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NATIONAL GREENHOUSE GAS INVENTORY REPORT FOR INDUSTRIAL PROCESSES IN LEBANON

2015 MINISTRY OF ENVIRONMENT

National Greenhouse Gas Inventory Report for Industrial Processes in Lebanon

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The United Nations Development Programme (UNDP) is the UN's global development network, advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. We are on the ground in 166 countries, working with them on their own solutions to global and national development challenges. As they develop local capacity, they draw on the people of UNDP and our wide range of partners.

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National Greenhouse Gas Inventory Report for Industrial Processes in Lebanon

Reference projects

Enabling Activities for the Preparation of Lebanon's Third National Communication to the UNFCCC

Lebanon's First Biennial Update Report

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Foreword

Ministry of Environment

Through the publications of Lebanon's Initial and Second National Communications to the United Nations Framework Convention on Climate Change, and the Technology Needs Assessment for Climate Change, the Ministry of Environment drew the large climate change picture in the country. The picture shed the light on a number of climate change matters: Lebanon's contribution to global greenhouse gas emissions, the sectoral share of national emissions, the socio-economic and environmental risks that the country faces as a result of climate change, and the potential actions that could and should be undertaken to fight climate change both in terms of mitigation and adaptation.

Through these series of focused studies on various sectors (energy, forestry, waste, agriculture, industry, finance and transport), the Ministry of Environment is digging deeper into the analysis to identify strengths, weaknesses, threats and opportunities to climate friendly socio-economic development within each sector.

The technical findings presented in this report (National Greenhouse Gas Inventory Report for the Industrial Sector) will support policy makers in making informed decisions. The findings will also help academics in orienting their research towards bridging research gaps. Finally, they will increase public awareness on climate change and its relation to each sector. In addition, the present technical work complements the strategic work of the National Climate Change Coordination Unit. This unit has been bringing together representatives from public, private and non-governmental institutions to merge efforts and promote comprehensive planning approach to optimize climate action.

We are committed to be a part of the global fight against climate change. And one of the important tools to do so is improving our national knowledge on the matter and building our development and environmental policies on solid ground.

Mohammad Al Mashnouk

Minister of Environment

Foreword

United Nations Development Programme

Climate change is one of the greatest challenges of our time; it requires immediate attention as it is already having discernible and worsening effects on communities everywhere, including Lebanon. The poorest and most vulnerable populations of the world are most likely to face the harshest impact and suffer disproportionately from the negative effects of climate change.

The right mix of policies, skills, and incentives can influence behaviour and encourage investments in climate development-friendly activities. There are many things we can do now, with existing technologies and approaches, to address it.

To facilitate this, UNDP enhances the capacity of countries to formulate, finance and implement national and sub-national plans that align climate management efforts with development goals and that promote synergies between the two.

In Lebanon, projects on Climate Change were initiated in partnership with the Ministry of Environment from the early 2000s. UNDP has been a key partner in assisting Lebanon to assess its greenhouse gas emissions and duly reporting to the UN Framework Convention on Climate Change. With the generous support of numerous donors, projects have also analysed the impact of climate change on Lebanon's environment and economy in order to prioritise interventions and integrate climate action into the national agenda. UNDP has also implemented interventions on the ground not only to mitigate the effects of climate change but also to protect local communities from its impact.

This series of publications records the progress of several climate-related activities led by the Ministry of Environment which UNDP Lebanon has managed and supported during the past few years. These reports provide Lebanon with a technically sound solid basis for designing climate-related actions, and support the integration of climate change considerations into relevant social, economic and environmental policies.

Ross Mountain

UNDP Resident Representative

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Acronyms

ALI	Association of Lebanese Industrialists
CCIA	Chamber of Commerce, Industry and Agriculture
CKD	Cement Kiln Dust
EDL	Electricité du Liban
EFL	Environmental Fund for Lebanon
EU	European Union
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Gigagram = 1,000 tonnes = 1,000,000 kg
GHG	Greenhouse Gas
hl	hectoliter = 100 liters
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
IPMS	Industrial Pollution Management System
LEPAP	Lebanon Pollution Abatement Project
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoET	Minstry of Economy and Trade
MoI	Ministry of Industry
NMVOCs	Non-Methane Volatile Organic Compounds
SNC	Second National Communication
SPASI	Strengthening the Permitting and Auditing System for Industries
TNC	Third National Communication
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization

Executive summary

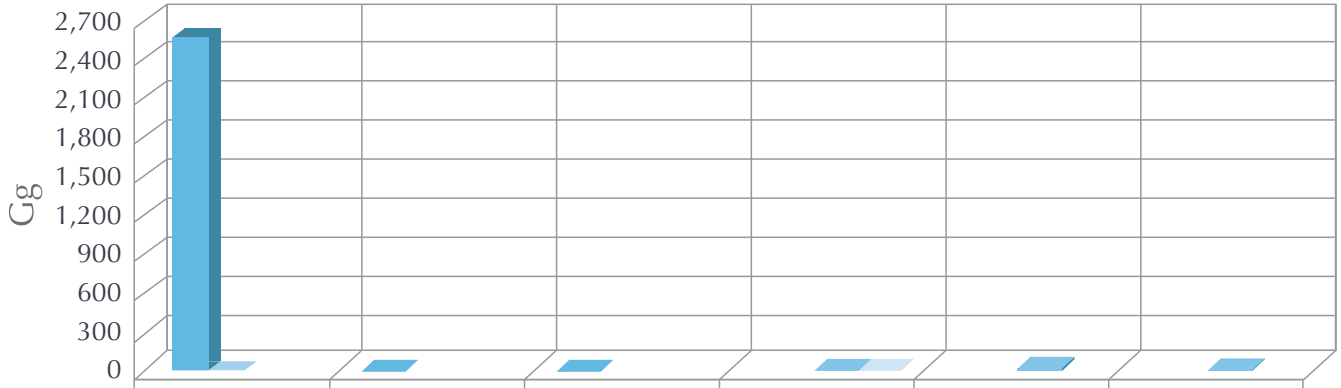
In the framework of Lebanon's Third National Communication (TNC) to the United Nations Framework Convention on Climate Change (UNFCCC), Greenhouse Gas (GHG) emissions resulting from the industrial sector in Lebanon were estimated for the years 2006 to 2011. Calculations were made using the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 1997) and the 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). The tier 1 approach of the IPCC guidelines was used in the calculations of the GHG of all the reporting categories, except for the cement production, where the GHG were calculated using the tier 2 approach.

Inventory

Among the reporting categories, some were not included in the GHG inventory. The emissions from ammonia and metal production were reported as not occurring due to the absence of the mentioned industrial activities in Lebanon. The GHG emissions from phosphate fertilizer production, coffee, and halocarbons were not estimated due to the absence of activity data. Recalculations were done for the year 2000 for the following categories: lime production, soda ash use and fish production.

The major greenhouse gas emitted was carbon dioxide (CO_2), along with the major precursors sulfur dioxide (SO_2) and non-methane volatile organic compounds (NMVOCs).

In 2011, total GHG emissions from the industrial sector in Lebanon amounted to 2,584 Gg of CO_2eq. The major sources of emissions from the industrial sector in 2011 were CO_2 and SO_2 from the cement industry with 2,578 Gg and 2 Gg respectively, CO_2 from lime production (3 Gg), CO_2 from use of soda ash (4 Gg) and NMVOCs from the asphalt roofing, the road paving (use of asphalt for road surface) and the food and beverages production industries, all together accounting for 41 Gg (Figure i).



	Cement production	Lime production	Use of soda ash	Production of asphalt roofing	Use of asphalt for road surface	Food and beverages production
CO_2	2,578	3	4			
SO_2	2					
NMVOCs				0.04	28.5	13
CO				0		

Figure i: Distribution of emissions from industrial processes per category and per gas for 2011

In 2011, the CO_2 emitted from the cement industry accounted for 99.76% of the CO_2 emitted from the industrial sector. Lime production's contribution to the national industrial CO_2 emissions was only 0.12%.

Generally, emissions from the industrial sector increased in 2011 compared to the base year 2000. The total CO_2 emissions from the industrial sector increased by 31.7% from the year 2000 to 2011. The cement industry was the major contributor to the increase of the CO_2 emissions. Up until 2011, the CO_2 emitted from the cement industry increased by 36.5% from the year 2000, due to the booming in the construction activities in Lebanon. The CO_2 emitted from the lime production industry increased by 33.33% over the same period (Figure ii).

