of waste. Various meteorological/physical factors influence the decomposition of waste. In the initial weeks or months, decomposition is aerobic and then during the anaerobic process, methane is emitted.

In Qatar, the solid waste disposal sites (or landfills) are generally used to dispose of all forms of waste ranging from construction (gravels/sand), tires, scrap metal and domestic waste. In 2013, 77% of the total waste was from the construction sector, followed by scrap metals (15%), domestic waste (8%) and the rest from others.

The Solid Waste Disposal Sites (SWDS) emissions are based on a First Order Decay (FOD) model described in Volume 5: Waste Chapter, IPCC report (IPCC, 2006). From 2004, waste data is reported in the Annual Statistics Bulletins with varying degrees of detail. I used the 9-year average of per capita domestic waste to estimate the total waste generation in the earliest years. On average, 0.49 tonnes of domestic waste is produced per person, which is equivalent to Norway (OECD, 2013).

The CH_4 emissions from SWDS are calculated based on the equation

CH_4 Emissions = $[\sum_x CH_4\ generated x, T - R_T]$* (1-$OX_T$)

Where:

T = inventory year

x = waste category or type/material

R_T = recovered CH_4 in year T (zero in our case, there is no record of CH_4 recovery)

OX_T = oxidation factor in year T, (fraction)

Based on the limited information, I made following assumptions:

a. The composition of waste as follows: Food (25%), paper (10%), wood and garden waste (10%), textiles (5%), plastic and other inert waste (50%). Garden waste is basically from the public landscapes (parks).
b. Default methane generation rate (*k*) values are taken from the IPCC report or the "dry tropical climate region." (pp 3.17)

Paper/textiles	0.06
Wood	0.04
Garden	0.08
Food	0.1

c. Methane Correction Factor (MCF) default value is 0.4 for unmanaged – shallow site

Activity Data

Waste data are increasingly reported in the Annual Statistics Bulletins with varying degrees of detail. The first data was reported in 2004, and previous data was calculated based on per capita municipal waste generation. Once the waste treatment plant came into operation, one of the landfills was closed; redirecting all the waste to treatment centres generating electricity, compost and incinerating the inorganic waste.

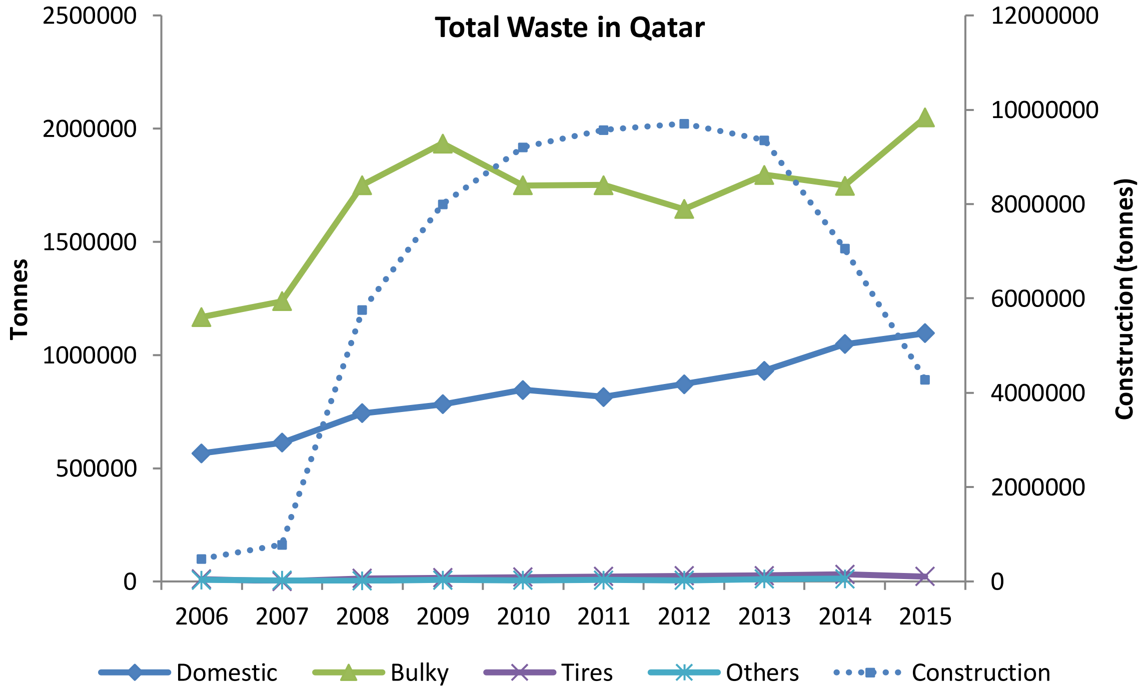


Figure 7.3 Total waste generated from different sectors.

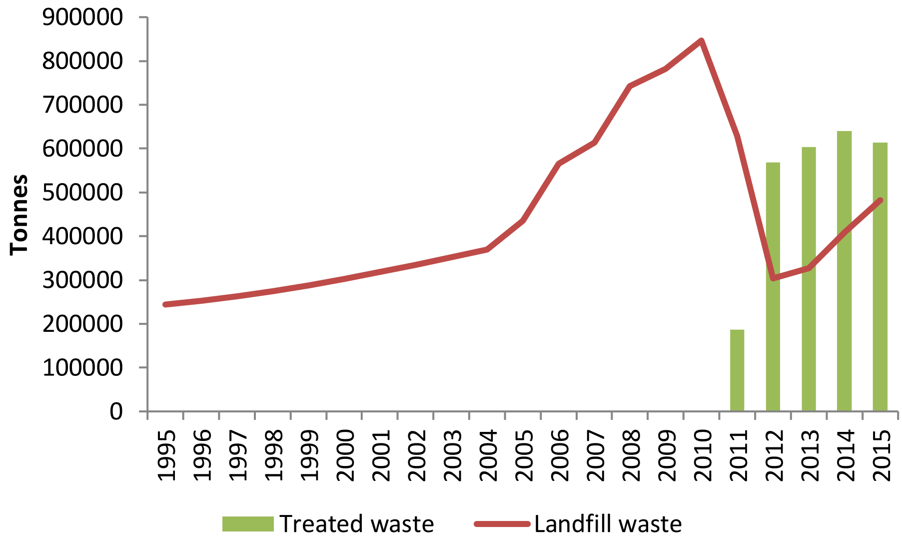


Figure 7.4 Total domestic waste (1995-2003 are estimated based on averaged per capita emissions of 2003-2013; 2003-2015 data are reported in the national bulletin)

Emissions

In 1996, nearly 5,000 tonnes of CH_4 emission was released from the landfills and this amount increased to 13,419 tonnes in 2013. There is a substantial reduction in landfill emissions from 2012 as shown in figure 7.3, because of the new facilities that treat domestic waste. In the next few years, I expect to see a further reduction of CH_4 emissions once the facilities are in full operation.

7.2 WASTEWATER HANDLING

Description

Wastewater handling and sludge account for 71 percent of the emissions in the waste sector. Between 1995 and 2015, the CH_4 emission increased three times as a result of an increase in population, urbanization, and collection of domestic wastewater and an improved sewerage network. CH_4 emission (CO_2eq) from wastewater handling increased from 74,531 tonnes in 1995 to 303,368 tonnes in 2013. N_2O emission is insignificant from wastewater handling. The CH_4 emission from sewage sludge is also very minimal, but the trend is upward. In 2004, the total emission from sludge was 5,832 tonnes; it increased to 24,817 tonnes in 2013. Figure 7.5 shows the emissions from wastewater. The N_2O emission from wastewater handling is insignificant.

Qatar began its first domestic wastewater treatment plant in 2004 with very limited capacity. In less than a decade, the capacity increased from 54,000 m^3/day in 2004, to 809,000 m^3/day in 2015. Nearly 1.6 million m^3 of water is untreated and discharged into open lagoons, which is significantly less when compared to 2011 (16.42 million m^3). Domestic sewage is collected from underground sewers in urban areas and transported to centralized wastewater plants located in three distinct locations. Fortunately, most of the treatment plants are equipped with advanced chemical/biological treatment units. The treated sewage effluent (TSE) is used primarily for agriculture, aquifer recharge and landscaping. The sludge (dry solids) generation increased from 6480 in 2004 to 40,099 tonnes in 2015. There is no further information on the processing of sludge and further use.

Huge quantities of industrial wastewater are treated every day as a result of water-intensive petrochemical/mining activities. I ignored industrial wastewater treatment units in this study because of a lack of access to sufficient information. Additionally, the industrial sewerage system is not connected to the domestic sewerage system. The industrial effluent is collected from the industrial cluster zones based in three different locations (Ras Laffan, Messaied, and Dukhan). Wastewater from the Industrial Area (labour residences) is connected to the domestic sewerage because there are no major industrial activities.

Methodological issues

CH_4

Methane emissions from domestic wastewater treatment and sludge are included in this inventory. Methane emissions from industrial wastewater treatment are not calculated. The emissions are calculated according to the IPCC methodology:

CH_4 Emissions = $[\sum_{i,j}(U_i * T_{i,j} * EF_j)](ToW - S) - R$

Where:

CH_4 Emissions = CH_4 emissions in the inventory year, kg CH_4/yr

TOW = total organics in wastewater in inventory year, kg BOD/yr (I took 40 g/person/day, based on the Asia, Middle East data) TOW is measured as the product of population and country specific per capita BOD.

S = organic component removed as sludge in inventory year, kg BOD/yr (Zero)

R = amount of CH_4 recovered in inventory year, kg CH_4/yr

U_i = fraction of population in income group *i* in inventory year (0.95, 95% of the population in Qatar are living in urban cities and most of them are middle-to-high income)

$T_{i,j}$ = degree of utlisation of treatment/discharge pathway or system, *j*, for each income group fraction *i* in inventory year (all the country uses underground sewers to collect wastewater)

i = income group rural, urban high income and urban low income

j = each treatment/discharge pathway or system (sewer – for urban high income its 0.95)

EF_j = emission factor, kg CH_4/kg BOD (0.48)

N_2O Emissions from Wastewater Effluent

Nitrous oxide (N_2O) emissions can occur as direct emissions from treatment plants or indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea. Direct emissions from nitrification and denitrification at wastewater treatment plants may be considered as a minor source.

N_2O Emissions = $N_{effluent}$ * $EF_{effluent}$ * 44/28

N_2O Emissions = N_2O emissions in inventory year, kg N_2O/yr

$N_{effluent}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr

$EF_{effluent}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N (default emission factor is 0.005)

The factor 44/28 is the conversion of kg N_2O-N/kg N into kg N_2O

In Qatar, over 95% of the wastewater is treated in central plants. So, I used a different equation for calculating N_2O emissions from wastewater based on the IPCC's subcategory of centralized wastewater treatment processes. The equation as follows:

$N_2O_{plants} = P*T_{plant}*F_{ind\text{-}com}*EF_{plant}$

P = human population

T_{Plant} = degree of utilization of modern, centralized WWT plants, %

$F_{ind\text{-}com}$ = fraction of industrial and commercial co-discharged protein (default = 1.25)

EF_{plant} = emission factor, 3.2 g N_2O/person/year

Methane Emissions from Sludge

The IPCC equation for CH_4 emission from sludge is:

Annual methane emissions = Annual sludge production (tonnes per year) * methane potential (g CH_4 per tonne) * emission factor

Annual sludge production – data is collected from the wastewater treatment plants from 2004 (figure 7.5)

Methane potential – 200 kg/tonne of sludge

Emission factor – 0.18

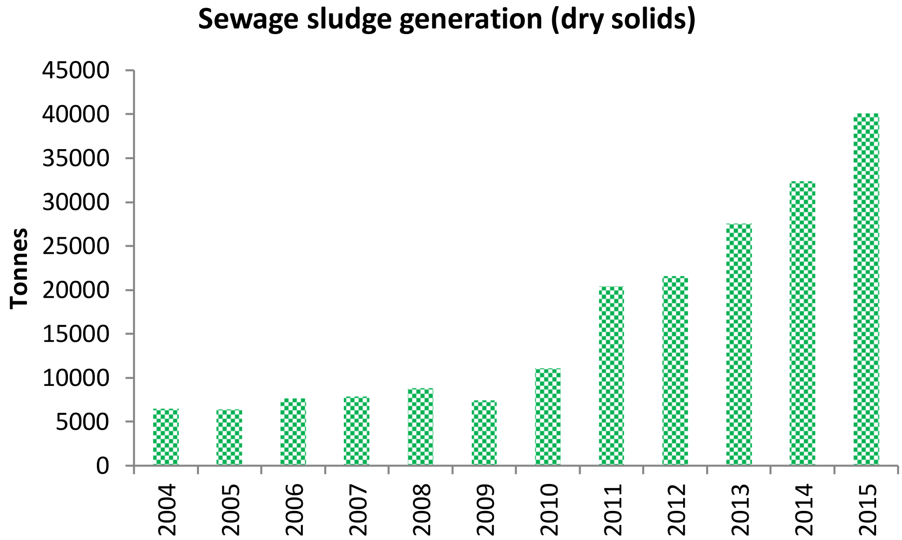


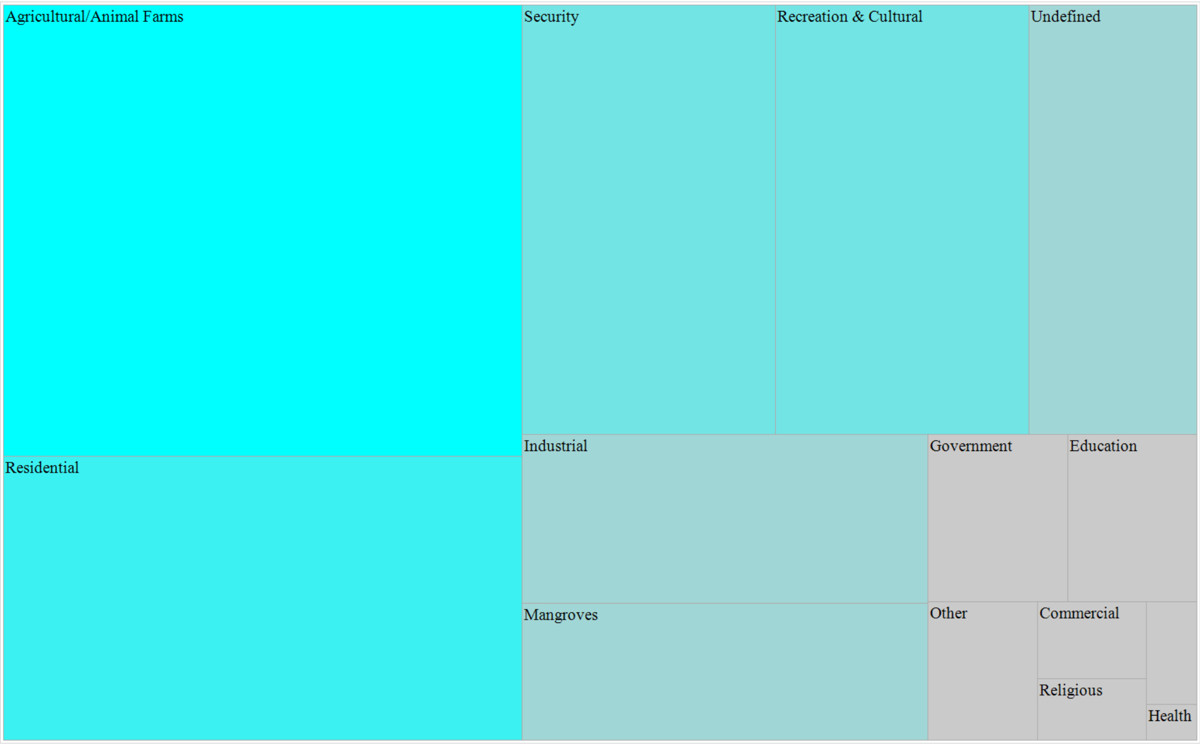
Figure 7.5 Annual Sludge Production from 2004 to 2015

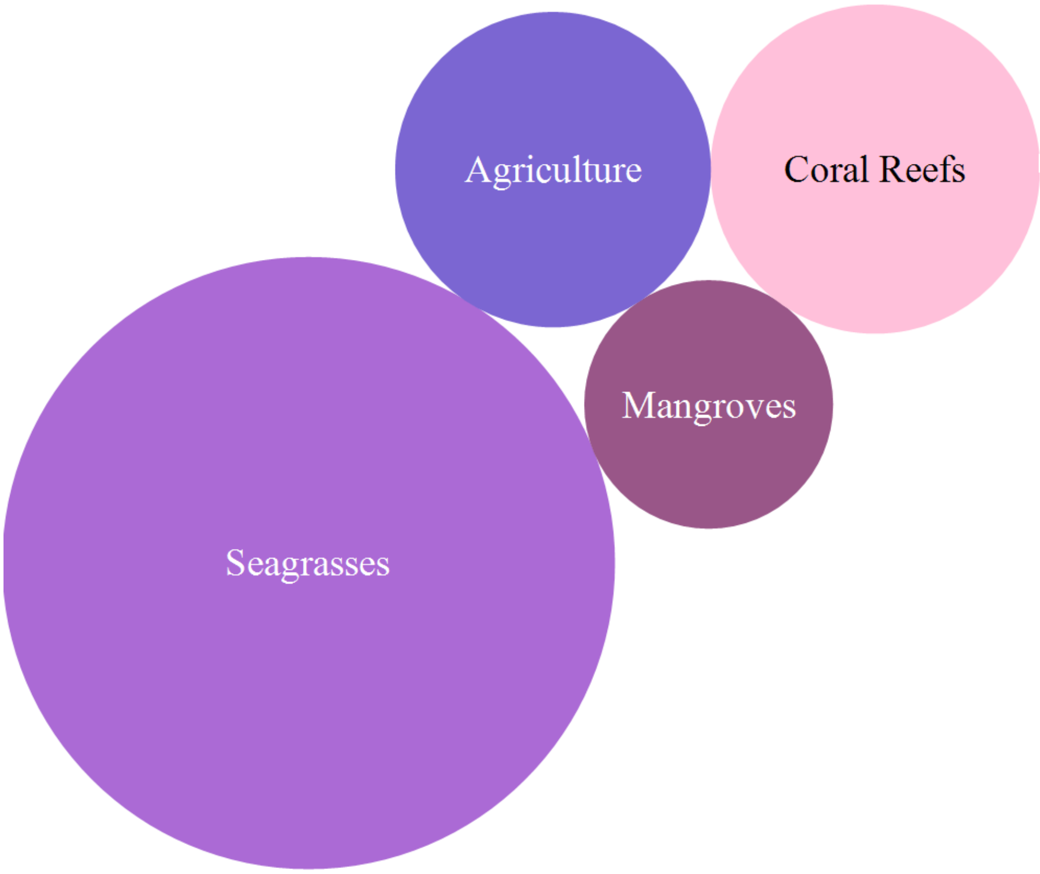
8. LAND-USE, LAND-USE CHANGE AND FORESTRY (LULUCF)

This chapter provides estimates of emissions and removals from Land Use, Land-Use Change and Forestry (LULUCF).

Qatar is an arid country with limited diverse landscapes and a total land area that equals 1.1 million hectares, of which 90 percent of the land is a desert. It has negligible forest area and limited land amenable to agriculture. Also, it has pockets of mangroves, coral reefs, and seagrasses dispersed over the coastal areas. In my study, I only estimated the emission removals from the terrestrial biomass – permanent croplands (woody crops) and mangroves. I ignored the emission removals from seagrasses.

Agricultural expansion during the last two decades was very limited because of biophysical limitations such as limited freshwater, poor soil quality, and extreme weather. There are several native and wild species grown that are acclimatized to the desert conditions. I believe the government has conducted some studies on its biological landscapes; however, I do not have access to such reports. In the last few years, the Ministry of Environment has taken some measures to protect terrestrial and marine biodiversity. There was a sudden shift in policy towards Protected Areas. In fact, protected areas received considerable attention from the highest level of the State. In 2013, the combined land and marine protected area was **3,463.48 km^2**. This accounts for 23% of Qatar's total land area.


Agricultural/Animal Farms
Security
Recreation & Cultural
Undefined
Residential
Industrial
Government
Education
Mangroves
Other
Commercial
Religious
Health


Agriculture
Coral Reefs
Mangroves
Seagrasses

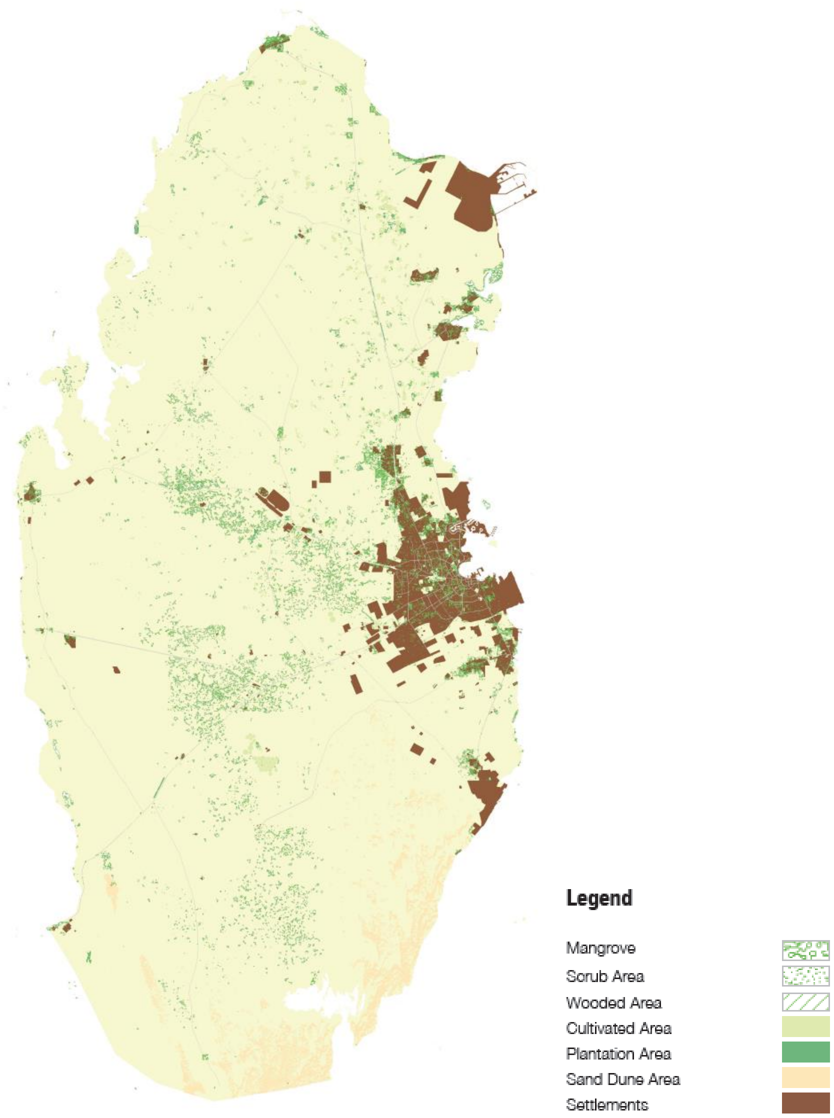


Figure 8.1 Qatar's terrestrial and marine land use (Source: Qatar Atlas 2010, MDPS; MMUP, 2015)

Mangroves occur at the coastlines of Al-Khor, Umm Saeid, and Khaw al-Udayd, with a total area of 7,073 hectares in 2015. There was no time series record of the mangroves area. I believe that in the past the mangroves area was much larger, and much of this area was sacrificed to the development of major oil/gas and petrochemical industries (in Al-Khor and Umm Saeid). Similarly, seagrasses and coral reefs occur on the eastern side of Qatar's coast, with an area of 42,853 and 12,387 hectares, respectively.

In 2015, the LULUCF sector contributed to total emissions with a net sequestration of 2.35 $MtCO_2eq$, which is only 2.14% of the total emissions. The average annual net sequestration from the LULCF sector was 2.44 $MtCO_2eq$ per year for the period 1995-2015. However, I believe this number will increase, if all kinds of land uses, such as wetlands, grasslands, mangroves, etc., are included.

Annual Carbon Stock changes for the entire AFOLU sector is estimated as the sum of changes in all land-use categories:

$\Delta CAFOLU = \Delta CFL + \Delta CCL + \Delta CGL + \Delta CWL + \Delta CSL + \Delta COL$

Where:
ΔC = carbon stock change
Indices denote the following land-use categories:
AFOLU = Agriculture, Forestry and Other Land Use
FL = Forest Land, considered as zero
CL = Cropland (Perennial Woody Crops)
GL = Grassland, considered as zero
WL = Wetlands, considered as mangroves
SL = Settlements, considered as zero
OL = Other Land

Removing land-use changes that are not applicable to Qatar and accounting for a lack of data for grasslands, the final equation is:
$\Delta CAFOLU = \Delta CCL + \Delta CWL$

A few assumptions are made to estimate the emission removals:

a. Permanent crops like date palm, fruits, and forage are considered to be perennial woody crops
b. The harvesting and removal of wood from these crops is negligible
c. Non-CO_2 emission is considered as zero

Broad Categories	**Sub Categories**
Fruit Orchards	Citrus (majority)
Plantation Crops	Date palm

Activity Data
To estimate carbon removal, I used the Tier-1 method, i.e. multiplying the area of perennial woody cropland and mangroves with the emission factor given in the IPCC report and other reports. The wood consumption from the woody forests is zero because citizens do not use the wood for any purpose.

The crop area is recorded in detail, and this data is available from 1995. The 2015 report was not issued for public use at the time of writing this report. Consequently, 2015 values are taken as being the same as 2014. The values provided in the annual reports for the year 2007 (category- green fodder), and 2008 (category – vegetables) have shown a significant increase because of the increase in demand for fodder by animal farms. Mangroves occur at the coastlines of Al-Khor, Umm Saeid, and Khaw al-Udayd, with a total area of 7,073 hectares in 2015. I maintained this value throughout the last two decades.

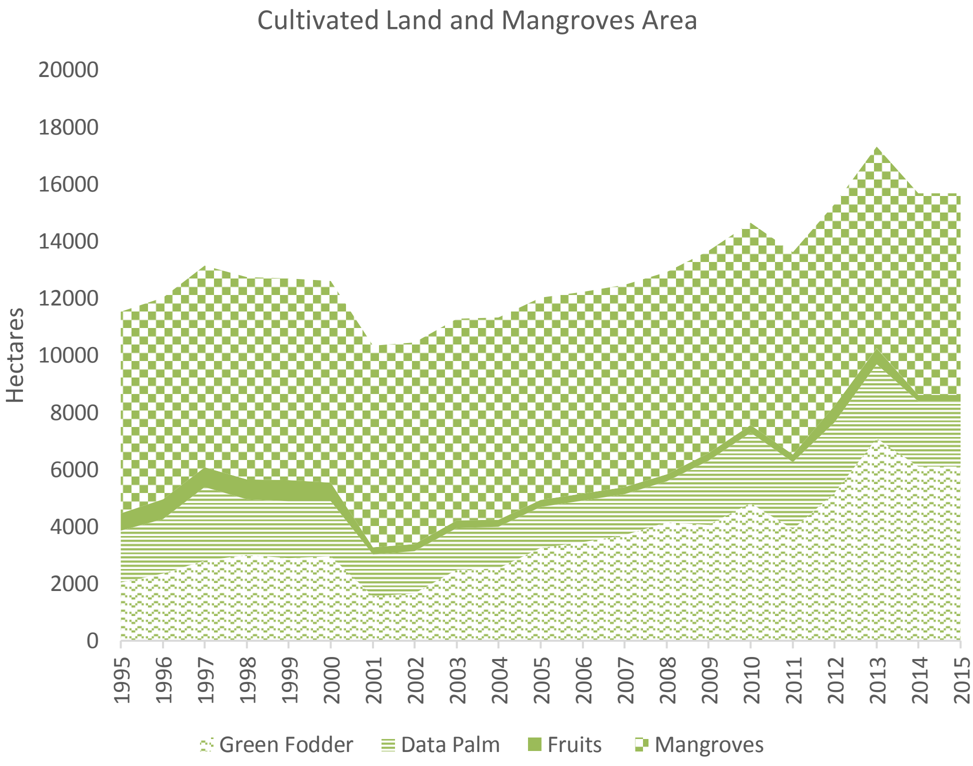


Figure 8.2 Total cultivated lands of perennial crops

Emission factor
Since there are no default emission factors for above ground woody biomass cropping system for arid lands, I applied the same value for the dry tropical environment. For mangroves, I used the lowest value 373 Mg CO_2eq published by the Blue Carbon Initiative:

Emission Removal = Area x default coefficient x 44/12

Area - The area of the annual biomass of crops is taken from the annual reports
Default coefficient for woody crops – 9 tonnes C ha^{-1}
Default coefficient for mangroves - 373 Mg CO_2eq ha^{-1}
44/12 – Conversion from C to CO_2

For mangroves, I used the simple method; since there is no detailed record of biomass growth, soil properties, etc.

Emission Removal = Area x default coefficient x 44/12

Area - The area of mangroves in 2015 was 7073 hectares, which was maintained throughout the years
Default coefficient for mangroves - 373 Mg CO_2eq(value taken from Blue Carbon Initiative)

Emissions

Emission removal from biomass is considerably less. The reasons are obvious - harsh weather, low precipitation and lack of natural water bodies. In 2015, over 2.3 million tonnes of CO_2 were removed, which is 2 percent of the total emissions. A significant amount of carbon is sequestered by mangroves. The emission removal rate compared to overall emissions has continuously declined from 1995 as shown in figure 8.4. However, the absolute emission removal has increased as shown in figure 8.3.

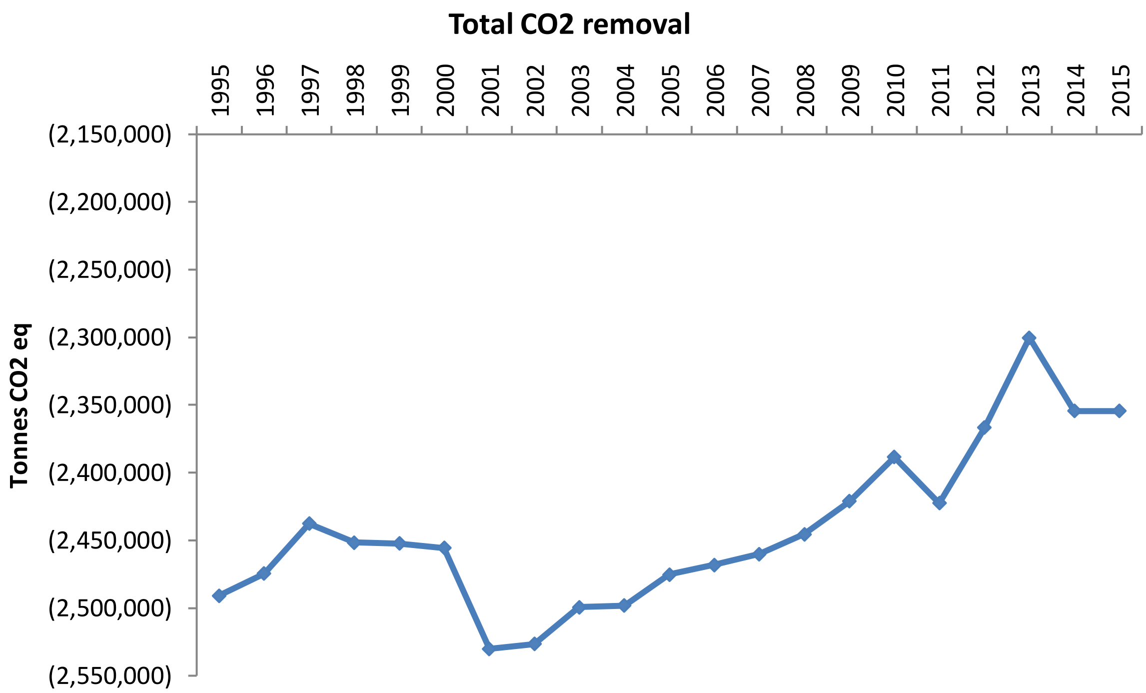


Figure 8.3 Total emission removals from land use

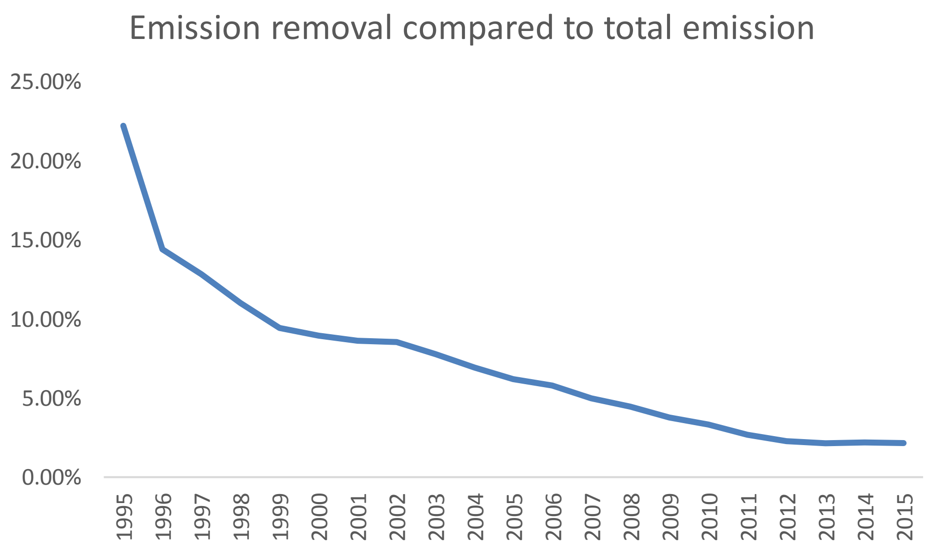


Figure 8.4 Emission removals from LULUCF compared to total emissions

9. BEST PRACTICES OF INDUSTRIES IN QATAR

In Chapter 1, I outlined the remarkable growth of Qatar's hydrocarbon and manufacturing sectors in the last two decades. As a latecomer country, energy and petrochemical companies adopted some of the best technologies helping the companies and the country to maintain a competitive advantage in the global market. Moveover, there is an ongoing effort to replace old technologies and processes. To my knowledge, some of the major companies have their R&D units' foster research and continuous process/technology improvement. However, the outcomes from internal R&D are unfortunately very low. The number of industrial design patents in the last decade was zero. This is contrary to most of the emerging latecomer countries, such as South Korea that has a total of 87,482 industrial design patents in 2014 (WIPO, 2015).

In this section, I attempt to highlight some (if not all) of the positive developments of the petrochemical, metal and mining industries. The information reported in this section is drawn extensively from the annual sustainability reports published by each company and targeted surveys. To understand their activities (which is not addressed in their reports), I sent a questionnaire to 25 major companies and I received a positive response from 20 companies, while some industries did not share any information (mostly oil production companies). For the latter, I used their annual sustainability reports (like Occidental Petroleum and Maersk Oil) and other websites to gather as much information as possible. Some industries have voluntarily developed plant-specific technical policies and actions over the course of last 10 years. They have done exceptionally well in their quest to reduce emissions, reduce water-energy-emission intensity and increase spending on environmental and biodiversity issues. I grouped the companies into different sectors, and each company's initiative will be documented. I maintained objectivity while analyzing their initiatives. In some cases, I copied the statements from their reports to avoid mistakes (in values) or misinform the reader.

For an emerging country, these achievements deserve merit. However, many industries are lagging behind and require tougher regulations and strict emission standards. Nearly all of the companies have no comprehensive plans and targets for reducing greenhouse gas emissions, with the exception of flaring emissions. The reason for the extraordinary success in flaring emission reduction is the national target and push for all companies to prepare a solid plan to mitigate flaring emissions. Unfortunately, over 95 percent of the companies have not set any targets to improve emission and energy intensity; this is primarily because there is no national requirement for companies to mitigate emissions and improve energy efficiency. Needless to say, the technological and process changes have reduced overall emission and energy intensity. On the other hand, efficient management of water resources is a national issue, which received significant attention in all the national strategies and reports. This enabled the companies to prepare a comprehensive water management plan, including a goal for zero liquid discharge and the recycling of industrial/produced/domestic wastewater. Some companies have a direct impact on terrestrial and marine biodiversity. Qatargas, Rasgas, and Shell GTL transport natural gas through subsea pipelines impacting the entire coral colony. Most of the coral reefs were “relocated” to “other safer zones” and monitored under the “supervision” of the Ministry of Municaplity and Environment. There is no public record of the status of these coral reefs and there has been a complete lack of transparency and accountability of the status of fragile ecosystems.

I believe there is considerable potential to reduce emissions and increase efficiency in all companies. There should be a collective effort from all companies to invest in emission (both GHG and non-GHG) reduction technologies and also reduce energy, water, and hazardous waste consumption at all levels. This will happen by increasing regulatory standards and renewing targets annually or at least once every three years. In the case of companies that are not meeting targets, the MME should toughen sanctions by increasing penalties and revoking consent to operate. The government should think about imposing a carbon tax or environmental tax for every ton of CO_2 emission. The collected tax could be used to help national mitigation efforts and support small-scale companies.

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Company Name	Environmental Management System (ISO 14001: 2004 Certification)	GHG Management Plan	Energy Management Plan	Flaring Reduction Target	Energy Efficiency (EE) & Emission Reduction Targets	Air Emissions (Nox, SO2, VOC)	Process/ Domestic wastewater treatment	Hazardous/Domestic Waste Management	Biodiversity Protection Plan	Environmental Expenditures
Qatargas	Yes	Under Preparation	No clear plans	Jetty-Boil Off Gas Flaring, Yes (44% reduction in 2014 compared to 2011)	No clear targets	NOx Emission Reduction Compliance Action Plan, Sulfur Recovery Unit Leak Detection and Repair (LDAR) program	Yes RO, MMF, MBR, 60-70% recycled	Under Process	Coral reallocation	$1- billion[a] JBOG Project $11,586,929, 76% for waste management initiatives
Rasgas	Yes	Yes, 2013	NO	Jetty-Boil Off Gas Flaring, Yes (40% reduction in 2014 compared to 2011)	No clear targets	Retrofitting existing installations with systems from compressors and gas turbines Plant-wide leak detection and repair (LDAR) programme to control VOC emissions	Yes MBR, RO	Corporate Waste Management Program, 2009	Yes! coral reallocation program, protecting sea turtles	$49,170,000[b]; 95% for Nox retrofit projects on gas turbines and utility boilers
Dolphin Energy	No	Yes, 2014	NO	Yes! QP Global Gas Flaring	No clear targets	Continuous Emissions	Under Process, Industrial	No plans	Coral habitat conservation	$9158477[c]; 86% in

				Reduction Initiative		Monitoring Systems Fugitive Emissions Monitoring Program	Water Management Project, tbc in 2017 Innovative evaporation technology to remove the chemical Kinetic Hydrate Inhibitor		& turtle protection	prevention and management
Oryx GTL	Yes	No comprehensive plan	NO	Yes	No clear targets	Continuous Emissions Monitoring Systems Smart Leak Detection and Repair Plan (Reducing VOC, Nox)	Zero wastewater discharge by 2018	No Plans	Supporting bird sanctuary in Irkaya Farm	No Information
Qatar Fuel Additives Company (QAFAC)	Yes	No comprehensive plan	NO	Yes! Implemented sophisticated ultrasonic devices	No clear targets	Leak Detection and Repair (LDAR) program	Zero wastewater discharge by 2016 47% of recycled sanitary wastewater to the Green Belt	No plans	No plans	$100,000,00 Carbon Dioxide Recovery Project
Qatar Petrochemical Company (QAPCO)	Yes	No comprehensive plan	NO	Yes	No targets	Sulfur recovery unit, NOX turbine replacement	Under process, revamping wastewater management by 2016	Cordinates with the local hazardous management company	No plans	$44,697,802[d]; 60% allocated to replacing turbines (reducing Nox emissions)

						Leak Detection and Repair (LDAR) program	Increase 80-85% recycling rate			
Qatar Fertilizer Company (QAFCO)	Yes	No comprehensive plan	NO	Not Applicable	QAFCO has EE target, but they haven't provided further information	Nox reduction program, H2S removal plan	Zero liquid discharge - Under construction	Yes, iron oxide catalysts sent to QatarSteel	Yes, fish farm hatchery, Al-Besheriya island monitoring, Artificial coral reef restoration	$54 millione
Qatar Aluminium Company (QATALUM)	Yes	No comprehensive plan	No	Not Applicable	No targets	Flourides and PFC components are recycled. Treatment of emissions of polycyclic aromatic hydrocarbons. No further details on Sox and Nox emissions	95% of water is recycled for on-site irrigation	Yes, the by-products (Carbon and Iron) were sold to Qatar Steel	No Plans	No Information
Qatar Steel	Yes	No comprehensive plan	NO	Not Applicable	No targets	No plans	Zero liquid discharge by 2016	Yes, recycling nearly 100% of all the steel scrap generated. Hazardous waste is sent to centralize Messaeid waste treatment facility	No plans	No Information

Messaied Power Company	Yes	No comprehensive plan	No	Not Applicable	No targets	Continuous Emissions Monitoring Systems Selective Catalytic Reduction (SCR) technology	Yes, water is recycled for green belt	No Plans	No plans	No Information

a- 2014; b- 2011; c- 2014; d-2015; e – since 2006

9.1 NATURAL GAS AND REFINING SECTOR[1]

Within two decades, the gross natural gas production increased from 18,400 MCM to 178,472MCM. The combined LNG production from QatarGas and Rasgas expanded to 77 million tonnes in 2010, thereby making history as one of the leading exporters of LNG to the global market. Natural gas production and refining sectors are energy and emission intensive. According to my estimations, in 2015, the natural gas and refining companies alone emitted 52.01 percent of total CO_2 emissions, which includes flaring and venting. The combustion process emits over 70 percent of total emissions, followed by flaring and venting. In the last five years, all companies have paid significant attention to reducing emissions primarily resulting from flaring. Many new joint initiatives and investments were established to mitigate the impacts on the environment by deploying new technologies/techniques. All companies complied with the Ministry of Environment Consent to Operate (CTO) by obtaining environmental permits that are renewed annually.

Flaring commonly occurs in all phases - extraction, production, and shipping. Flaring is used to protect equipment during process upsets, start-up, and shutdown of production units. Flaring results in a major loss of natural gas, this can be recovered for economic use. Also, flaring emits CO_2, black carbon, and other pollutants. For instance, approximately 140 billion cubic meters of natural gas are flared, and 300 million tonnes of CO_2 are emitted annually. With new technologies and practices, natural gas can be recovered and reduce emissions. Qatar is one of the top 20 gas flaring countries in the world. To reduce flaring emissions, Qatar is the first Gulf state to partner with the World Bank's Global Gas Flaring Reduction partnership (GGFR) in 2009 and renewed in 2012 (IISD, 2009). Ever since this partnership was formed, significant strides have been achieved in reducing flaring emissions. This initiative is endorsed by the National Development Strategy 2011-2016 and committed to halving the volume of gas flaring to 0.0115 billion cubic meters per million tonnes of energy produced. The strategy encourages all hydrocarbon sectors to take proactive actions in reducing further flaring emissions. Cottages, Rasgas, Oryx GTL and Dolphin Energy have prepared a comprehensive plan to reduce flaring emissions.

1-QatarGas, Rasgas, Dolphin Energy, Oryx GTL. Shell didn’t provide information regarding this topic, neither were there any publicly available reports to cite.

QATAR GAS

Currently, Qatargas has 13 active CTOs and renews on an annual basis. The CTOs require the companies to monitor, track and report all compliance requirements issued by the MoE. In many cases, high priority environmental issues are reported on a weekly basis. However, this information is not available for public use, making it very difficult to assess the frequency and reliability of it. All companies maintain ISO 14001-certified Environmental Management System (EMS) to document all activities and services. The companies' aim to make the entire process centralized, transparent (for whom, I'm not sure), easily verifiable and secure.

Jetty Boil-off Gas Recovery Project (JBOG)

According to Qatargas, JBOG is one of the most expensive environmental projects ever commissioned in the State of Qatar. The total cost of the project exceeded over $1 billion. JBOG connected to the six LNG loading berths (one of the largest natural gas terminals), reduces 90% of flaring emissions and recovers 0.821 billion cubic meters of gas annually that is enough to produce 750 MW of power. The construction activities began in mid-2011 and it became fully operational in October 2014. The recovered gas from the berth line is routed to Rasgas and Qatargas LNG trains to be used as fuel gas and any excess recovered gas is used for the Mesaieed pipeline.

Qatargas Flare Management System (QGFMS) is "designed to provide management and oversight of flare minimization efforts." In 2014, Qatargas reduced total hydrocarbon flaring by over 76% compared to 2009, and has shut down flaring by 88% since 2011. In 2015, it was expected to reduce 70-75% of flaring compared to the baseline period 2011. Figure 9.1 shows the flaring reduction trend. Besides massive investment in reducing flaring, it embarked on several other initiatives to reduce its impact on the environment. Also, it has developed a three-phased GHG Management Strategy to understand and quantify their emission profile and explore emission reduction opportunities. For the existing plant, the strategy focuses on energy efficiency, waste heat recovery, process integration and flare reduction. Qatargas installed low NOx combustion systems on QG1 boilers and gas turbine generators (GTGs) that resulted in a 20% reduction in annual NOx emissions from 2012. Also, there is a marked reduction in VOC emission compared to previous years because of active monitoring units and integration with the Leak Detection and Repair (LDAR) initiative. Qatargas has developed a 5-year plan focusing on long-term strategies to minimize its impact on the environment. This plan will guide ongoing and future initiatives not only involving flaring (or CO_2), but also other related emissions. For future developments, new technologies will be deployed to reduce emissions further.

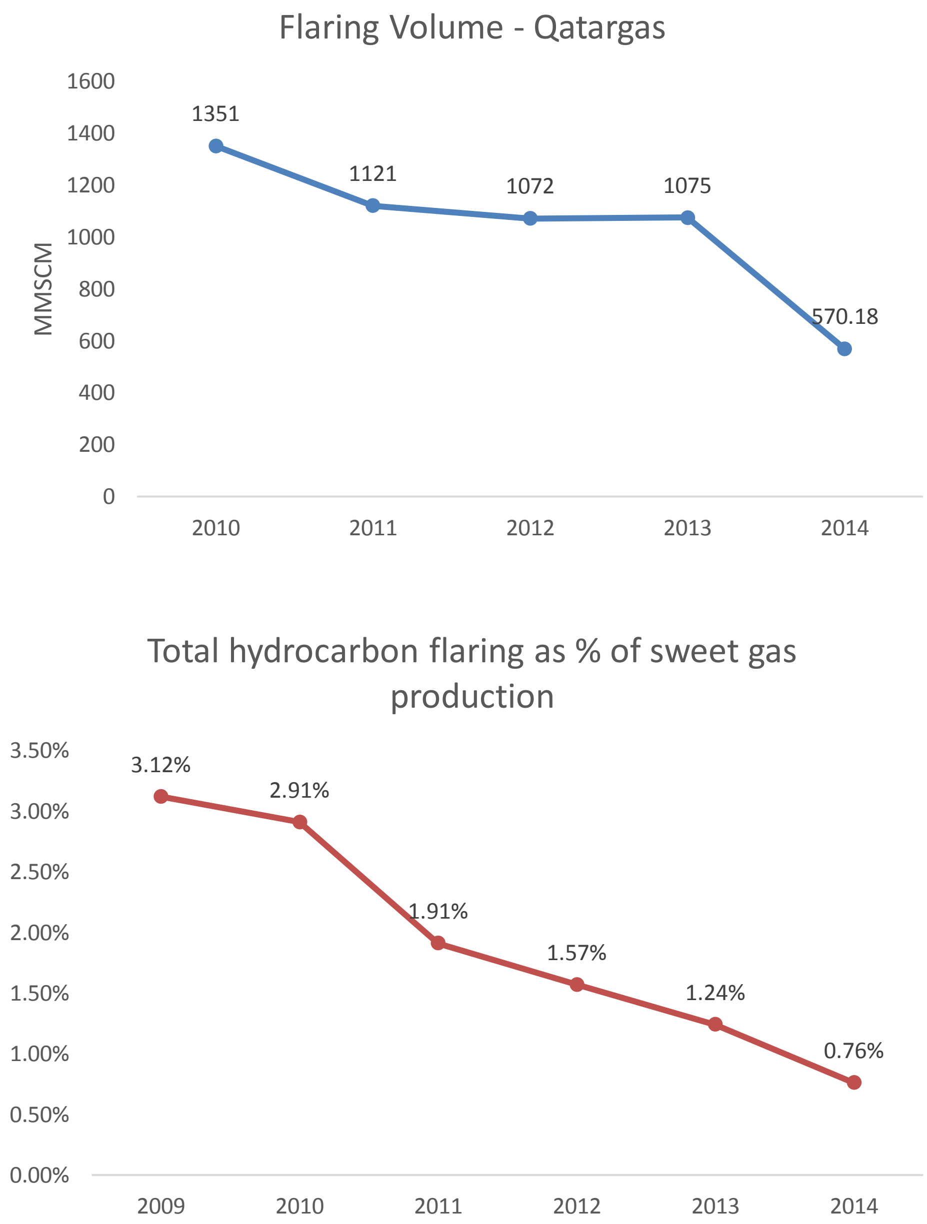
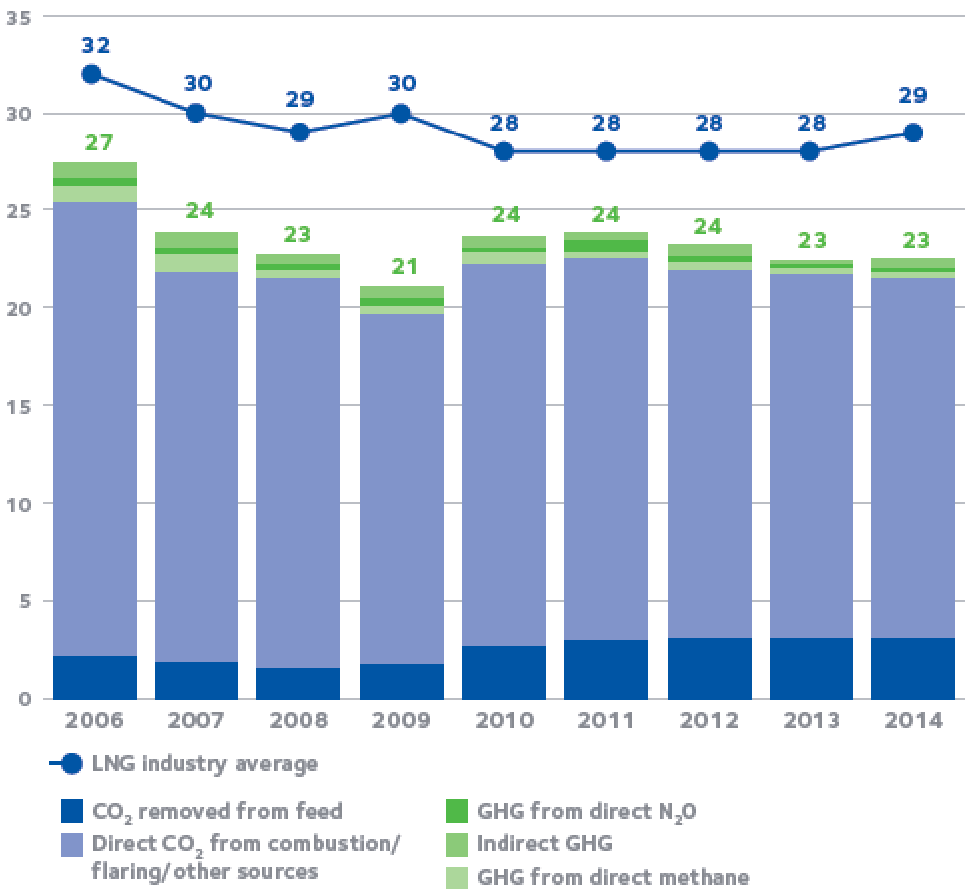


Figure 9.1 Flaring volume and emission reduction in Qatargas

RASGAS

Rasgas is also one of the major LNG producers in Qatar. Rasgas' commitment to reducing emissions and protecting the environment is commendable. Rasgas' sustainability reports are clear, fair, transparent and accessible. Environmental parameters are compared with international LND industry averages, and to my surprise, Rasgas managed to reach and exceed international standards as shown in figure 9.2 (top). Like Qatargas, Ragas is committed to reducing flaring emissions and in the last few years, they have been successful in reducing flaring emissions significantly. Rasgas is also part of the JBOG recovery project and contributed 47% of the total cost of the project. As a result, it recovers 300,000 tonnes of natural gas and saves 600,000 tonnes of CO_2 emissions annually. Rasgas' target is to reduce flaring emission by 90% between 2005 and 2016. Figure 9.2 (bottom) shows Rasgas' flaring intensity reduced by 82% in 2014 compared to 2005. In 2012, Rasgas launched a fresh five-year flare minimization plan covering its Ras Laffan facilities (both on-site and off-plot), and a continuation of the inaugural five-year plan that ran from 2006-2010. The new plan, expected to be completed by 2016, aims to reduce flaring emissions from a baseline of 1.26 percent (volume of flared gas per unit of gas intake) in 2011 to 0.43 percent in 2016.

In addition to flare minimization efforts, Rasgas operates the Acid Gas Injection (AGI) facility that stores CO_2 and hydrogen sulfide (H_2S) to reduce CO_2 and sulfur dioxide (SO_2) emissions from production processes. Between 2007 and 2014, Rasgas injected over 8 million tonnes of CO_2 into a saline aquifer. Also, Rasgas commissioned Regenerative Thermal Oxidizer (RTO) in their helium production process to burn CH_4 before venting. Rasgas, in cooperation with the Ministry of the Environment, developed a retrofit program to introduce low NOx technology to its turbines and boilers built before 2005. Since 2007, Rasgas has been implementing this program to ensure that all existing and applicable combustion units will meet and be even lower than regulatory limits. The last two sources under this program will be completed in 2016 and are expected to reduce the NOx emission intensity by 86% compared to 2006. In the last five years, NOx and VOC emission was reduced moderately and is considered to be the best among the LNG industries. Also, Rasgas' EMS takes significant measures to increase energy efficiency in all of its processes (including shipping). The energy use (from intake) is reduced to 26.4% in 2013 compared to 2006.



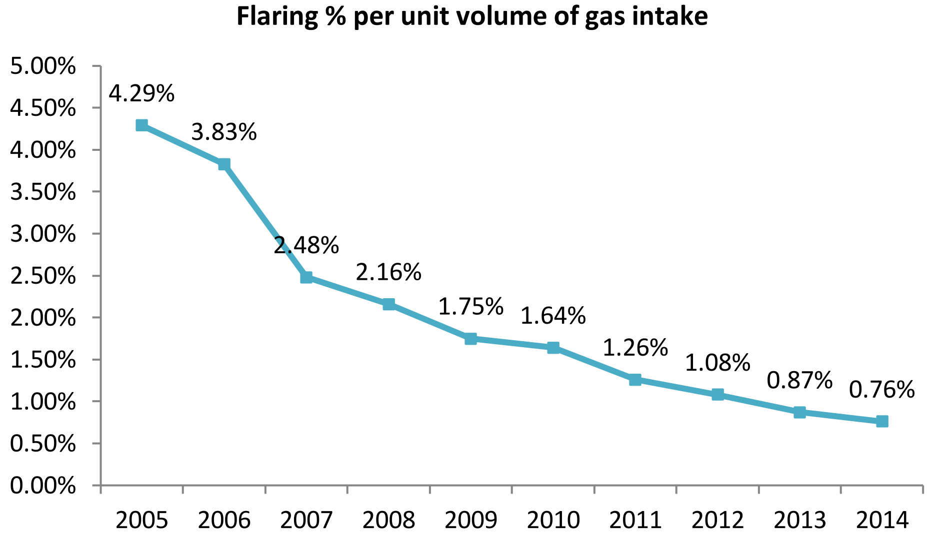
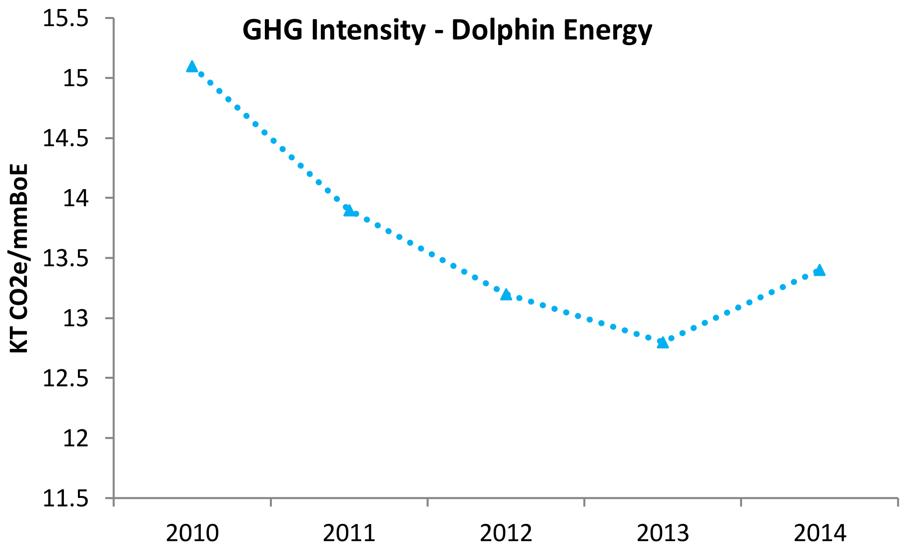


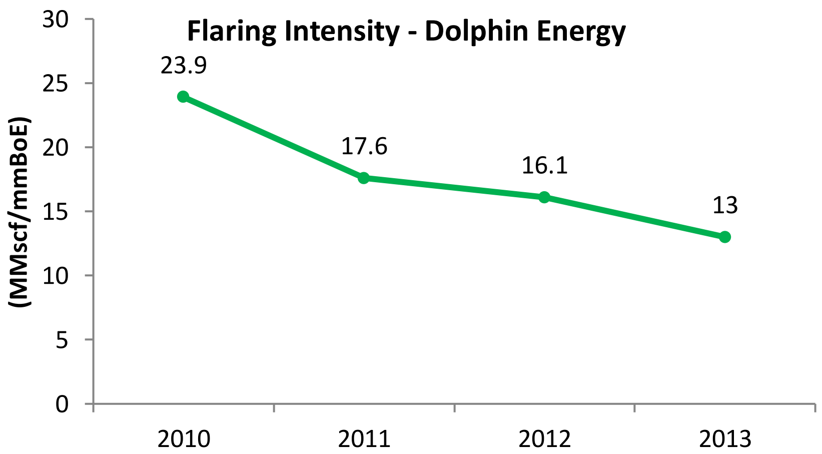
Figure 9.2 Emission breakdown of different processes compared with international average (top), flaring percent per unit volume of gas intake (bottom)

DOLPHIN ENERGY

Dolphin Energy is a relatively new gas processing plant that began operations in 2007. The company's efforts to control its greenhouse gas emissions and other emissions began at the most important stage – the design stage, to ensure that all planned facilities incorporated the Best Available Technology (BAT) and adopted the Best Practicable Environmental Option (BPEO). All combustion sources are equipped with dry low NOx burners to reduce NOx emissions. The production process is optimized in a manner through which the sulphur content in the raw gas supply is separated and stored for future sale, thus avoiding the majority of potential Sulphur Oxides (SOx) emissions. These initial investments have had a major impact on the overall environmental impacts including greenhouse gas emissions from operations since the plant went operational. Dolphin Energy committed to taking further steps in ensuring their entire processes is efficient beyond the compliance requirements of the local environmental regulations of Qatar. In 2013, Dolphin Energy signed off on a five-year environmental program management plan to improve environmental performance and allocate adequate investments to meet increasingly regulatory, shareholder and societal expectations. For the last three years, Dolphin Energy's annual sustainability reports are fair, informative, transparent and consistent.

Dolphin Energy is also an active member of the Qatar Petroleum Global Gas Flaring Reduction Initiative. As part of their flaring minimization program, in November 2012, Dolphin Energy installed four Infrared (IR) Closed Circuit Televisions (CCTVs) to continuously monitor flare flames from the flare risers. These cameras have built-in intelligence to detect changes in the temperature profile around the flare tip. The software displays the temperature profile in a range of colours which are invisible to naked eyes. The selected area can be monitored for temperature below a preset point. An alarm is triggered if a low temperature is detected that indicates the absence of flame. This has resulted in the conservation of natural gas and safeguarding of a national asset (instead of wasting natural gas by flaring), overlooking costs and consequences of revenues (e.g. in the event of reducing throughput to avoid flaring every time it is necessary). As a result of these efforts, the company's carbon footprint decreased due to the fact that flaring was significantly reduced, thus enhancing environmental performance and strengthening the company's commitment to environmental sustainability. Figure 9.3 shows greenhouse gas emission (top) and flaring (middle) intensity and flaring volume (bottom) trend. A 51 % reduction in the tonnage of gas flared from 2010 to 2013 resulted in a 55% reduction in CO_2 emissions to the atmosphere over the same period. The total cost of this project is $250,000. The company successfully reduced its flaring by 20% between 2012 and 2013. The annual flaring rate fell below 0.3% (0.28%) of total natural gas export that is the regulatory requirement of the MoE. As a part of its wider plan, Dolphin Energy implemented a VOC Fugitive Emissions Monitoring (FEM) program to detect, monitor and repair potential leakage sources in onshore processing and pipeline networks. In 2013, Dolphin Energy completed its feasibility study on carbon capture and sequestration. Since that time, there have been no further announcements as to what kind of sequestration techniques (technologies) will be deployed and when it will be implemented.





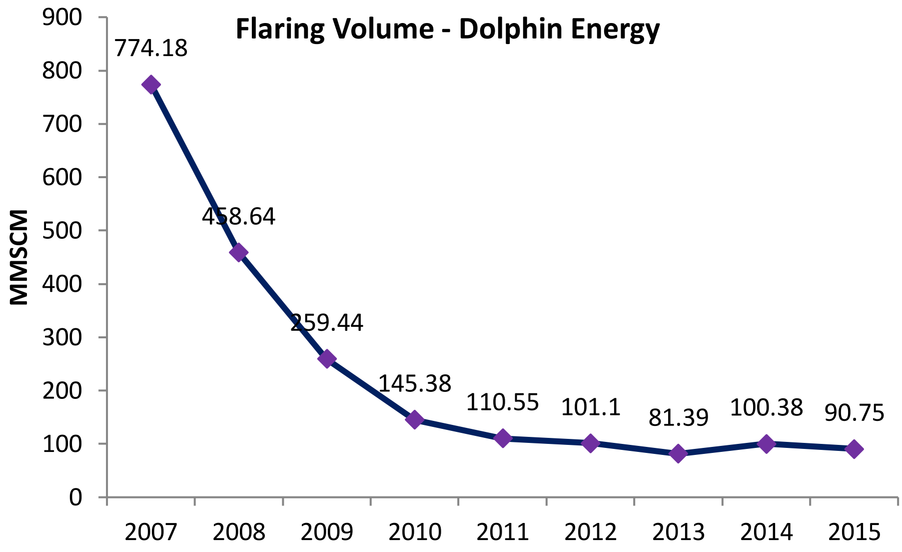
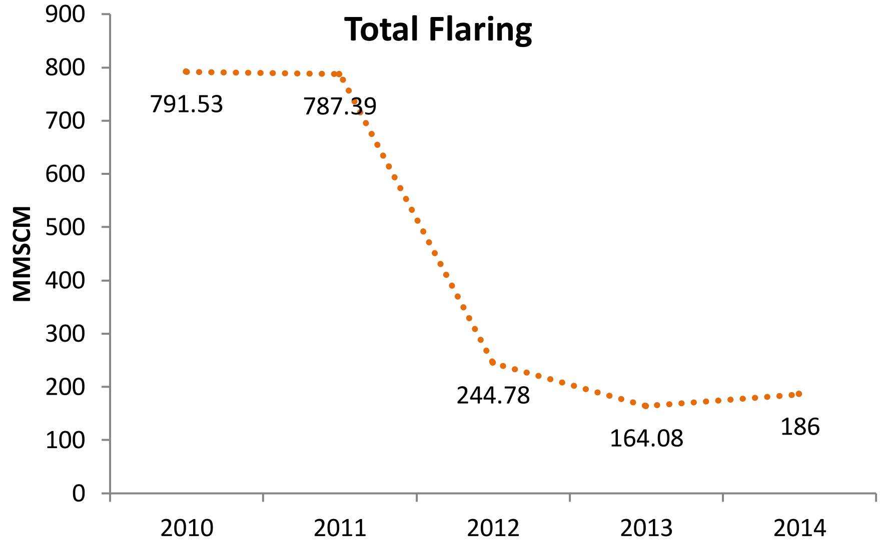


Figure 9.3 Greenhouse gas emission (top) and flaring (middle) intensity and flaring volume (bottom) trend of Dolphin Energy

ORYX GTL

Oryx is Qatar's first gas-to-liquids (GTL) company converting natural gas into high-quality GTL products including diesel, naphtha, and liquid petroleum gas. Oryx GTL is also part of Qatar's flaring reduction initiative. From the very beginning of the commissioning process, Oryx GTL adopted the best available technologies to reduce flaring, CO_2, and other non-GHG emissions. Oryx GTL reduced its flaring volumes to 0.18% of total feed gas (which is well below the MoE requirement of 0.3%). Flaring has reduced over 77% (and the corresponding emissions 70%) in 2013 (see figure 9.4) compared to previous years and has aimed to achieve near-zero flaring by 2017. Because of their concerted efforts, overall emission reduced 19% in 2013 compared to 2010 and emission intensity reduced to 25% during the same period. Besides flaring initiatives, Oryx GTL initiated the Smart Leak Detection and Repair (Smart LDAR) program to identify and monitor VOC emission leaks. In 2013, 184 leaks were identified and emitted 280 tonnes of VOC and managed to contain 70% of the leaks resulting in a 70 % reduction in fugitive emissions.



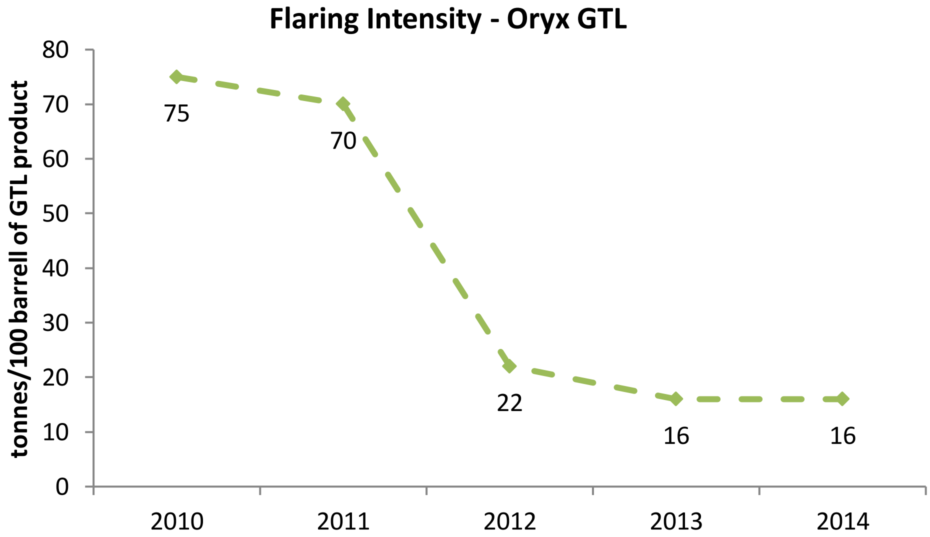


Figure 9.4 Flaring volume and intensity reduction between 2010 and 2014

9.2 OIL PRODUCTION SECTOR

There are several stages of oil production - exploration, extraction, production, and processing. Each stage emits different GHG and non-GHG gases. I requested that all major oil producing companies share their initiatives in reducing emissions from different stages. Companies like Maersk Oil Qatar, Oxy Qatar, Qatar Petroleum, denied access to information citing reasons of sensitivity and confidentiality. Unfortunately, I had to rely on the annual sustainability reports published by Maersk and Oxy Qatar. Very limited information is reported in these reports, making it difficult to show any positive trends in the oil sector.

Qatar Petroleum is the national petroleum company, essentially in charge of all petroleum activities from exploration to production and sales in partnership with many subsidiary companies. As outlined before, there is no sufficient information available for this organization except their annual sustainability report and annual reports, which publishes limited information about their activities. So far, Qatar has registered only one project under the Clean Development Mechanism project under the framework of the Kyoto Protocol. Al-Shaheen Oil Field Gas Recovery and Utilization Project commenced in 2007, and was directed to reduce associated gas flaring. This project helped to reduce 10.5 million tonnes of CO_2eq from its initiation until May 2014 and is expected to further abate 8.4 million tonnes by 2021. In addition, QP engaged in many projects including QP HSE strategy to reduce emission, improve energy efficiency, and deploy monitoring systems. In 2014, Ras Laffan Industrial City (under the leadership of QP) started the Ambient Air Carrying Capacity (AACC) study to map criteria pollutants SO_2, NOx VOC, ozone effects and particulate matters.

Maersk Oil Qatar is one of the leading producers of oil in Qatar and operates in partnership with Qatar Petroleum and other MNCs. Maersk Oil Qatar developed an environmental management system to identify relevant environmental objectives and targets and to improve environmental key performance indicators. Their key areas of focus are to reduce emissions, minimize water discharge to the marine environment and use resources efficiently. Since 2007, the total GHG emission from all activities has been reduced considerably (assuming the overall production during that period is same). In 2013, the annual GHG emission was reduced nearly 33% compared to 2009. By and large, this reduction has come from their flaring minimization initiative. Maersk Oil Qatar has cut average daily flaring rates by more than 92% since 2007. In other words, in 2007, 104.1 MMSCFD of oil is flared and reduced to 7.5 MMSCFD in 2013 as shown in figure 9.5.

Very little information is available about Qatar Petroleum and Occidental Petroleum (Oxy) Qatar, which restricts me from writing in detail about their emission mitigation initiatives. Despite this fact, I sent an official request to Qatar Petroleum and followed-up with them for more than a year to provide the requested information. The 2013 Oxy Qatar's Annual Report discusses several strategies to enhance energy efficiency, and maximize the productive use of natural gas that is co-produced with oil for electricity generation and operational purposes. In the last few years, significant investment has been allocated to install energy-efficient turbines, engines, and compressors, to reduce GHG emissions. Over the last seven years, Oxy Qatar maintained consistent GHG emission intensity below 25 tonnes CO_2e/MBBL as shown in figure 9.6. Similarly, since 2005, Oxy Qatar reduced flaring by 90 percent in partnership with QP. Oxy Qatar's flare intensity in 2013 was less than 2.265 scm/BBL.

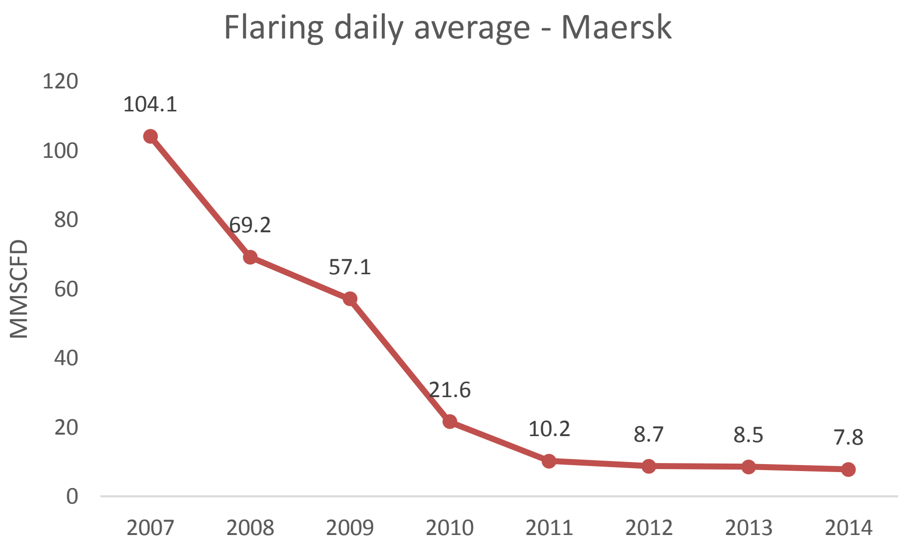


Figure 9.5 Flaring volume trend of Maersk Oil Qatar

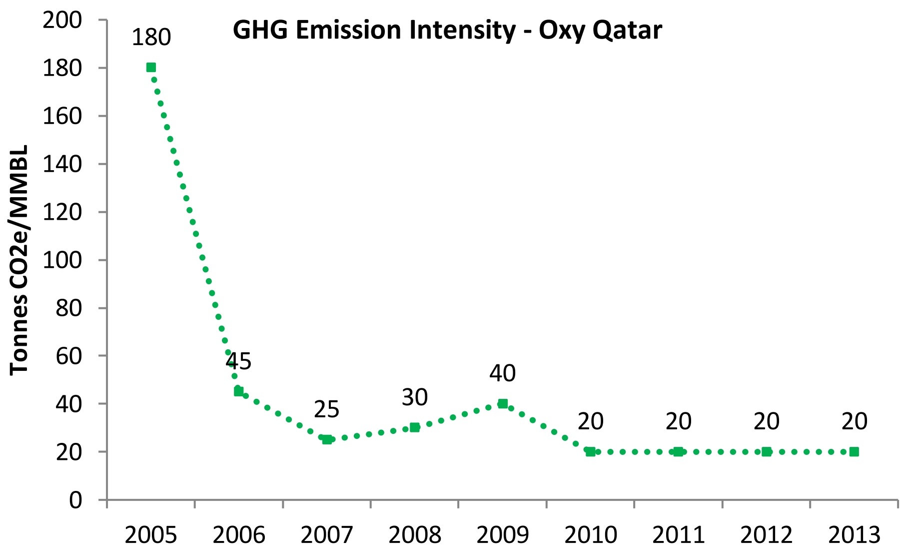


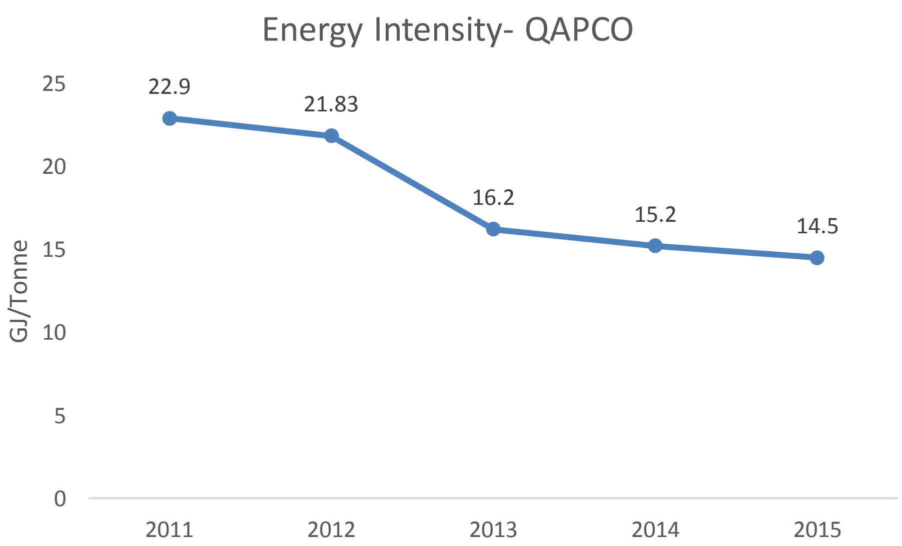
Figure 9.6 Greenhouse gas emission intensity trend of Oxy Qatar

9.3 PETROCHEMICAL AND MINERALS SECTOR

Like oil and gas, petrochemical and metal manufacturing is also an emerging sector in Qatar, adding value to the national economy by expanding existing facilities and establishing new chemical/mineral production units. The GDP contribution of the manufacturing sector increased 2797% between 1995 and 2013. The petrochemical and metal sector alone contributes 25.3% of overall emissions in 2013. The emission (CO_2eq) increased to 25.88 million tonnes in 2013, up from 2.92 million tonnes in 1995. This steep increase is due to the expansion of steel, ethylene, and cement production and a new facility for aluminium production. Some of the companies established in post-2000 had a comparative advantage of acquiring best available technologies (BAT) from the market and operate on par with international standards.

QAPCO

Qatar Petrochemical Company (QAPCO) is one of the oldest petrochemical companies in the region, established in 1974 and is one of the major producers of low-density polyethylene (LDPE) and Linear-LDPE. QAPCO continues to expand their production facilities reaching 2 million tonnes of ethylene production in 2013. Like other industries, QAPCO has well-established environmental management system (EMS) to improve environmental performance indicators and operational efficiency. As a part of the initiative, between 2012 and 2013, QAPCO invested more than $118 million to replace burners, gas turbines, water treatment and flaring minimization initiatives. This investment resulted in a subsequent reduction of emissions. QAPCO replaced six cracking furnaces and upgraded five gas turbines in 2014. In 2012, the emission of sulphur oxides (Sox) decreased by 48%; whereas, there was a notable increase in NOx emission, despite new NOx reduction burners that were installed in the process plants. Since 2011, natural gas intensity reduced by 29% and the company also made significant advances in reducing GHG emission intensity over 20% in the last three years (8.5% between 2012 and 2013). Figure 9.7 shows 36 and 44 percent reduction in energy intensity and emission intensity in last five years.



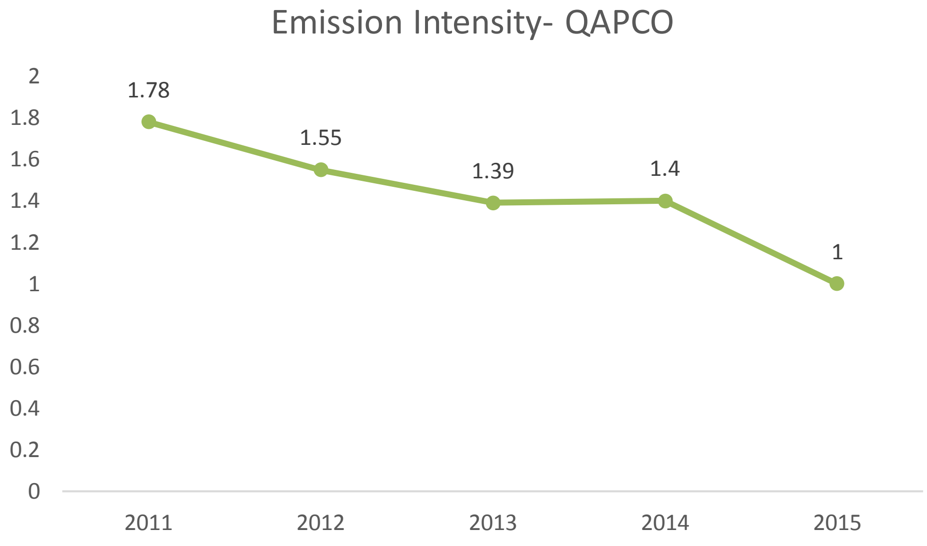


Figure 9.7 Energy and Emission intensity trend in last five years in QAPCO

QAFAC

Qatar Fuel Additives Company (QAFAC) is a leading producer of methanol and high-value derivatives and butane sub-products. QAFAC established a sustainability management plan to track and monitor energy efficiency, water consumption, GHG and non-GHG emission. The plan implemented some initiatives and deploys advanced technologies to reduce GHG emissions. Some of them include Lead Detection and Repair (LDAR), flare reduction, and a carbon dioxide recovery plant. QAFAC has constructed a CO_2 Recovery (CDR) Plant to recover a portion of CO_2 from its flue gas. With this CDR plant, it can recover 21 MTPH (metric tonnes per hour) of CO_2 from the flue gas vented to the atmosphere. The CDR plant is the largest of its kind and is the first to recover carbon dioxide from a methanol plant and reinject it into methanol production. Nearly 500 tonnes per day of CO_2 emitted to the atmosphere is converted to clean fuel. Despite the deployment of the CDR, the GHG emission intensity has not changed significantly over the last few years. Because of a lack of technical details, it is difficult to assess whether it has reached maximum efficiency with the available advanced technologies, or if there is further room to reduce CO_2 emissions. Moreover, the plant will recover 35 cu. m of water an hour from flue gas, which will be reused in the production process. This is expected to reduce the company's total water intake by 16% based on the latest intake figures.

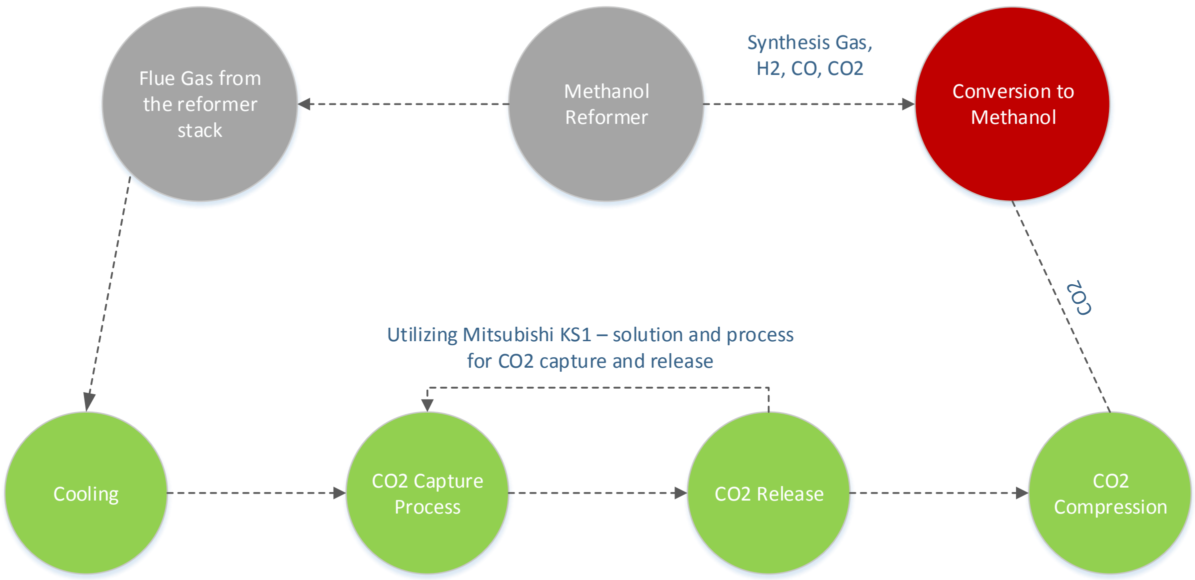


Figure 9.8. Carbon capture from Methanol Reformer Flue Gas

QCHEM

Qatar Chemical Company Ltd. (Q-Chem) is a petrochemical plant producing high-density polyethylene, hexane, and other products using state-of-the-art technology. Q-Chem has laid down robust environmental policies and systems and invested more than $30 million in direct and indirect projects, at three locations: Q-Chem, Q-Chem II, and RLOC. QChem's acid gas flaring reduction successfully recorded a 65% reduction of total amount flared. Q-Chem initiated the concept of near zero acid gas flaring aiming to have a final action plan in 2016/2017. Moreover, Q-Chem started working with upstream feed gas suppliers to reduce any feed rate or feed composition interruptions which will further reduce any potential acid gas flaring. In the past three years, Q-Chem has successfully reduced ethylene flaring against the ethane gas processed by 77%, Q-Chem II 39%, and RLOC 95.3%. In the past five years, acid gas flaring was reduced by 65% and initiated the concept of near zero acid gas flaring aiming to have a final action plan in 2016/2017. The NOx major contributors are the boilers. In 2009, Q-Chem modified boiler burners to be an Ultra-Low NOx type. This resulted in substantial reduction of NOx overall emissions by 54%. In the past three years, NOx emission was reduced by 33.9% and 63.2% at Q-Chem and Q-Chem II, respectively. In the past three years, CO_2 emission was reduced by 13.6% at Q-Chem, 74.9% at Q-Chem II, and 55.1% at RLOC. The energy use intensity (per unit of production) decreased by 41% between 2010 and 2014 as shown in figure 9.9a. Similarly, the GHG emission intensity reduced 32% during the same period. This will also mean more reliable Sulphur Recovery Unit operation and hence less CO2 emission (i.e. lesser GHG) and less SO_2 emissions. To increase the reliability of the data, Q-Chem re-built GHG emission calculators based on the revised EU ETS and QP standards for more accurate reporting that would also trace discrepancies of online measurements. The total investments on these reductions were in the range of 15 to 18 million dollars. The next m step is SO_2 Flaring Reduction (~ 60 million dollars) to meet Acid Gas Flaring < 0.006% a year as a target. This is still in the early stages of concept studying and feasibility.

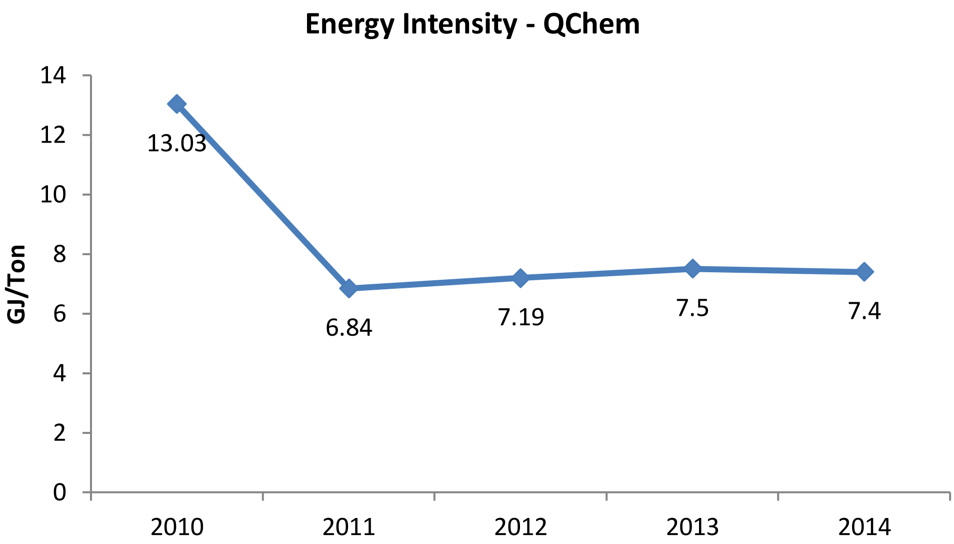


Figure 9.9a Energy intensity of Q-Chem

QAFCO

QAFCO (Qatar Fertilizer Company) is one of the leading ammonia and urea producers in the world. It was established in the late 1960s with modest production and has continued to grow ever since. After its full expansion in 2012, which was fully operational in 2013, QAFCO's capacity is 3.8 million tonnes of ammonia and 5.6 million tonnes of urea. Fertilizer production is an emission-intensive process. Before 2011, QAFCO faced an issue with excessive amounts of CO2 released into the atmosphere and reduced these amounts by increasing urea production capacity and diverting partial CO_2 to neighbouring plants — Qatar Fuel Additives Company and Qatar Vinyl Company — that used CO_2 as feedstock for methanol production. Exports to the neighbouring plants were stopped in 2012 after Urea-6 plant came online in the same year. In 2013, with QAFCO-5 and 6 being fully operational, the company maximized the use of process CO_2 for urea production. When synthesizing ammonia and urea from natural gas, ammonia is always formed in excess, and there is a shortage of CO2. The excess hydrogen is used as fuel for the steam reformer, an excess amount of ammonia is sent to urea production and the CO_2 produced by the reforming process and the CO_2 recovered from the flue gas reformer or boiler is then fed together with the urea synthesis section. This maximizes the urea production, minimizes reconstruction and reduces overall CO_2 emissions. Furthermore, GHG emission intensity improved by 25% between 1999 and 2013. The new developments will raise energy efficiency in Ammonia 1 and 2 plants consuming only 35GJ per tonne instead of 46.5 GJ per tonne.

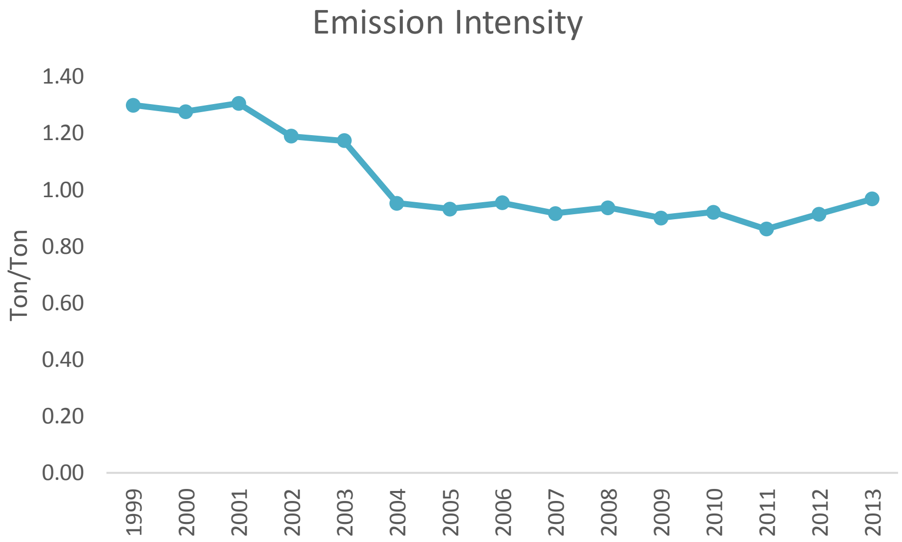


Figure 9.9b Energy intensity of QAFCO between 1999 and 2013

9.4 ENVIRONMENTAL INVESTMENT

In the previous section, I noticed a dramatic increase in revenues from the hydrocarbon and manufacturing sectors, resulting in massive spending in non-energy infrastructure projects (see above). I use the capital expenditures as a proxy to measure the level of significance given by the State. Unfortunately, the environmental projects did not get sufficient attention from the government. This is contrary to the vision and national policies proposed in the NDS-1. The amount of budget allocated to the Supreme Council for Environment and Natural Reserve (SCENR) between 2007 and 2014 increased 18 times, reaching a maximum of $29.4 million in 2011-2012 as shown in figure 9.10. Putting that figure into context, in 2013-2014, the SCENR received only 0.16% of the total capital expenditures.

As a part of the national strategy to become a knowledge economy, the government stresses the importance of science and research. In the last decade, I saw a surge in investment in education and research. In the heydays, the government allocated 2.8% of the GDP to science and research. The establishment of the Qatar National Research Fund (QNRF) is a step in the right direction. Since its inception, the funding body has funded nearly $800 million in various fields. Limiting this discussion to the energy/environmental sector, between 2007 and 2014, QNRF funded $289 million, representing 36% of the total funding. The budget is distributed as following: Qatar University (49%, 162 projects), Texas A&M University Qatar (47%, 128 projects), and Qatar Environment and Energy Research Institute (4%, 14 projects). Figure 9.10 shows the trend and breakdown of funding. Considering the small population and economy, the funding for energy and environmental research is growing significantly. However, the funding is primarily targeted in technological-oriented research. Moreover, pressing issues such as biodiversity protection, dryland agriculture, climate change, low carbon transition, and political/social dimensions of sustainability received less attention. Following the global trend, QNRF funding for social and natural science is very weak. Likewise, the link between natural and social science is very weak. From a research perspective within the context of Qatar, this relation is unexplored. Therefore, the agency should fund on interdisciplinary issues bridging disciplines –social and natural sciences, understanding values, beliefs and behaviours that are essential pillars of sustainability.

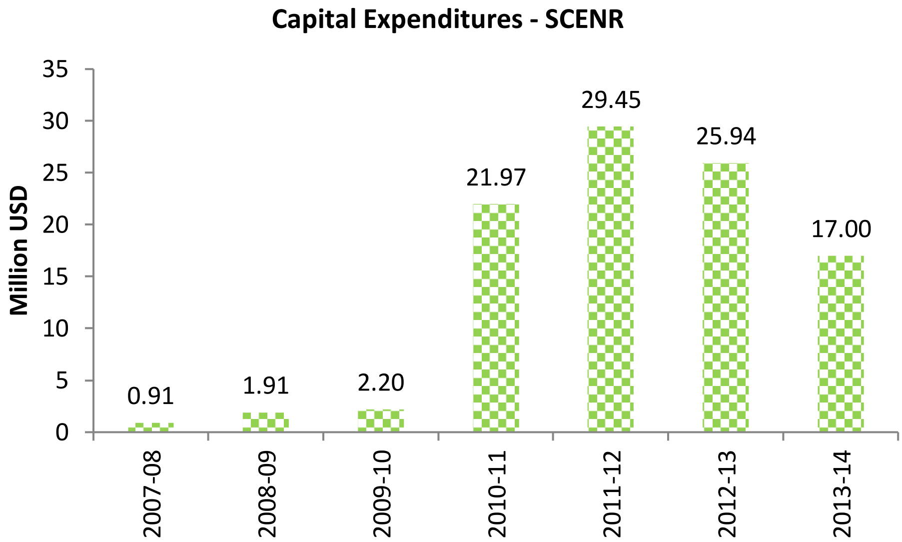
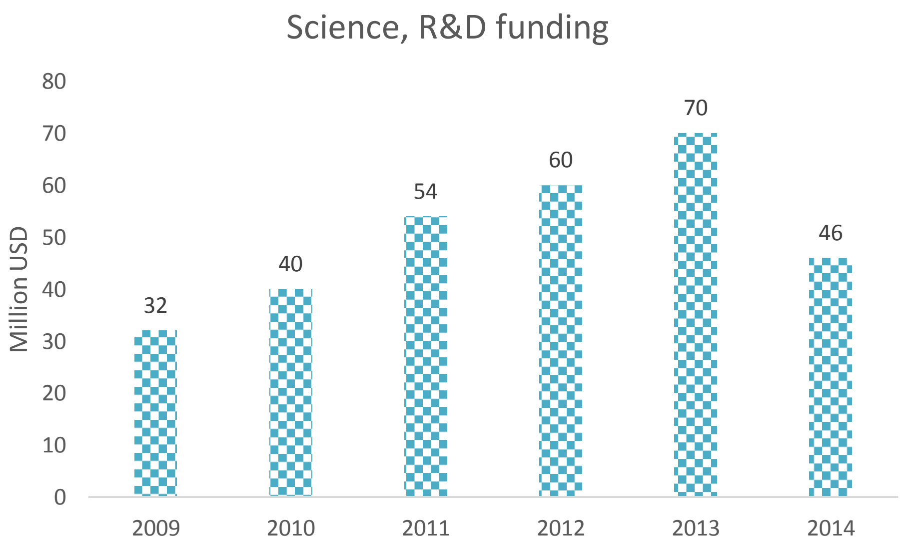


Figure 9.10 Total capital expenditures of SCENR



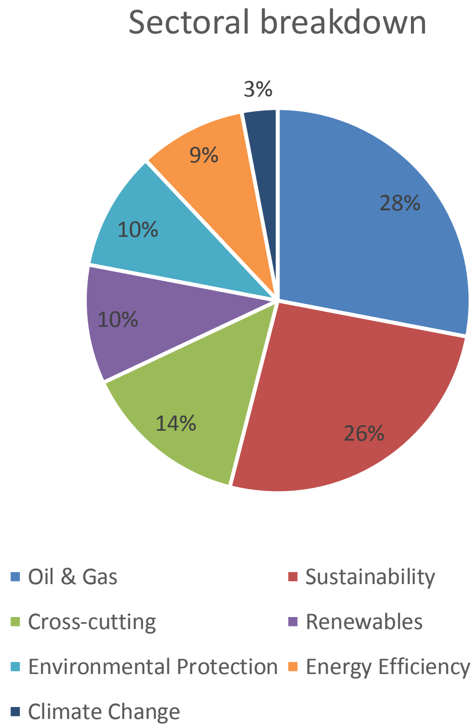


Figure 9.11 Science and R&D funding between 2007 and 2014 (source: www.qnrf.org)

As a result of increasing revenues, company expenditures increased for various reasons: from paying higher wages to modernizing the company by replacing old methods and technologies. In the last few years, the concept of sustainability and QNV 2030 streamlined to all industries and businesses in Qatar, which led to increasing investment to improve the environmental performance of companies. Moreover, the Ministry of Environment is stepping up regulations (though modestly compared to other advanced O&G countries like Norway) encouraging companies to invest in new emission, water, and waste reduction technologies. Qatar was the first country in the region to take the lead in reducing flaring emissions. So far, this initiative has received significant attention from all of the oil and gas companies. Reducing flared natural gas makes more economic sense. For instance, in 2012, nearly 4162 MMSCM of natural gas is flared and reduced to 3605 MMSCM in 2013, which is 32% of natural gas consumed for electricity generation in 2013 and can add 3% more to the exported natural gas volume. QatarGas and other gas companies sponsored a major project with a total budget of $1 billion to end flaring from the six LNG berths at Ras Laffan Port. This initiative has resulted in positive benefits by reducing 90% of the flaring volume of natural gas and 1.6 million tonnes of CO_2 annually. In addition to this action, over the last few years, many companies allocated significant portions of their budget to reduce GHG emissions, increase energy efficiency, and reduce water and hazardous waste consumption. Based on my survey and the information reported in the annual sustainability reports, I compiled the total investment for environmental projects. From 2011, the investment for environment projects skyrocketed and reached a maximum of $113 million as shown in figure 9.12. Though one must keep in mind, these figures are only for seven companies out of 33 major companies. It is apparent, that the recent surge of investment in environmental projects is because of growing pressure from government authorities to curb emissions, prevent further environmental degradation, and improve economic and operational efficiency and to increase their publicity as "environmental stewards." Notwithstanding for any reason(s), all industries should allocate investment based on their core activities, and its negative impact on the environment. The good news is that corporate expenditures on environmental projects far exceeded the national expenditures.

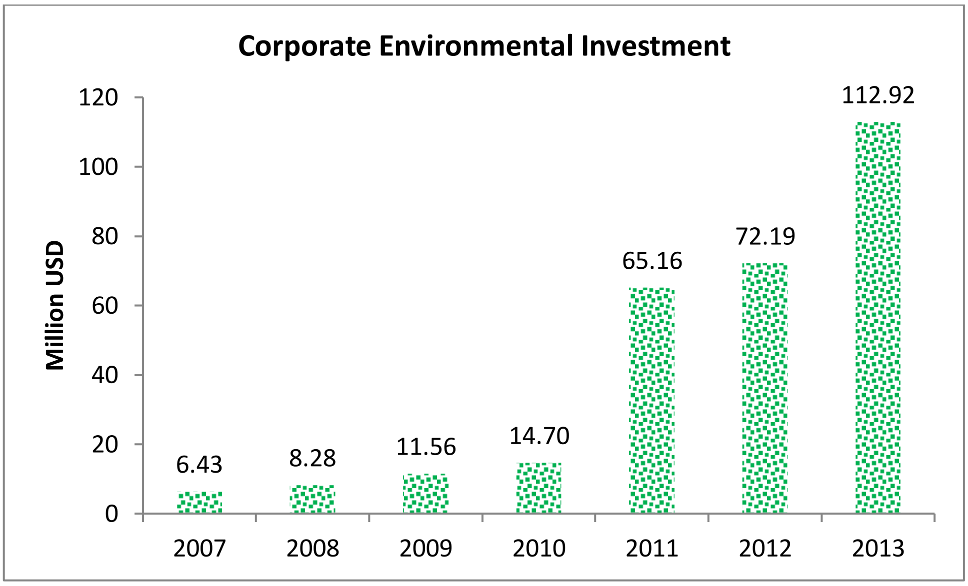


Figure 9.12 Corporate environmental investments between 2007 and 2013 (The values are far from complete, the numbers will increase, if I include all companies)

10. POLICY RECOMMENDATIONS

10.1 ADVANCING DATA COLLECTION AND REPORTING

As outlined in chapter 1, there were significant positive developments in data collection in Qatar over the last two decades. Many sectors, especially economic and social sectors received considerable attention. Unfortunately, the environmental sector remains very weak. Although the NDS 2011-2016 called for a comprehensive action to address this gap, the actions are far from reality. Based on two years of observation and collecting data from over 40 organizations, I highlight some of the major challenges faced in reporting GHG emission inventory, or environmental statistics at large:

a. Lack of transparency
b. Lack of adequate capacity (in terms of heads and competence)
c. Lack of coordination between and within institutions
d. Lack of trust between institutions
e. Lack of accessibility for public use

Lack of transparency and accessibility is one of the major concerns that limit the implementation of adequate policies to protect the environment. Furthermore, I identified severe capacity shortages (in terms of the number of personnel and also the competency of staff) in several ministries. Many agencies do not understand the importance of building a strong capacity in measuring, collecting, and reporting the information. With the recent budget cuts and administrative changes, environmental and sustainability issues seems to be a luxury. Lack of coordination between and within institutions is another concern that's been repeatedly highlighted by many agencies. Some ministries find it extremely difficult to gain access to agencies like Qatar Petroleum, Kahramaa, and the Ministry of Municipality and Environment. Most of the information is deliberately kept from public access. Addressing all of these challenges/concerns is of paramount importance to policy makers. Procrastination and negligence hinder genuine progress in all sectors. This can be managed through strong regulations and awareness among the institutions by hosting regular capacity building workshops and seminars. I have already identified several data gaps and challenges I faced in compiling the data from all agencies, yet, the number of organizations/industries are far smaller when compared to other countries. Even so, the difficulty in obtaining the data is equally challenging. Keeping in line with the GHG emission inventory and sustainable development goals (SDGs), I propose several prescriptive recommendations based on the best practices adopted by developed and developing countries.

10.1.1 GREENHOUSE GAS INVENTORY MANAGEMENT

Increasingly, the GHG emission inventory and other relevant environmental indicators are becoming very useful in assessing the nation's trend and helping the country to develop effective policies in mitigating sectoral emissions. Unfortunately, there is no clear strategy either from the Ministry of Municipality and Environment (MME) or from MDPS to address this major data gap. The name of the organizations is used only for the sake of clarity, not predilection towards MDPS or MME. The proposed recommendations are based on the insight and interaction with several stakeholders over a period of two years. I encourage readers to take these recommendations objectively. There are several dimensions in building an accurate GHG emission inventory system such as institutional, human resources, financial, and technological capacities. All of these factors, if put it in place together will improve the quality, efficiency and sustainability of the national inventory system.

Institutional Capacities

Central Authority – Appointing a ministerial agency (either MDPS or MME) to initiate, coordinate and report GHG emission inventory on an annual basis.

Multilayer Coordination Mechanisms – **Inter-agency coordination for data collection is a key ingredient for success.** A credible GHG inventory requires multiple government agencies to coordinate data collection, and can benefit from the support of research institutions. In many cases, the higher authorities (Ministers) agreed to cooperate but failed to address the "real" challenges at the mid-management level. The collaboration at the mid-level management level between different stakeholders is always problematic. These differences have to be addressed to ensure smooth communication.

Timeline - Setting firm deadlines to publish annual reports. Data collection - 3 months, calculation - 3 months, and reporting -1 month.

Methodology – A standard methodology (for different sectors) should be prepared and sent to all small and big companies. The companies/agencies should report fuel consumption (natural gas, petrol/diesel) for material and electricity production, electricity/water consumption, emissions in disaggregated form (CO_2, CH_4, N_2O, VOC, etc.) Also, the companies should report the consumption of all natural materials used in the production process.

Public Accessibility – The Central Authority should ensure that all organizations/companies must report their emissions/emission factors/emission reduction initiatives online for the public to access.

Human Resource Capacities

Personnel – This is one of the challenging issues facing Qatar. As employees continue to turnover in organizations, it is difficult to maintain communication with stakeholders. New employees or delegates request the same information again; the process is repeated all over, which delays the entire procedure. Dedicated personnel should be assigned from each organization and company to communicate with the Central Authority. In any case, if the dedicated expert is leaving, then he/she should explain the nature of the process to new personnel to avoid delays. Personnel should be trained to collect, analyze and archive data from their own companies and learn how to feed the data into the inventory management database.

Follow-up meetings – Inventory experts (or delegates) from each organization should meet three times a year during different processes (refer above). This helps to address various concerns and learn best practices from other organizations.

Training/Workshops – Capacity building is an important task of building a strong inventory. The experts should be equipped with updated knowledge about the GHG emission inventory. This can be done through regular workshops and training programs. The Central Authority should take the lead in hosting a workshop at the beginning of every year; that would help experts facilitate the process and possibly provide a chance to train new personnel.

Technological Capacities

Facility-based data – All the major companies should invest their financial and human resources into measuring emissions from their processes. This helps to achieve a reliable and robust inventory. Also, it helps companies show how their emission reduction initiatives are bearing fruit. For instance, Dolphin Energy installed four Infrared CCTVs to continuously monitor flare flames from the flare risers. These cameras have built-in intelligence to detect the temperature profile around the flare tip.

Also, I suggest that all the key hydrocarbon companies such as Qatar Petroleum, Qatargas, and Shell develop a comprehensive life cycle emission inventory from the oil and gas production system. This will help to identify primary sources of fugitive and combustion emissions and helps to create accurate inventories in the future. Currently, methane and black carbon emission reporting are insufficient. In fact, none of the companies report explicitly. It is unclear whether the companies measure (or estimate) emissions in their annual sustainability reports in aggregate form, or if they lack instruments to measure methane or carbon black emissions.

Database Management System – The Central Authority should develop a database with access and privileges to all reporting organizations/companies. Also, this system should interface with existing databases like QALM; QIX managed by MDPS.

Quality Analysis/Quality Control – Quality analysis and quality control mechanisms should be put in place to verify the data fed into the system.

User-friendly website - A dedicated website should be created, where annual emissions and other supplementary materials are documented.

Financial Capacities - The Central Authority should invest in creating a database with joint support from major companies. The smaller companies with limited financial earnings should be supported by the Central Authority or State-management grants in building their capacity.

10.2 CONSUMPTION-BASED GHG INVENTORY

Production-based emission inventories are often misleading, especially, where the domestic consumption of locally produced emission-intensive products is minimal. Using a conventional approach such as per capita emissions to gauge the country's status is evasive. In countries with high levels of export volume, it is appropriate to use consumption-based emissions to determine their accurate contribution to global emissions. With an ever-increasing global trade, the embodied emissions (imported emissions in the form of products) are high. Many advanced countries show that if the consumption-based accounting is taken into consideration, the emission, on average, is 11% higher than production-based emission accounting. Whereas, in major developing countries (BRIC) production-based emissions were 18% higher than in consumption-based ones. "The consumption-based accounting fully counterbalances the unilateral responsibility of the producer for the pollution inherent to the production-based GHG inventory." (Boitier, 2012) To illustrate, Qatar produced 178,472MCM of natural gas in 2015 and exported 72 percent (129,877 MCM) to the global market (OPEC, 2016). A similar case is observed with all emission-intensive products such as ethylene, urea, aluminium and so on.

Even the Environmental Sector Strategy (ESS) suggest that Qatar should use consumption-based accounting to report emissions. Only 33 percent of the total emissions in 2007 accounted for domestic consumption.

> If emissions are disaggregated by source, CO_2eq from production far outweighs CO_2eq consumption. Qatar is therefore disadvantaged by having these production-based emissions attributed to it. Its emissions data would be greatly reduced if a consumption-based accounting system was followed.

Therefore, I strongly recommend the government and academic institutions estimate consumption-based emission as a means to assess the country's actual emission.

10.3 FAIR SHARE OF EMISSION REDUCTION

Year after year, we witness global temperatures break previous records; new climate results indicate that the country has already crossed several tipping points. It is a global imperative for all countries to reduce their fair and equitable share of greenhouse gas emissions. Global emissions in 2014 have increased 60 percent compared to 1990. The recent COP21 summit showed extraordinary leadership and commitment, but ambitions fall short. Ambitions determine the probability level of keeping the warming below 2°C. Based on recent findings, the combined commitments of all countries proposed in their INDCs "will not keep temperatures below 2°C" and even if the proposed commitments were fulfilled, the world is likely to experience a temperature increase by 3°C or more. In order to maintain the global temperature below 2°C, three global mitigations pathways (explained below) were proposed by scientists and policymakers. All of the countries' leaders agreed to minimize GHG emissions to curtail the impact of climate change. However, the commitment, ambition and political efforts will significantly fall short. The INDCs are insufficient to keep the temperature below 2°C. According to the Civil Society Review report, "the ambition of all major developed countries fall well short of their fair shares." The INDCs of the US, EU, and Japan represent only one-fifth and one-tenth of its fair share. Whereas, developing countries such as Kenya, China, Indonesia, and India pledged more than their fair share (Civil Society Review, 2015).

The Climate Equity Reference Calculator (CERC) is an online tool developed by EcoEquity and Stockholm Environment Institute to assess the fair share of emission reduction of each country. The notable feature of the tool is that it is dynamic and diverse, takes into account of the responsibility and capacity of each country, macroeconomic data and a wide range of equity approaches. In order to better understand the tool, it is important to understand the terms used in the tool: mitigation pathways, responsibility, and capacity. For the sake of the discussion, I provide brief definitions. If readers are further interested in the tool, please visit the following website. https://climateequityreference.org/calculator-about/

The definition of three pathways are given below [2]

> The **Strong 2°C pathway** is defined to be an extremely ambitious mitigation pathway that can still be defended as being techno-economically achievable (Höhne et. al. 2013). Emissions peak in 2014 and reach an annual peak reduction rate of about 6.1% per year (6.0% for fossil CO_2 only). Cumulative carbon dioxide emissions after 2012 are 780 gigatonnes CO_2 (Gt CO_2), which is well within the IPCC's budget of 1,010 GtCO_2 for maintaining a 66% likelihood of keeping warming below 2°C.
>
> The **Weak 2°C pathway** is fashioned after well-known and often-cited emissions pathways that are typically presented as having a "likely" (greater than 66%, in the IPCC's terminology) chance of keeping warming below 2°C. Emissions peak in 2014 and reach a maximum annual reduction rate of 3.3% per year (4.4% for fossil CO_2 only). Cumulative carbon dioxide emissions from 2012 onward are 1,270 Gt CO_2. This exceeds the IPCC's budget of 1,120 GtCO_2 for maintaining a 50% chance of keeping warming below 2°C, suggesting that this pathway carries substantially higher risks than previously believed.
>
> The **G8 pathway**, a marker of the high-level of political consensus in developed countries, is based on emissions targets given in an official declaration of the Group of Eight industrialized countries at its 2009 Summit in L'Aquila, Italy (G8 2009). This pathway is not precisely specified in this declaration, but is sufficiently well-defined that it can be compared with IPCC budgets. Emissions peak in 2020 and then decline by a maximum of 4.9% per year (6.0% for fossil CO_2 only). Its cumulative carbon dioxide budget of 1,610Gt CO_2 considerably exceeds the IPCC's budget of 1,410 GtCO_2 for maintaining a 33% chance of keeping warming below 2°C. Thus, the chance of keeping warming below 2°C is far less than 33%.

Key data for the three pathways (and the IPCC carbon budgets against which to compare them)			
	Strong 2°C pathway	Weak 2°C pathway	G8 pathway
Peak Year	2014	2014	2020
2020 emissions (GtCO2eq)	40	44	55
2030 emissions (GtCO2eq)	24	35	50
Peak Rate of Decline (fossil CO2 / all GHGs)	-6.0% / -6.1%	-4.4% / -3.3%	-6.0% / -4.9%
Year Peak Decline Rate Reached	2019 / 2019	2050 / 2020	2038 / 2038
% reduction by 2050 vs 1990	-71%	-44%	-41%
Budget (2000-2011) (GtCO2/GtCO2eq)	390 / 520	390 / 520	390 / 520
Budget (2012-2050) (GtCO2/GtCO2eq)	715 / 1050	1000 / 1375	1315 / 1685
Budget (2012-2100) (GtCO2/GtCO2eq)	780 / 1390	1270 / 1985	1610 / 2325
IPCC carbon budgets	>66%	>50%	>33%
Budget (2012 forward) (GtCO2)	1010	1120	1410

Table 10.1. Key data for the three pathways, and the IPCC carbon dioxide budgets against which to compare them (GDR, 2014)

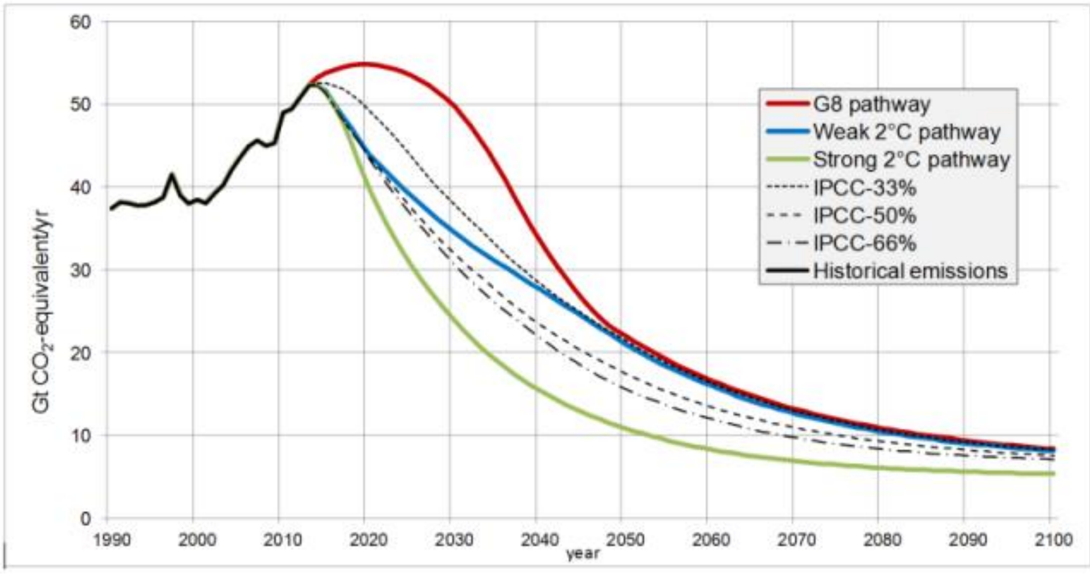


Figure 10.1 Three politically salient mitigation pathways: G8 (red), Weak 2°C (blue), and Strong 2°C (green). Also shown (dotted lines) are three pathways consistent with the carbon budgets given by the IPCC, consistent with limiting warming to 2°C with 66%, 50%, and 33% probability, given non-CO_2 emissions as per RCP2.6 (GDR, 2014)

For instance, if there is a global consensus to adopt Strong 2°C pathway, the probability of keeping warming below 2°C is above 66 percent as shown in the table 10.1 and figure 10.1. The atmospheric carbon budget varies for different pathways. The Strong 2°C pathway and the G8 pathway has remaining 780 and 1610 GtCO2eq, respectively. In my study, I used different mitigation pathways and associated mitigation efforts. There are three differ

Capacity determines the ability of the country to mitigate emissions. Capacity is not limited to financial terms, but also technological and institutional capacity. The climate calculator sets two income thresholds – the lower or development threshold ($7,500) and upper or luxury threshold ($50,000). The population with less than lower threshold does not incur any climate obligation as they struggle to meet basic daily needs. But countries with higher levels of income consume more goods and services emitting more emissions. Therefore, they bear higher capacity. The per capita income of Qatar in 2015 was $ 132,099 (PPP), which is way above the luxury threshold.

Responsibility is represented by cumulative GHG emissions. The calculator set dates from 1850 to 2010. Countries with a long history of emissions

must take into account historical emissions in their calculations. Developing countries should take into account emissions from the year where they observe a significant share of the increase in emissions. In the case of Qatar, I took the year from 1990 like other developing countries. The total emission of Qatar in 1990 was 13 $MtCO_2e$ which is far less than many developing countries as well.

“The Responsibility and Capacity Index (RCI) combines measures of responsibility and capacity (using a user-specified weighting) into a combined indicator of national obligation.

The RCI is then used to straightforwardly calculate each country's fair share of the global climate effort -- a country's fair share of the global effort (say, in total Tonnes of mitigation required) is proportional to its RCI.”

In my study, I used the following parameters to estimate the fair share of emission reduction for Qatar. I selected three pathways – 1.5℃, 2℃ and the G8 pathway. I selected two cases of responsibility weighting, one is default – 50% and other 10%, since Qatar’s responsibility to global emissions is very low. Emission accounting is based on production-based instead of consumption-based. The income threshold is an upper threshold. The responsibility and capacity index (RCI) for Qatar shows 0.4% and 0.35% respectively. The different pathways show different mitigation efforts and the weakest of all is the G8 pathway. The emission reduction potential for two cases varies from 49 - 86% and 43 – 75% respectively (see Table 10.2). Figure 10.2 shows Qatar’s business as usual emission scenario and 2℃ pathway. With the current economic activities and technological limitations, it is practically infeasible to reduce emissions to the lower limits (43-49%) and nearly impossible to increase to the highest threshold (75 – 86%). In such case, Qatar could fulfill its fair share in reducing emissions by setting up ambitious mitigation efforts domestically and supporting mitigation efforts in poor countries in the region and beyond through financial support and technological assistance.

Global Mitigation Pathway (for the year 2030)	1.5°C	2°C	G8	1.5°C	2°C	G8
Responsibility Weighting	10%			50%		
Capacity Weighting	90%			50%		
Qatar's RCI	0.40%			0.35%		
Qatar's baseline emission, MtCO2e	161			161		
Qatar's fair share of the global mitigation effort (MtCO2e)	138	111	79	121	97	69
Expressed as a (%) reduction below 1990	86%	69%	49%	75%	61%	43%

Table 10.2 Global Mitigation Pathway for Qatar

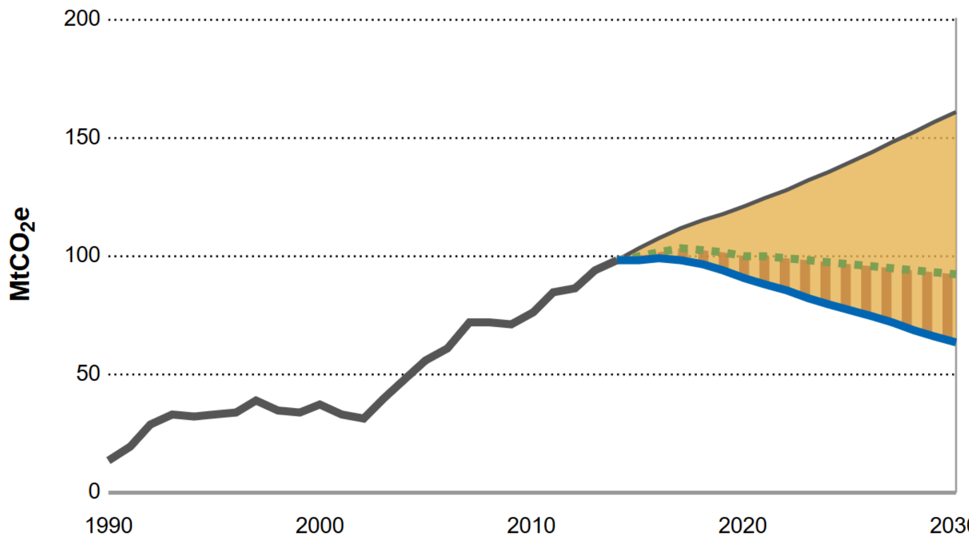


Figure 10.2 Qatar's fair share of emission reduction under 2°C pathway, responsibility weight – 50%, RCI – 0.35%. The black line indicates the business as usual emissions in 2030 and the blue line indicates the fair allocation of emissions for Qatar in 2030, which is 63 $MtCO_2e$ (which is 67% reduction compared to the baseline emission).

10.4 MAINSTREAMING CLIMATE POLICY

In this section, I discuss a broader climate policy framework for Qatar. The idea of this framework is to initiate a dialogue among policymakers and further build on it. A dedicated study is required to assess the linkages and tradeoffs between different sectors and it's short-term and long-term policy implications. It is important to emphasize that framing policies are just one part of the climate policy; but implementing, tracking and evaluating in a consistent manner is pivotal for the successful implementation of the policy.

The UNFCCC Convention recommends *all* parties take common but differentiated responsibilities (CBDR) in fighting the perils of climate change. Since the inception of the Convention in 1992, developing countries call for a burden sharing approach or fair share in emission reduction. Also, they demand significant financial and technical support for mitigation and adaptation from developed countries. Climate policy is increasingly becoming a political agenda for many developed and developing countries, especially countries that are highly vulnerable to climate change. Though, the current rate of emission reduction is insufficient to meet the 2°C target. To maintain within the limits of 2°C, developed and developing countries should aggressively pursue a development path that is sustainable.

The Cancun Agreements encourages the non-Annex I parties to develop low carbon strategies and require them to take national appropriate mitigation actions (NAMAs) and national adaptation plans and actions (NAPAs). Similarly, all of the parties were requested to submit Intended Nationally Determined Contributions (INDCs) before the COP21 summit in Paris. The INDCs shows the government's action to reduce GHG emissions considering its economic circumstances and capabilities. Though Qatar submitted INDC to the Convention, it failed to make any commitment for emission reduction. The local media, academia, and civil society failed to push the government to make a pledge. Unfortunately, there is also no record of NAMAs and NAPAs for Qatar and it failed to make any pledges and commitments to reduce GHG emissions. This signals there is no clear goal when it comes to climate policy in Qatar.

Before discussing the framework (Figure 10.3), I would like to highlight some of the key initiatives taken by the government to minimize GHG emissions. The NDS 1 acknowledges the unsustainable economic and population growth and recognizes its fragile local ecosystem. The report calls for actions to reduce environmental stress in key areas - water scarcity, air pollution, climate change and biodiversity. Among the key targets, Qatar aims to halve gas flaring by 2016 (see Section 9). The national utility company, Kahramaa, started a campaign called "Tarsheed" to reduce energy and water consumption. The objective of the campaign is to promote rational use of water and electricity with a target of reducing 35 percent of water consumption by 2016. Recently, Kahramaa claims that it has saved 600 million QR ($165 mn), reduction of 11% in the total consumption of water and electricity, and 1.8 million tonnes of CO_2 emissions as a result of this ongoing campaign (Gulf Times). It is hard to say, whether the reduction in per capita consumption is because of the actual behavioural change among the residents or growth in the low-income population that shows the per capita decline in water/energy consumption. There is no independent study on the effect of this campaign. Therefore, it is difficult to assess the effectiveness of the Tarsheed campaign. Recently, the government increased tariffs and is planning to phase off electricity and water subsidies in response to a decline in oil prices and a shrinking state budget. Additionally, the government planned to ban "energy-hungry" air conditioners by September 2015; however, the plan was scrapped for unknown reasons. Over the last few years, many energy-intensive companies have taken a proactive role in voluntary emission reduction initiatives by developing comprehensive environmental management plans which include energy efficiency, wastewater management, and domestic/hazardous waste management. A wide variation exists in the scope of initiatives taken by these companies. For more details about the industries' initiatives, please refer to Chapter 9

Currently, MDPS is preparing a Second National Development Strategy (NDS2) in partnership with all the relevant stakeholders and partial assistance from the World Bank. The environmental section of the NDS-2 will address climate change and biodiversity. I believe NDS-2 will set ambitious targets and create a clear action plan to minimize GHG emissions and adaptation measures. Therefore, this report will be helpful in formulating a comprehensive action plan. The climate policy framework proposed in this Report is not comprehensive by any means. This is to provide a broader framework to the policymakers. The framework has six broader themes with several sub-themes or areas.

According to the UNEP's MCA4 climate initiative, the national climate change policy plan is comprised of four elements:

a. A statement of objectives, or policy goals;
b. A set of policy instruments and specific measures;
c. A strategy, or a plan, for achieving them (adaptation and mitigation); and
d. Institutional framework, for both formulating and implementing the policy.

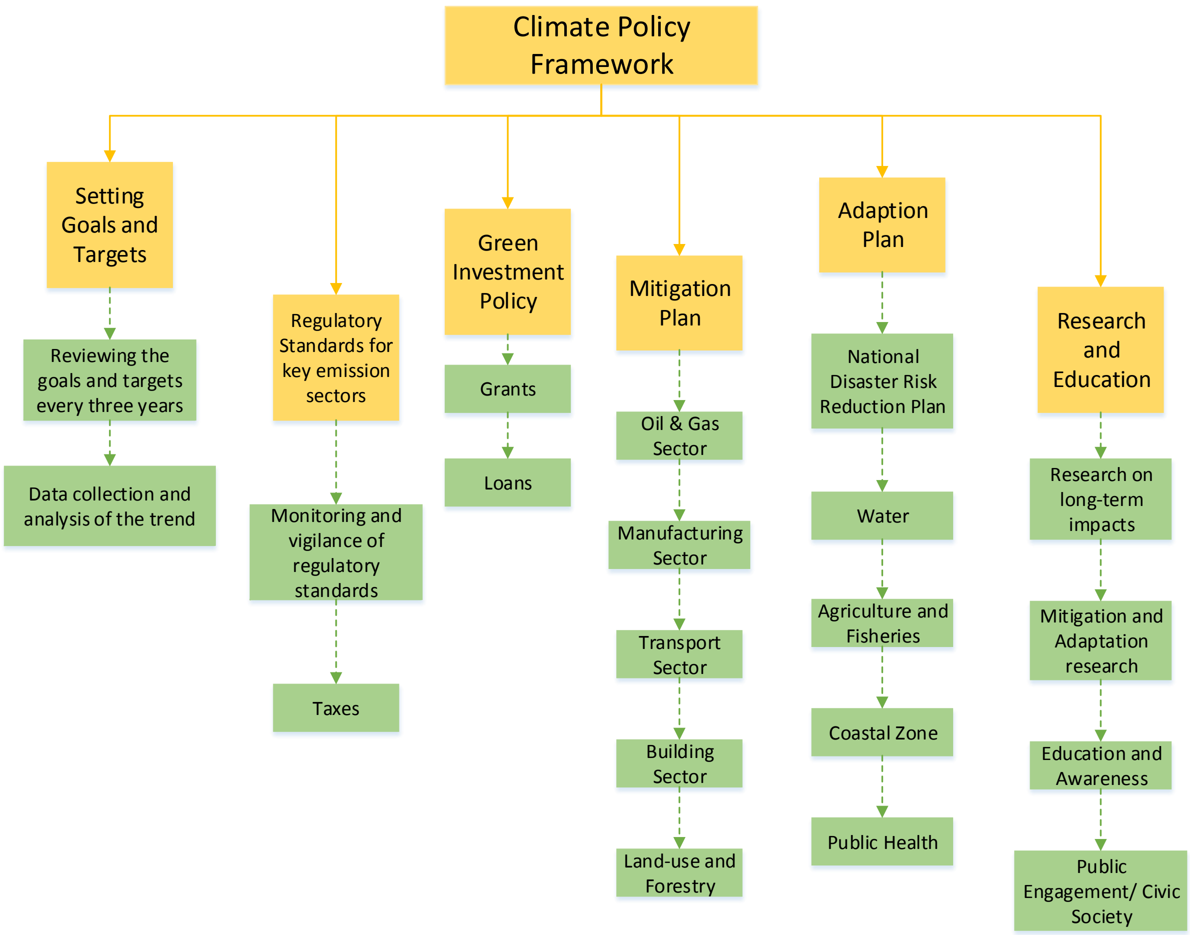


Figure 10.3 Proposed Climate Policy Framework of Qatar

10.4.1 CLIMATE POLICY GOVERNANCE

I believe appropriate policy, legal, and institutional factors which are collectively called a climate policy governance framework are an essential prerequisite for the development and implementation of an adaptation and mitigation plan. For successful climate policy outcomes, an effective governance system is required which provides the basis for legal and institutional arrangements as shown in figure 10.4. The climate governance framework is comprised of the enabling framework, institutional arrangements, and coordination mechanisms. The governance framework must be clearly stated and distributed to all concerned stakeholders. There are several opportunities, challenges, and barriers to implementing this framework. Some are generic like the lack of sufficient information and awareness, whereas others are very specific – regulatory and institutional. A comprehensive material should be provided along with this framework to the stakeholders for smooth implementation and to avoid confusion. Moreover, most of the companies are state-supported, and consequently, have strong financial support. A funding mechanism and technical assistance should be created to support small-scale companies that are not state-sponsored. This provides a level playing field. Explaining each category is beyond the scope of this report. In subsequent reports, I expect to provide a detailed picture. Before writing this section, I have sent several emails to the Ministry of Municipality and Environment to learn about further developments in the Climate Change

Department and stance of MME on climate policy. No response was received until the time of completion of this final review. The framework would have been more realistic, if I had received inputs from the relevant stakeholders.

Climate policy governance is organized around five key principles: i) clarity of vision, goals and targets (of the country), ii) institutional capacity, iii) policy coordination, iv) transparency, and v) stakeholder engagement. (WRI, 2014)

At a minimum, all mitigation and adaptation action plans should be reviewed every year to monitor the progress and make necessary modifications. Another key challenge is effective communication with all stakeholders which seems to be a common barrier. As explained before, all agencies have to work with mutual trust, respect and in good spirits to see the successful implementation of the plan. Also, the Climate Policy Framework must include a Climate Policy Tracking Framework to assess the success of the policy itself.

Setting Goals and Targets - The government should set targets for reducing GHG emissions from the base year. The goals should be ambitious and at the same time achievable without causing adverse economic impacts. A separate and "independent" body should be established to collect, monitor and analyze the data of emissions and propose recommendations to the concerned authorities. The body should periodically review the targets and goals. Respective Ministries must create a detailed action plan for achieving the policy target. The action plan should be based on a consultative process, inviting and reviewing proposals from all stakeholders. The policies should be designed to maximize co-benefits and minimize co-costs.

Data Collection - To assess the effectiveness of the policy, the leading institution should receive data from respective stakeholders on time to create an annual progress report. I have iterated the importance of strong data collection in previous chapters. The institution should decide the desired level of detailed data required to assess the success of the policy. Along with the policies and action plans, the stakeholders should be notified ahead of time about the nature of data (including standardized units of collection) and frequency of data collection. This will help industries or other agencies invest in data collection and validation. An online portal must be created to maintain easy accessibility and transparency.

Regulatory Standards – Targets can be achieved only when there is a strong regulatory and enforcement mechanism. The emission reduction initiatives in the key emission-intensive sectors will be reviewed by the "independent" body not the existing institution, i.e. Qatar Petroleum. The body should recognize, support and promote the initiatives that have shown positive results and equally penalize the organizations that failed to uphold the policy's targets.

Tracking – The government should create a robust climate policy tracking framework. The framework will determine whether the policy or action plans have been adopted and implemented (adoption and implementation are two different things, paying lip service to the policy is one thing and actual change on the ground is another). The framework must identify policy adoption milestones and policy implementation indicators. The policy implementation indicators can be further classified into input indicators (such as finance), activity indicators (compliance and enforcement, information monitoring), and intermediate indicators (technology/process changes) and its effects (amount of overall GHG reduced from each policy instrument).

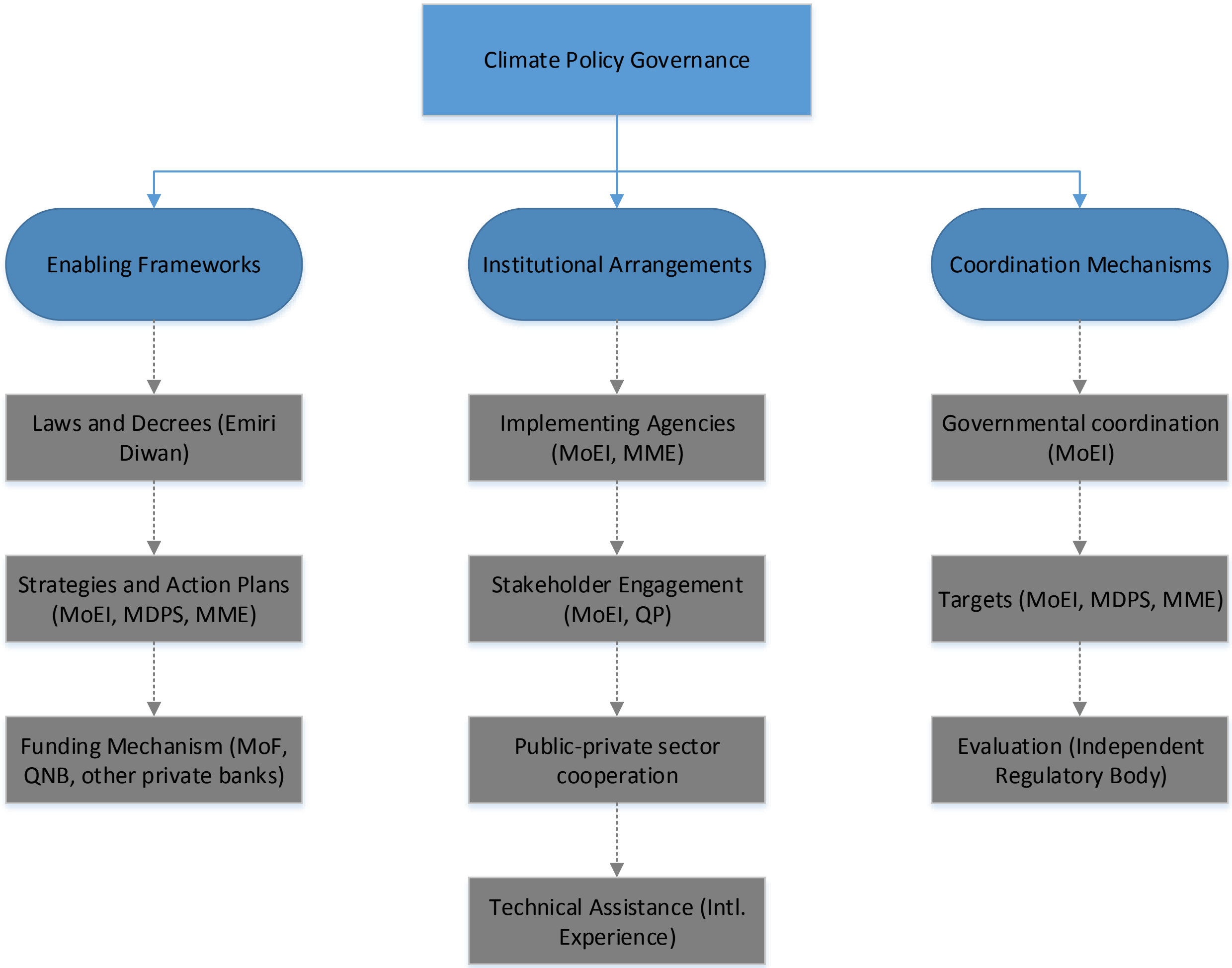


Figure 10.4 Climate Policy Governance Framework (Source: IEA, slightly modified)
MoEI = Ministry of Energy and Industry; MDPS = Ministry of Development Planning and Statistics; MME = Ministry of Municipality and Environment; MoF = Ministry of Finance; QNB = Qatar National Bank; QP = Qatar Petroleum.

Setting up Special Grants and Funds – In the previous section, we have seen many state-sponsored companies invest heavily in reducing flaring emissions, most notably, the JBOG project with a cost of over $1 billion. However, in the wake of a dip in oil prices and a sharp reduction in companies' revenues, whether the momentum will remain is questionable. The government plays a central role in allocating a stable budget to minimize GHG emissions (mitigation) and long-term adaptation to climate change and concurrently develop policies to build a resilient society. Mitigation and adaptation (M&A) require stable and consistent funding. Some M&A measures are cost-effective and easy to implement, while others require long-term planning and a massive budget. Some adaptation and mitigation responses require behavioural and attitude changes that can go contrary to the current social perceptions and cultural norms. The government should begin by focusing on key emission sectors such as the oil/gas, power, manufacturing, and construction sectors.

Although many major companies allocated substantial portions of their budgets to emission reduction initiatives, many small companies incur technical and financial difficulties in implementing emission reduction initiatives. Much of the constraint is financial. Setting up a state-sponsored green fund will help to overcome this financial barrier. The fund will be allocated either from different sources such as a dedicated annual state budget, environmental tax (if it is ever implemented), or a small percentage of the profits from all of the major publicly traded companies. The government should support and promote small and medium enterprises that can provide support services to the green projects. The funding body could use a range of investment instruments, funds, and structures to support the low carbon infrastructure and climate mitigation projects.

Additionally, the government can create green investment banks that focus on promoting investment in renewable energy, energy efficiency, retrofitting and other key environmental projects. According to the OECD, the rationale for green investment banks (GIBs) includes, "meeting ambitious emissions targets, mobilising private capital, lowering the cost of capital, lowering energy costs, developing green technology markets, supporting local community development and creating jobs. These goals are reflected in the range of metrics GIBs use to measure and track their performance and demonstrate accountability: emissions saved, job creation, leverage ratios (i.e. private investment mobilised per unit of GIB public spending) and, in some cases, the rate of return. Governments are using GIBs to channel private investment, including from institutional investors, into low-carbon projects such as commercial and residential energy efficiency retrofits, large-scale onshore and offshore wind, rooftop solar photovoltaic systems and municipal-level, energy-efficient street lighting."

There are significant challenges and barriers in creating special grants and funds for low carbon projects because of high subsidies for fossil fuels, a lack of mandatory policies that promote industrial efficiency, and poor return on investments. There are many other financial-related risks that are beyond the scope of the paper to discuss. Interested readers can read the following sources (OECD, 2013, 2015, 2016).

Moving towards Efficient Public Infrastructure - Studies suggest that investment in the low-carbon infrastructure would generate both financial and carbon savings for a much longer period. Over the last two decades, Qatar's investment in both energy and non-energy infrastructure increased significantly. This trend remains upward to meet the infrastructure demand for sporting events and the fledgling tourism sector. The government should develop a strategy to integrate climate and other environmental policy goals into infrastructure planning. Because most of the infrastructure that has been built has longer operational lifetimes, this results in a "carbon lock-in" effect. Eventually, this will force Qatar to lock-in investment. In one instance, Ashghal has not included climate risk component in their infrastructure design and planning. This is a timely opportunity for Qatar to rethink development plans and avoid locking into carbon intensive and fossil-based infrastructure. The government should leapfrog by building forward-looking infrastructure and development strategies that are directed towards a low-carbon pathway. Though, the upfront cost will be higher, the long-term benefits will far outweigh the costs and risks. Therefore, it is imperative to make calculated and wise decisions about the kind of future they aspire to and make a careful investment in a clean and efficient infrastructure. This will result in substantial savings in the future by avoiding retrofitting and replacing equipment. The government, industries, and development banks should develop means to share their best practices that can mainstream the climate goals into infrastructure policies, plans and projects.

The investment decision for major projects is determined by cost and its long-term benefit to the country's economic and social development. However, the cost does not truly reflect the social cost of emissions. The government should make efficient use of public funding to promote low-carbon infrastructure and encourage private investors/companies towards this direction.

Environmental Tax – Taxing or pricing carbon will help companies innovate and invest in energy-efficient and clean technologies. I augment the policy proposed in the Natural Resources Management Strategy. The report suggests,

> …to switch to modern technologies by introducing regulations and fiscal incentives on the national level… it could also enforce regulations on emission caps and establish pricing mechanisms that reflect the social and environmental costs of wasting gas. These mechanisms could include taxation on greenhouse gas emissions for industrial and power generation plants.

Environmental taxes, for instance, in many advanced countries helped in reducing GHG and non-GHG emissions. Also pricing basic raw materials such as feedstock (natural gas), electricity, water will encourage firms to change behaviour and adopt/replace new technologies and processes. Currently, the electricity (0.08QR/kWh) and water (5.4/m^3) charges for the industrial sector are lower compared to other sectors, such as residential (0.08-0.22QR/kWh), commercial (0.09-0.18/kWh) and government (0.22QR/kWh) (Kahramaa, 2015). A bare minimum flat-tax should be levied on all of the pollution emitting firms. Taxes should be increased to firms exceeding emission limits. The tax revenues collected by the State should be used as public abatement expenditures: cleaning up pollution, supporting small-scale firms in replacing old equipment, energy/resource-efficient processes and establishing hubs for local innovation. The challenge of imposing green/carbon tax is enormous, because the mining and manufacturing sector's contribution to the national GDP is very high. A detailed study is required to understand the implications (impact on national GDP) of taxing revenue-generating companies. It is tempting for firms to make voluntary reduction measures. How far this strategy will work is questionable.

10.4.2 MITIGATION PLAN

As outlined before, there is no national mitigation plan, except for flaring emission reduction. There is an immediate need for policies and measures that can swiftly bend the path of growing emissions. Although, some companies have taken voluntary initiatives in reducing GHG emissions as wells as improving energy efficiency and improved environmental management system, the government needs to promote voluntary initiatives and encourage all companies to participate.

The government and research institutes should look for ecosystem-based adaptation and mitigation strategies that are suitable to local climate changes without causing unintended consequences.

Mining, Quarrying and Manufacturing Sector – Industrial sector (including oil and gas) is the largest emitter in Qatar. This sector contributes nearly half of the GDP and brings over 80 percent of the government revenues. Therefore, it is essential to develop a comprehensive emission mitigation plan without compromising its valuable addition to the economy. I propose generic measures that can help emission reduction in the long-run.

- ✓ Setting up a new target for flaring reduction in offshore and onshore facilities and helping companies to develop their flare reduction plans
- ✓ Setting emission and energy intensity targets for each subsector and periodic review of the targets
- ✓ Establishing a Fugitive Emission Reduction Plan to reduce fugitive emissions from the oil and gas fields and in onshore facilities such as venting, flaring and evaporation losses
- ✓ Helping companies to develop a GHG Emission Management Strategy
- ✓ Providing special funds to companies that are implementing/replacing new technologies/processes to reduce GHG emissions
- ✓ Developing a comprehensive GHG measurement and reporting guideline for companies
- ✓ Establishing a committee to review the effective GHG emission reduction initiatives and create technical reports and help other companies to follow suit
- ✓ Promoting renewable energy for heating and cooling
- ✓ Creating a consortium of R&D in partnership with Qatar University, Qatar Foundation, Qatar Science & Technology Park to develop innovative ways of utilizing CO_2 (like using CO_2 to produce methanol)
- ✓ Registering for Clean Development Mechanism Projects

Transport Sector – Qatar is heavily dependent on private transportation. If one excludes low-income workers, then every individual owns a car. Over the last decade, there was record growth of passenger cars and heavy vehicles. Because of increased traffic congestion and growing concerns of local air pollution, the government started to expand its public transportation network and develop a railway infrastructure from scratch. Like other GCC countries, Qatar is building an advanced metro rail system connecting the centre and suburbs of the city. The total cost of the metro rail is $36 billion. This could be considered to be a part of the broader mitigation plan. Though, there is no detailed assessment of emission reduction from the metro rail. The public transport provider – Mowasalat – increased the number of public buses, encouraging citizens to use public transit. However, the number of public ridership has declined to half over the last five years. Qatar tested 65 compressed natural gas (CNG) buses, there is no detailed record of their economic and environmental performance. But the plans of Mowasalat to increase the CNG fleet suggest that the experiment has been successful. However, there is only one CNG filling station in the Industrial area making it difficult for the buses to fuel regularly. Qatar Petroleum in partnership with Woqod planned to build seven additional CNG stations by 2018. Though most of the recommendations were already proposed in the Qatar National Development Framework, I am reiterating some of the key initiatives,

- ✓ Increasing cycling and pedestrian facilities and its associated infrastructure
- ✓ Expanding the public transport system, i.e. large capacity buses, connecting light rail transit to low-income, densely populated areas
- ✓ Switching to low-emission fuels such as CNG and LPG
- ✓ Implementing proper urban planning to reduce travel distance
- ✓ Halving per capita vehicle ownership by 2030

Building Sector –Qatar's population increased four times in less than two decades, and so does the housing demand for the expatriate population. The number of building permits issued and completed buildings has increased every year reaching a peak in 2010. On average, the residential sector consumes 35 percent of the total electricity in Qatar. This excludes electricity consumption of the low-income workers based in the industrial areas. There is a growing awareness among the real estate builders and policymakers to build energy efficient buildings. Recently, the Gulf Organization for Research and Development (GORD) developed building codes that are suitable to the local climate called Global Sustainability Assessment System (GSAS). These codes are similar to the LEED building codes but differ in some key areas. According to GORD, the GSAS objective is to "create a sustainable built environment, considering the specific needs and context of the region." GORD aggressively lobbies to incorporate GSAS guidelines into existing building regulations. The behavioural and attitude change should work in parallel to see a significant difference in energy consumption per household.

- ✓ Enforcing GSAS codes for different types of building infrastructure (including commercial and industrial buildings)
- ✓ Promoting onsite energy generation through renewables (rooftop PV)
- ✓ Providing subsidies to independent house owners in building energy-efficient and renewable-based electricity homes
- ✓ Setting up energy consumption limits for each household
- ✓ Developing green corridor to reduce heat island effect

Land use, Forestry and Waste – Agriculture and the waste sector contribute less than 2 percent of the overall emissions. Any emission reduction possibility will slightly influence the overall emission reduction. However, the state should consider all possible, low-cost options in emission reduction.

There is very limited potential for emission reduction because of a lack of diverse landscapes in Qatar. In 2009, 6% of the total land area is used for urban development, 4% for agricultural areas, 30% of the total area is designated for Environmental Protected Areas (EPA), and 60% was a natural desert. The EPA includes mangroves, salt marshes (sabkhas), coral reefs, seagrass beds, coastal islands, sand dunes, and the like. Recently, the areas designated for EPA increased from 19 km^2 to 3,383 km^2 between 2007 and 2009. In 2013, Qatar built one of the most advanced domestic solid waste management centres in the world, producing 245 GWh in 2015. Fifty-six percent of the total domestic waste is treated in this centre.

- ✓ Protect and enhance the natural environment in the Protected Areas
- ✓ Protect and enhance marine biodiversity (mangroves, seagrass, etc)
- ✓ Develop plans for carbon sequestration in soils
- ✓ Shift the current agricultural to low-input agroecology-based agriculture
- ✓ Develop a comprehensive plan for restoration ecology and restoring degraded soils
- ✓ Develop plans for dryland afforestation
- ✓ Eliminate landfill emissions by expanding the current solid waste management facilities
- ✓ Improve recycling rates by 30% by 2030

10.4.3 ADAPTATION PLAN

Adaptation should go hand in hand with the mitigation process. Unlike developed countries, where most of the infrastructure is already in place, developing countries have an opportunity to build infrastructure with no-regrets. IUCN explains, “No-regret actions include...measures taken by communities [and/or facilitated by organisations] which do not worsen vulnerabilities to climate change or which increase adaptive capacities and measures that will always have a positive impact on livelihoods and ecosystems regardless of how the climate changes” (IUCN, 2014). Fortunately, many developing countries ramp up support for sectoral adaptation measures, especially for ones that threaten the livelihoods of the poorest and most vulnerable communities (WRI, nd). Regional climate models suggest that the Arab countries including Qatar will suffer from higher temperatures, frequent and intense heat waves, prolong droughts, frequent flash flooding, an increase in sea-level rise, and saltwater intrusion.

Currently, there is a poor understanding of climate risks, hazards and adaptation measures and the consequences of climate change in different sectors in Qatar. Also, there is a yawning gap of current knowledge about adaptation measures. A thorough and comprehensive study is required to assess the possible risks and hazards to the society, economy, and infrastructure. Without which any adaptation measure will not yield satisfactory results. The adaptation measures should be proactive. The latter minimize economic and social loss. It is in the country’s best interest to strengthen its adaptive capacity and rebound from climate shocks with less economic and social damage. Qatar must examine sectoral issues thoroughly to make an effective national adaptation strategy. Qatar needs a paradigm shift in infrastructure planning. Incorporating adaptation measures will protect its long-term infrastructural investment and citizens from adverse climate impacts such as flash flooding, sea-level rise, increased temperatures and water scarcity shortages. QNDF acknowledges the grave environmental threats and has included several measures in the development framework. Besides climate-resilient infrastructure planning, the government should allocate a separate budget for adaptation projects.

The adaptation plan is comprised of five major blocks:

a. Scoping and designing an adaptation project
b. Assessing current vulnerability
c. Assessing future climate risks
d. Formulating an adaptation strategy
e. Continuing the adaptation process

Disaster Risk Management Strategy - Qatar adopted the Hyogo Declaration in 2005and submitted its first implementation plan under the Hyogo Action Plan in 2015. The Hyogo Declaration promotes "strategic and systematic approach to reducing vulnerabilities and risks to hazards. It underscored the need for, and identified ways of, building the resilience of nations and communities to disasters." The government should create a robust disaster risk management plan for all sectors:

- ✓ Identify sectors that are vulnerable to risk and hazards, and development of an early warning system for each sector
- ✓ Develop plans to minimize risks and hazards
- ✓ Prepare for effective response and recovery

Water Sector – Qatar has an extreme scarcity of water and is under threat because of excessive withdrawals and increasing weather variation. Protecting water resources is key to human security and prosperity. Comprehensive analysis of water resources under different climate change scenarios is essential to make an effective adaptive strategy.

- ✓ Projected changes in groundwater resources
- ✓ Analyse impact of sea-level rise on water resources
- ✓ Research impact of Arabian Gulf acidification on desalination
- ✓ Develop water harvesting techniques across the country, especially in flood-prone areas

Agriculture and Fisheries Sector – Food production is very limited in Qatar and its growing aspiration for increasing food self-sufficiency is confronted with declining groundwater shortages. Domestic fish catch meets nearly 40 percent of fish consumption. Over the last few years, Qatar witnessed several incidents of fish death along its coast. Experts argue it is because of an increase in sea temperatures. The seawater temperature exceeded 35℃. Impact of climate change on the agricultural and fisheries sector is understudied in Qatar. In order to maintain its current level of production, Qatar should develop a comprehensive plan for adaptation to climate change.

- ✓ Promoting climate-smart agricultural methods (agroecology-based agriculture, agroforestry, etc.)
- ✓ Promoting water harvesting techniques and test methods to increase agricultural yield
- ✓ Improving soil moisture and organic matter
- ✓ Growing native trees in grasslands
- ✓ Conducting a detailed study of the impact of increasing seawater temperature and acidification on fisheries

Coastal Zone Management – Qatar is a peninsula surrounded by shallow Arabian Gulf. The climate projections suggest that the sea-level rise will have a disastrous impact on Qatar more than any other coastal cities located in the Arabian Gulf. Most of the energy and commercial infrastructure is built across the coastline. Any increase in sea-level will have serious consequences on the expensive infrastructure. Qatar National Development Framework aimed to develop Integrated Coastal Zone Management (ICZM) plan in the coming months. The ICZM includes "the identification, monitoring and management of coastal zone assets, Coastal Zone Protection Areas, biodiversities and their habitats, including fish habitats."

- ✓ Explore ecosystem-based coastal zone management techniques
- ✓ Expand the area of mangroves to stem coastal erosion and inundation
- ✓ Designate Coastal Zone Protection Areas that are subjected to erosion, inundation, storm surge and sea-level rise

Public Health – Climate change poses a direct and indirect threat to public health. Heat-related and infectious diseases are the major causes of death from extreme events such as flooding, storms, etc. As outlined in the earlier section, the Gulf countries will become inhabitable in the coming decades because of increasing temperatures and humidity. Consequently, there will be increasing incidents of heat-related deaths. To develop a comprehensive adaptation plan, the first step is to assess the impact of climate change on public health. The study will help to identify the potential health risks and necessary measures to mitigate the risk.

- ✓ Identification of gaps in current knowledge needed for assessment of coping capacity
- ✓ Identification of vulnerable groups
- ✓ Assessment of current coping capacity and the need for adaptation

10.4.4 RESEARCH, EDUCATION AND PUBLIC AWARENESS

Globally, there is a growing awareness of climate change among citizens at varying degrees. Although, there is a wide gap between different communities when it comes to a clear understanding of the major drivers of climate change. In order to witness a systematic and long lasting attitudinal and behavioural change, environmental education is mandatory. Treading lightly on the planet requires a shift from a profligate to a frugal culture. It takes generations for a cultural change, but a planned education can heighten awareness and consciousness. Currently, the initiatives are fragmented, sometimes duplicating others. In partnership with academia and civil society, the government should develop a comprehensive plan for integrating environmental education into the formal education system. Recently, Hamad Bin

Khalifa University started four postgraduate programs (two masters and two PhD) in Sustainable Environment and Sustainable Energy. Many universities have started sustainability initiatives; however, some are namesake and superficial.

- ✓ Establishing the Environmental Education Council, developing sustainability curricula with broader support from cultural, religious and ethical institutions
- ✓ Establishing the Environmental Education Network that can help promote and coordinate the curricula in all schools
- ✓ Easing access to establish youth-led environmental NGOs and facilitating them to promote environmental education and awareness programs
- ✓ Setting up special grants to promote action-based and community-based environmental education in schools
- ✓ Hosting effective awareness campaigns for different aged groups.
- ✓ Highlighting the perils of overconsumption and environmental stress in the religious sermons targeting adults and older citizens.
- ✓ Creating public forums to discuss various environmental initiatives and ideas
- ✓ Creating a Community Information Portal (CIP) providing information to citizens about various environmental problems (local and global), energy rating schemes for appliances and equipment, labelling of products, etc.
- ✓ Creating platforms for public consultation for major infrastructure projects

When it comes to education and research, Qatar is far behind compared to many developed and developing countries. In last few years, there is widespread acknowledgement of the significance of education, research and development. Since early 2000, Qatar's R&D budget increased substantially leading to establishing reputed universities, funding agencies, and research institutes. Energy and environment are one of the key areas of Qatar National Research Strategy. Under that broader umbrella, research is primarily focused on renewable energy, new materials for solar cells/batteries and novel methods of desalination. During the COP18 summit, Qatar Foundation signed the Memorandum of Understanding (MoU) with Potsdam Institute (Germany) to establish a climate change research institute. The institute's objective was to develop comprehensive research and monitoring activities related to climate change in the region. However, the idea was short-lived. Climate change is not part of current research portfolio in either Qatar University or the Qatar Foundation. Even the government has not done any serious analysis of the impacts of climate change on its society, economy, and infrastructure. It relies heavily on the international forecasts made by the leading intergovernmental institutions. Although there is a dedicated climate change department (set up after COP18) in the Ministry of Municipality and Environment, there is no ongoing climate research or any clear agenda of the department. Consequently, the following recommendations are proposed:

- ✓ The country should set up a Climate Change Research Programme focusing on climate change impacts on agriculture, water, infrastructure, marine and terrestrial biodiversity and public health

- ✓ Increase funding for research on climate change, low carbon transition, adaptation and mitigation measures. QNRF already spends substantial funding and this has to be redirected to climate change studies (see section above)
- ✓ Build research capacity for industrial emission mitigation options through industry-academia partnerships
- ✓ Build strong research collaboration with regional and international research institutions
- ✓ Create open innovation labs for catering to a future low-carbon and circular economy

There is a growing trend for highly efficient and environmentally friendly products in the world. Besides lab-based research programs, it is important to create an "Open House" that can bring citizens to generate new ideas to tackle environmental challenges and develop products that suit local needs. The products can be commercialized and encouraged to produce at a mass scale to cater to demand at a regional level.

As a part of its diversification program, the government is keen to create new economic activities. One such case is Qatar Solar Tech (or QSTec). It is a $1 billion polysilicion manufacturing plant that can produce 8,000 metric tonnes of polysilicion annually. However, it is challenging to remain competitive in the market because of cheap photovoltaics from China. Additionally, the government is building new economic zones that can rival neighbouring economic zones. The objective is to encourage local and foreign companies to establish new industries and sectors. The new economic zones (Manateq) can best be used as a strategic area to develop and produce low carbon technologies that can supply the local and regional markets.

The government, industries, small/medium enterprises, development banks/private investors and aspiring entrepreneurs should develop a long-term strategic plan to focus on creating a low carbon industrial model. The low carbon economic activities can be classified into three distinct areas,

A low carbon technology implementation sector – the successful development of economic activities focused on reducing carbon emissions through the implementation of existing and developing technologies;

Manufacturing led growth in low carbon activities - the development of world class, export orientated low carbon activities based on manufacturing;

A Low carbon services led sector – the development of world class, export orientated low carbon activities based on business, financial and technical services.

Qatar has a distinct advantage of brand recognition in the global gas and petrochemical market. The country should capitalize on the experience it has achieved, and advance its new low carbon businesses and services.

10.5 GREENING FOREIGN AID AND INTERNATIONAL SUPPORT

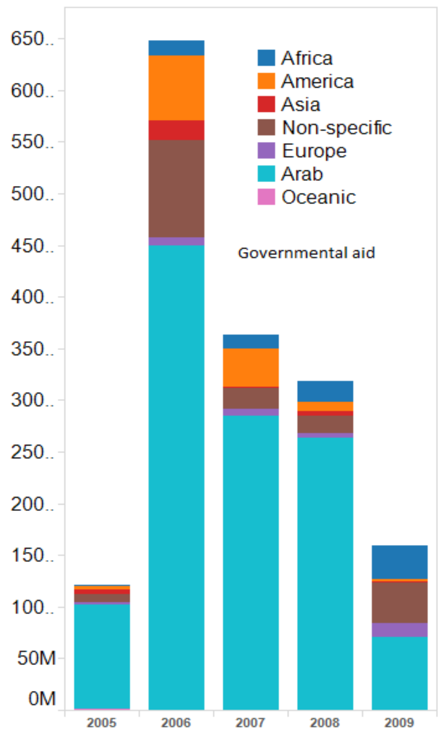
Besides emission reduction, the industrialized countries agreed to support developing countries through financial support and technology transfer. There are a wide range of multilateral institutions and global initiatives that support key environmental and developmental challenges in developing countries. There is plenty of literature about climate finance, for more details, visit http://www.climatefundsupdate.org/about-climate-fund/global-finance-architecture

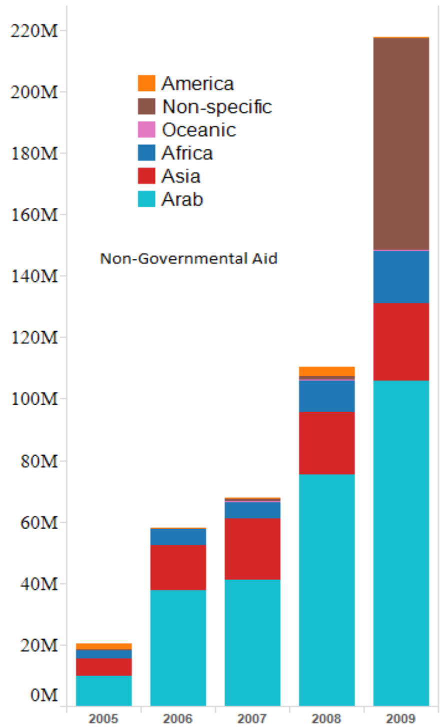
As a developing (and non-Annex) country, it is not obliged to provide financial aid or overseas development assistance (ODA) to developing countries. However, Qatar has a long tradition of providing support to financially poor countries through development aid and humanitarian relief. The governmental assistance witnessed a substantial increase in the seventies, reaching $198 million and fell ($18.1 million) in the eighties reflecting the decline in oil prices and budget deficit in the country. Between 1974 and 2003, governmental assistance amounted to $2.8 billion and nearly $2 billion during the period 2005-2009. In 2012, the total ODA by the state and charitable foundations were $0.82 billion. In addition, Qatar has extremely active charity organizations based in several countries in Asia and Africa. During 2005-2009, 76.7% and 54.5% of the government aid went to Arab countries. Nearly 70 percent of the aid was allocated to construction/reconstruction and humanitarian relief, followed by education as shown in figure 10.5. Supporting environmental projects is not considered to be a priority, the total fund for environmental projects testify to this claim. Qatar's development aid and charity focused on countries that are facing a dire crisis such as famine and conflict. However, these countries are mired with environmental problems and sometimes the conflicts result from the mismanagement of natural resources.

Although, the government realizes the significance of environmental issues and perils of climate change in developing countries, the then Foreign Minister of Qatar, Khalid Bin Mohammed Al-Attiyah said in the foreword of the 2013 annual Foreign Aid Report, "require new challenges and paradigms that rationalize foreign aid… way to deal with climate change and its ongoing risks that jeopardizes international partnership efforts for sustainable development in the world." However, the number shows a different reality; only 0.01% of aid is allocated to sustainable development and other relevant issues as shown in figure x. Similarly, the charity organization's focus is on humanitarian relief, access to drinking water, and religious activities. It is high time for the government and charity organizations to shift its focus from short-term humanitarian relief to long-term issues such as:

- ✓ Clean Energy;
- ✓ Indigenous Agriculture Practices;
- ✓ Livelihood-based Poverty Reduction Strategies;
- ✓ Natural Resource Protection and Governance
- ✓ Rural Infrastructure Development
- ✓ Ecological Restoration; Ecosystem-based adaptation and mitigation
- ✓ Disaster Preparedness and Climate Risk Mitigation
- ✓ Supporting implementation of Millennium and Sustainable Development Goals

Additionally, the funds could be channeled beyond traditional bilateral government-to-government; supporting multilateral environmental agencies and initiatives, grassroots NGOs and civil society organizations in the recipient countries.





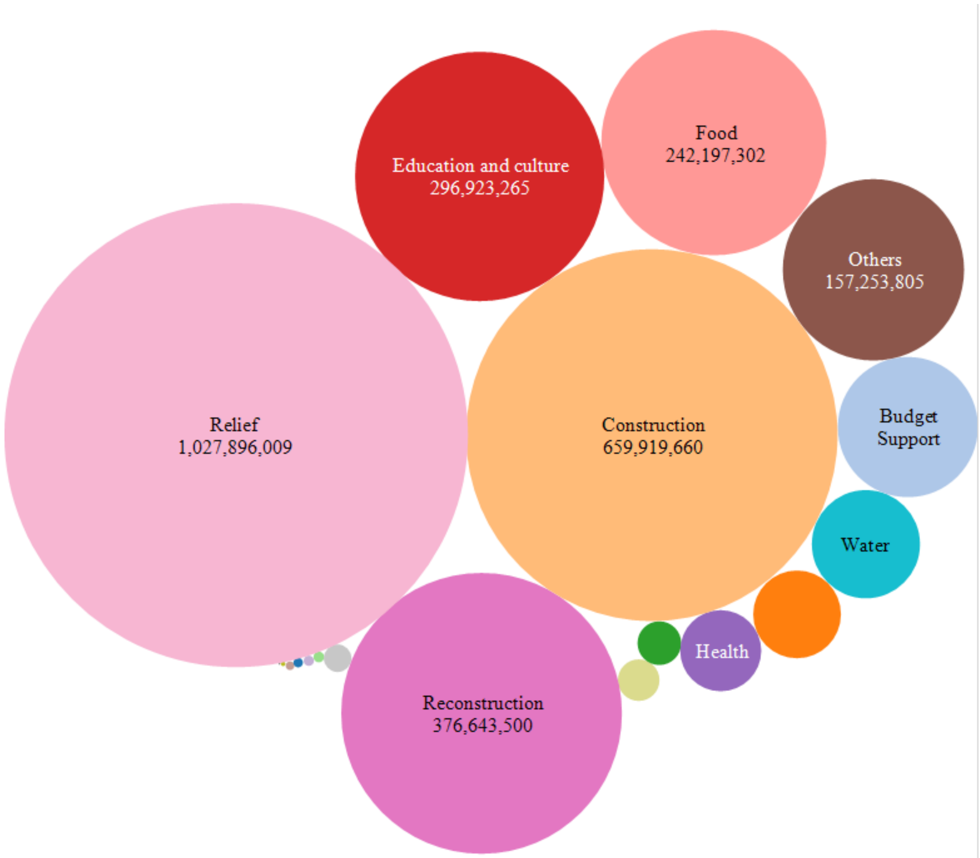


Figure 10.5 Total governmental aid in 2012, all values are in Qatari Riyals

10.6 ENVIRONMENT AND SDGs

Ever since the Qatar National Vision 2030 was published, sustainability captured the attention of policy makers, industrialists, and academics. The vague concept of sustainable development has often been misconstrued and taken at a superficial level. To be pragmatic, the policymakers mould a concept that suits national aspirations and needs. In order to operationalize sustainable development, a new brand of indicators needs to be developed to get a deeper understanding and "bridge the gaps between the concept and day-to-day decision making." Indicators help to measure progress, compare the trend at different periods, and act as a signpost to avoid danger and risks. With the evolving complexities and nexus of different disciplines; developing, monitoring and tracking indicators became a challenging task. There are far too many indicators now than in the past two decades. Indicators vary in size, measuring the sustainability of a household to the national carrying capacity. Indicators require resources to gather information. It is in the countries or firms interest to select indicators that are cost-effective and have a meaningful contribution to the economy and society. There are many elements to the development of sustainability indicators:

a. Enhancing information exchange among interested actors;
b. Developing a methodology to collect necessary data made available to necessary actors
c. Training and capacity building to gather and process the data
d. Evaluating indicators at disaggregated and aggregated levels
e. Advancing the conceptual framework of the indicators through collaboration of experts from different disciplines

There are various types of indicators covering broader dimensions of sustainable development. Some of the indicators, especially in the environmental burden and material resources indicators, are mentioned below:

- Normative and Ethics indicator
- Psychological Indicators
- Qualification Indicators
- Organizational Indicators
- Living Condition Indicators
- Welfare and Social Conditions Indicators
- Material Resources Indicators
- Financial and Economic Indicators
- Dependence Indicators
- Environmental Indicators

At a global level, sustainability has maintained the interest of policy makers for the last three decades. With the growing global ecological crises, definitive measures must be taken at a global, national and local scale to avoid major catastrophe and remain safe within planetary boundaries. After the partial success of millennium development goals (MDGs), the world sought something bigger and bolder than MDGs covering the entire geography of the world.

After years of intense debate among different stakeholders, mediated by the UN; 17 goals and 169 targets were put in place. These are called the Sustainable Development Goals (SDG). During the 70th session of the UN General Assembly, SDGs were officially launched, ushering in a new area for concrete objectives and goals to speed up the process to mitigate global environmental, social and economic crises. The SDGs were built on MDGs, representing broader issues ranging from poverty to inequality, climate change to inclusive societies. Environment, natural resources, climate change, sustainable energy are some of the main environmental goals included in the SDGs. Goals help to allocate resources, direct attention to key areas, and help to measure the effectiveness of policies.

It received high-level support; during the 70th UN General Assembly meeting, all of the leaders endorsed SDGs and took the idea back home to incorporate them into their national goals. One major problem with the SDGs is there are far too many goals and sometimes they lose the importance of the goals itself. This builds tension between different interest groups as each sector tries to get maximum attention. Unfortunately, this is the reality of our society - complex, interconnected and interdependent. It is in the best interest of the state to build relevant and composite indicators in each sector and create necessary policy choices.

At the time of writing this section, SDGs have still not entered into the daily discourse of policy making, except for a small group in the Ministry of Foreign Affairs and Ministry of Development Planning & Statistics. To my knowledge, no workshop or focus group discussion or committee has been formed to integrate SDGs into national policymaking. I believe in the coming months several subcommittees will be formed. To implement and achieve SDGs in the given time frame, the country should develop long-term ambitions goals related to all sectors. A new SDG framework should be developed that address three major components:

- The *analytical framework* assesses actors, policy interlinkages, enabling conditions and sources of finance.
- The *institutional framework* assesses government approaches, such as awareness, political commitment, priority setting, and stakeholder involvement, as well as aspects of policy coordination, such as coordination mechanisms, country-specific SDG targets, and interlinkages across governance levels.
- The *monitoring framework* assesses the need to strengthen and adapt monitoring and reporting mechanisms.

Restricting this discussion to the environmental sector, the government in the coming months should address these ambitious goals, which will lead to concrete indicators. Long-term policy plans should be developed and enforced in all institutions in order to achieve these indicators. Coincidentally, the Qatar National Vision and SDG targets converge at the same time. It is crucial for the Planning Committee to integrate both policy targets in their upcoming National Development Strategies. Also, each ministerial organization should incorporate SDG targets in their organizational plans. To my knowledge, there are very limited environmental targets set by the government. The state should set targets in consultation with a broad range of actors within society, such as academia and corporations. Qatar has to intensify its efforts, in many cases, it should broaden its policy designs, and in some cases, it should fundamentally redesign its policies.

Nonetheless, in the meantime, I take the luxury to draft an initial set of environmental indicators, which in my view, are relevant to Qatar. These indicators might not be comprehensive, with the participation and consultation of ministries, civil society groups, academia we will be able to develop holistic and locally-relevant environmental indicators addressing key SDGs. Although, in the last few years, the Environmental Statistics Department in the MDPS managed to report some indicators consistently. Before talking about the indicators, let us situate the role of the environment in the SDGs, and I address only relevant goals and targets. I deliberately excluded goals that are vague and defined at a global level making it difficult to establish reliable targets at the national level. Of 169 targets, there are 41 environmental-related SDG targets and some targets are quantifiable while others are not (see Appendix). Some targets leave ample of room for subjective interpretation. Also, I emphasize that all targets should be based on fairness and equity. The success of SDGs depends on the interaction between the stakeholders at the highest planning level (i.e. Emiri Diwan/Shura Council/MDPS) to a functional level (ministries, municipalities, and individual organizations). Some indicators fulfil multiple targets and require support from different institutions to work together in setting the targets. The synergies and tradeoffs between SDGs and the current national policies should be taken into account and find tangible solutions to address tradeoffs. The government should allocate sufficient public finances and a policy mechanism to facilitate SDGs. Additionally, independent monitoring and evaluation committees should be formed and assess the trend of setting targets through indicators. These SDG Monitoring Reports should be disseminated to all stakeholders and the public at large addressing the positive trends, and challenges faced in achieving the SDGs. It is vital for the country to set high standards and redesign policies, while at the same time, stay grounded in reality and the local challenges that can transform the country and position it to be a role model in the region.

These initial set of indicators drafted in this Report are collected from different sources. Some indicators are taken collectively from one source such as the UN System of Environmental-Economic Accounting (SEEA); others are taken from independent scholarly studies. I believe the policy makers will take into account all indicators. Also, many important indicators are omitted for the sake of space.

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SDG Goal	Target	Suggested Indicator	Local Target	Responsible Institutions
2	2.3	Value of production per labour unit (measured in constant USD)	Increase the productivity by x% by 2025	MoE, MoEC, MoF
		Water productivity (m3/ton)	Increase the water productivity by x% by 2025	MoE
	2.4	Percentage of agricultural area under sustainable practices	Increase the sustainable agricultural area by x% by 2030	MoE
	2.5	Ex-Situ Crop Collections Enrichment Index	Creation of seed banks	MoE
3	3.9	Population in urban areas exposed to outdoor air pollution levels, above WHO guideline values	Reduce the air pollution level below WHO guidelines by 2025	MoE, MoEI, MoT, MoPH
6	6.2	% of population using safely managed sanitation services*	Already achieved	
		% of population has full access to potable water*	Already achieved	Kahramaa
	6.3	% of wastewater safely treated, disaggregated by economic activity	Increase the industrial and domestic wastewater treatment capacity by x%	Ashghal
		% of utilization of wastewater	Increase the full utilization of wastewater for productive purposes	Ashghal
	6.4	% change in water use efficiency over time	Increase the water use efficiency in agricultural, industrial and other sectors by x% by 2025	Kahramaa, MoE, Ashghal, MoEI, QP
		Per capita water consumption	Decrease per capita water consumption by x% by 2020	Kahramaa, PWC
		%of total available water resources used, taking environmental water requirements	Sustainable withdrawal of water	MoE, Ashghal, Kahramaa
	6.5	Degree of integrated water resources management	x% of implementation of IWRM by 2025	PWC, Kahramaa, MoE,

7	7.1	% of population access to affordable energy*	Already achieved	Kahramaa
	7.2	% of energy (final consumption) from renewables	Increase x% of solar energy and x% of wind power by 2030	Kahramaa, MoEI, QP, QEWC
	7.3	Rate of improvement in energy intensity (%) measured in terms of primary energy and GDP	Increase energy intensity by x% by 2025	Kahramaa, MoEI, QP
		Improvement in the net carbon intensity of the energy sector (GHG/TFC CO2eq)	Reduce carbon intensity by x% by 2025	MoEI, QP
		Energy per unit of production	Reduce x% of energy per unit of production	MoEI, QP
		Energy per unit of km travelled	Reduce x% of energy per unit of km travelled	MoT, Woqod
		Per capita electricity consumption	Reduce per capita electricity consumption by x% by 2020	Kahramaa
11	11.2	Passenger km per capita	Reduce x% VKM per capita by 2025	MoT, MoI
		Increase access to public transport within 0.5 km	Increase x% of passengers using public transit	MoT, MoI
	11.3	Efficient land use		
	11.4	Share of national (or municipal) budget dedicated to preservation, protection, and conservation of natural heritage	Allocate x% of municipal budget every year	MoE, MMUP
	11.7	Area of green spaces (parks, etc.)	Increase x% of green spaces by 2030	MMUP
		Area of public space for everyone's access	Increase x% of public area for recreation	MMUP, MoE
	11.8	Phasing out all old buildings and retrofitting to resource-efficient buildings	Increase x% of green buildings against all buildings by 2025	MoE, MMUP, MoEC, MoF
	12.2	Per capita material consumption	Reduce x% per capita material consumption	MoE, MMUP, MDPS

12		Resource efficiency	Increase x% of resource efficiency by 2030	MoE, MMUP, MDPS
	12.3	Per capita food waste	Halve per capita global food waste at the retail and consumer levels by 2030	MoE, MDPS, MMUP
	12.4	Reduce chemical and oil spills	Halve the chemical and oil spill incidents in the industrial clusters and Persian Gulf by 2020	QP, MoE
	12.5	% of urban solid waste regularly collected and well managed	Increase x% of waste treatment facilities	MMUP
		Per capita waste	Decrease x% per capita domestic waste by 2025	MMUP
		% of recycling organic and inorganic waste	Increase x% of recycling (organic and inorganic)	MMUP
13	13.2	Reduce GHG emissions (disaggregated, sector wise)	Reduce GHG emissions by x% by 2030 from each sector	MoE, MoEI, MMUP, MoT, MDPS
		Reduce per capita CO2 emissions	Reduce per capita CO2 emissions by x% by 2025	MoE, MDPS
		Emission Intensity (tco2eq/GDP)	Reduce emission intensity by x% by 2030	
		Ozone Depleting Substances	Reduce x% ODP by 2020	MoE, MoEI
14	14.2	% of coastal and marine development with implemented ICM plans	Increase the area by x% by 2020	MMUP, MoE
	14.4	Proportion of fish stocks within biologically sustainable level	Maintain sustainable level of fishing beyond 2020	MoE
	15.1	Coverage of protected areas	Increase or maintain the protected areas	MoE, PEO
		Restore ecologically sensitive areas (Mangroves, shrublands, grasslands)		PEO, MoE, MMUP

15		Red List Index	Avoid further endangering of species	PEO, MoE, MMUP
	15.3	Trends in land degradation	Reduce/restore land degradation area by x% of total degraded area by 2025	PEO, MoE, MMUP
	15.9	Increase investment in protection of ecologically sensitive areas	Allocate x (QAR) every year to ESA	PEO, MoE, MMUP
General Indicators		Ecological Footprint (Energy and Water)	Reduce ecological footprint by x%	MoE, MDPS
		Increase environmental expenditures	Increase annual state and corporate and environmental expenditures	MoE, MDPS, MoEI, QP, and all companies
		Increase groundwater levels and area	Restore groundwater lens area to 1972 level by 2050	MoE
		Signatories to major environmental agreements		MoFA, MoE

* The recent survey shows the 100% of households connected to water/electricity and 88% to sewerage, Source: Housing and Establishment Survey, MDPS, June 2015

MMUP	Ministry of Municipality and Urban Planning
MoE	Ministry of Environment
MoEC	Ministry of Economy and Commerce
MoEI	Ministry of Energy and Industry
MoF	Ministry of Finance
MoFA	Ministry of Foreign Affairs
MoI	Ministry of Interior
MoPH	Ministry of Public Health
MoT	Ministry of Transport
PEO	Private Engineering Office
PWC	Permanent Water Committee
QEWC	Qatar Electricity & Water Company
QP	Qatar Petroleum

11. FINAL REMARKS

This Report provides reliable estimates of greenhouse gas emissions from 1995 to 2015. I have seen a remarkable increase in GHG emissions in Qatar and the industrial sector contributed over 90 percent of the GHG emissions. Currently, the uncertainty level in the greenhouse gas emissions from the oil sector is very high; considerable work is needed to improve the calculation methodology and reporting of emissions. The Report is far from complete and has a huge potential to improve. Nonetheless, it is my humble effort to fill the existing data gap, aiming to influence policymakers to take effective decisions in reducing greenhouse gas emissions for its own economic benefit. Data accessibility is a real challenge; if the current status quo remains, there is a very little chance to see a meaningful collaboration between academia, public and private sector. And, the dream to achieve a knowledge economy will be very difficult.

Many new environmental initiatives in last five years resulted in substantial financial and emission savings. More needs to be done. The piecemeal approach should be replaced with a comprehensive climate policy addressing near-term and long-term policy interventions. Currently, industrial policy development and execution process is obscure; policy enforcement and surveillance is weak. Without a strong regulatory body, there will be no enforcement and frank assessment of the situation. Therefore, it is vital for the government to create an independent regulatory body to monitor the climate policy targets. The recent changes in the operation of Qatar Petroleum and Ministry of Energy and Industry will give an important role to the latter. I believe MoEI will be authorized to develop and enforce policies for the hydrocarbon, electricity, and manufacturing sector.

There is growing evidence that proactive industries remain competitive in the market and maintain goodwill and trust among stakeholders and shareholders. The companies should go beyond emission reduction, addressing issues such as biodiversity, hazardous waste management, material recycling and resource efficiency. The Ministry could introduce performance incentives for companies that contribute to reducing emissions and improving resource efficiency. Also, I urge the Ministry of Energy and Industry to develop a compendium of low-carbon measures for oil, gas, and manufacturing industries and also facilitate mechanisms to implement them. Special funds could be allocated for small and medium companies or large industries implementing emission abatement technologies. As the sustainability reporting initiative crumbled, many companies retracted and became reluctant to publish their annual sustainability reports. This indicates, if there is subtle pressure or voluntary requirement or recognition for their effort, companies take such initiatives seriously.

For the betterment of the nation, and to facilitate framing of comprehensive policies; the ministerial agencies should demand all industries and other agencies report data on an annual or quarterly basis. These data should regularly be synthesized, reviewed and published in a public portal either managed by the Environmental Statistics Department of the Ministry of Development Planning and Statistics or the Ministry of Municipality and Environment. I encourage MDPS to collect a wide range of data from the industries and other stakeholders and increase the role of the Environmental Statistics Department in publishing various dimensions of environmental issues. Careful examination of the latest Annual Statistics Bulletin shows a disturbing trend, some of the key information is omitted. The earlier versions publish more data than the newest versions. I strongly advocate MDPS to publish key information such as air quality, hydrocarbon production and consumption data, electricity/water consumption in different sectors and the like. Also, I recommend the Ministry of Municipality and Environment publish annually the "State of the Environment of Qatar," addressing all key elements of the environment, covering all sectors including oil and gas, constantly monitoring trends and compiling new policies and initiatives for a better environment. This can be done in partnership with academia, industry and civil society. Also, to engage with the public, it is advisable to have special launch programs targeted to the general public. With regards to SDGs, I underscore the role of MDPS and other institutions that have been instrumental in the past and with the new requirements their role needs to be enhanced. Since Qatar is an energy-intensive, export-led economy, most of the indicators should be directed to the industrial sector that can complement national goals. The indicators must be discussed thoroughly with major industrial stakeholders to set relevant and achievable targets.

The lack of cooperation between and within agencies stifle all opportunities for meaningful cooperation, and the growing mistrust exacerbates the situation. Researchers, citizens and even employees of certain ministries lament the difficulties in accessing data and often restricted public use. The culture of mistrust is prevalent. If the trend continues, it will be difficult to see a meaningful cooperation between different agents and agencies. This can be avoided through strong legislations from the Emiri Diwan to publish all the data/reports for public use. The very idea of knowledge economy requires "exchange and sharing of knowledge."

Currently, Qatar lacks high-resolution country-specific climate models and its impact on different sectors. The real extent of the long-term impact is unknown. The government should conduct a thorough analysis to develop a comprehensive national adaptation strategy for its welfare and protection of citizens and infrastructure. The government, policymakers, and planners should make a concerted effort in integrating mitigation and adaptation plans, wherever possible, into all development efforts. As a rich, non-Annex country achieving all its basic goals of wellbeing, its moral imperative is to reduce emissions and also support financially weak countries in climate-resilient development. I hope the respective authorities increase/shift the development aid to climate-smart development, including ecological agriculture, ecological restoration, and climate change mitigation and adaptation.

Finally, transitioning towards a resource-efficient and decarbonized economy requires long-term policy targets, initiatives, and financing. I urge the government to develop a coherent strategy to implement the system changes and redesign environmental policies. Given the changing sociopolitical circumstances and global expectations, a cautious and adaptive policy approach is recommended. It is unwise to expect these changes happen overnight. Transitions take time. It has to overcome several administrative challenges, financial deficit, resistance from interest groups and societal response at large. Since environmental sustainability is very much part of the QNV 2030, I believe, the government will take all necessary measures i.e.

institutional capacities, policy interventions, and financing mechanisms that can have a transformative impact on the economy and encourage wider and deeper decarbonization.

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13. APPENDIX

Annex I Parties include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.

Annex II Parties consist of the OECD members of Annex I, but not the EIT Parties. They are required to provide financial resources to enable developing countries to undertake emissions reduction activities under the Convention and to help them adapt to adverse effects of climate change. In addition, they have to "take all practicable steps" to promote the development and transfer of environmentally friendly technologies to EIT Parties and developing countries. Funding provided by Annex II Parties is channelled mostly through the Convention’s financial mechanism.

Non-Annex I Parties are mostly developing countries. Certain groups of developing countries are recognized by the Convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others (such as countries that rely heavily on income from fossil fuel production and commerce) feel more vulnerable to the potential economic impacts of climate change response measures. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer.

Sustainable Development Goals

Goal 1	End poverty in all its forms everywhere
Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3	Ensure healthy lives and promote well-being for all at all ages
Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5	Achieve gender equality and empower all women and girls
Goal 6	Ensure availability and sustainable management of water and sanitation for all
Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10	Reduce inequality within and among countries
Goal 11	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12	Ensure sustainable consumption and production patterns
Goal 13	Take urgent action to combat climate change and its impacts*
Goal 14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17	Strengthen the means of implementation and revitalize the global partnership for sustainable development