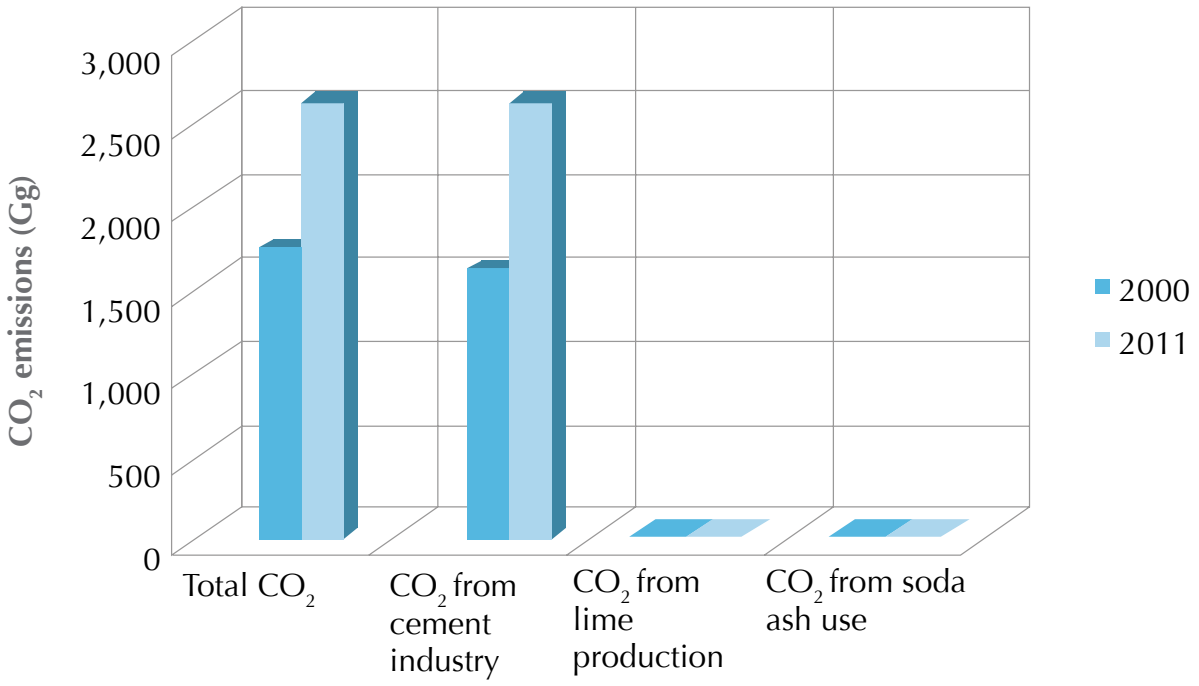


Figure ii: Evolution of emissions of CO_2 from industrial processes between 2000 and 2011

الملخص التنفيذي

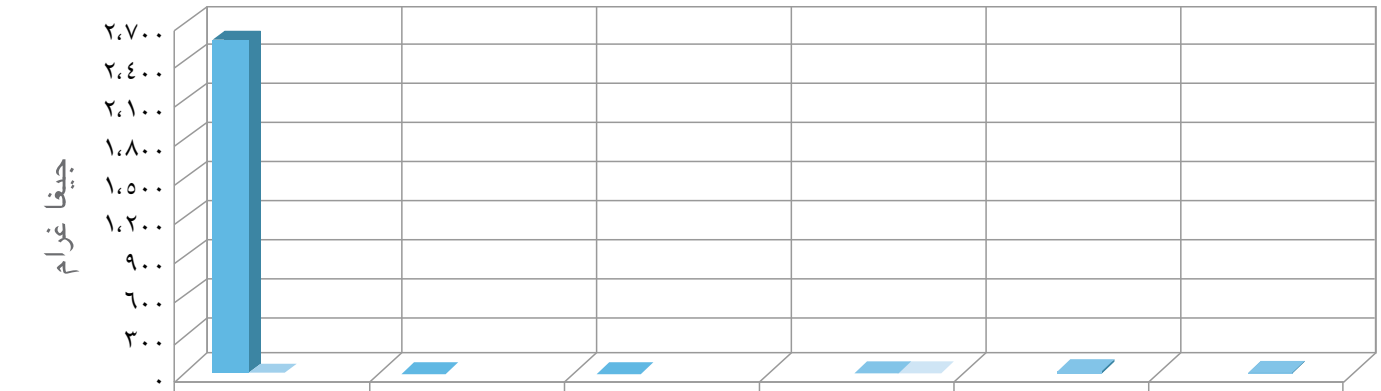
في إطار البلاغ الوطني الثالث للبنان إلى اتفاقية الأمم المتحدة الإطارية بشأن تغير المناخ، تم تقدير انبعاثات غاز الاحتباس الحراري (الغازات الدفيئة) الناجمة عن القطاع الصناعي في لبنان خلال الفترة ٢٠٠٦ – ٢٠١١. وتمت العملية الحسابية باستخدام الخطوط التوجيهية المنقحة للهيئة الحكومية الدولية المعنية بتغير المناخ لعام ١٩٩٦ بشأن عمليات الجرد الوطنية لغازات الإحتباس الحراري ودليل الممارسات السليمة في عمليات الجرد الوطنية لغازات الإحتباس الحراري ودرجة عدم اليقين في تقديراتها. وتم اعتماد المبادئ التوجيهية لمنهجية المستوى ١ للهيئة الحكومية الدولية المعنية بتغير المناخ (IPCC) في احتساب الغازات الدفيئة لكافة فئات التقارير باستثناء إنتاج الإسمنت، حيث تم احتساب الغازات الدفيئة باعتماد منهجية المستوى ٢.

قوائم الجرد

لم يتم ضم بعض فئات مصادر الإنبعاثات (غاز الأمونيا والمعادن) في قوائم جرد غازات الدفيئة وذلك بسبب غياب هذه الأنشطة الصناعية في لبنان. ولم يتم تقدير انبعاثات الغازات الدفيئة الناجمة عن إنتاج الفوسفات والأسمدة والقهوة والهالوكربونات نظرًا لعدم وجود بيانات هذه الأنشطة. وقد أجريت عمليات إعادة الحساب (للقوائم سنة ٢٠٠٠) للفئات التالية: إنتاج الجير واستخدام رماد الصودا والمنتجات السمكية.

أما الغازات الدفيئة الأساسية المنبعثة فكانت ثاني أكسيد الكربون إضافة إلى السلائف الأساسية وهي ثاني أكسيد الكبريت (SO_2) والمركبات العضوية المتطايرة غير الميثانية (NMVOCs).

في العام ٢٠١١، وصل إجمالي انبعاثات الغازات الدفيئة الناجمة عن القطاع الصناعي في لبنان إلى ٢،٥٨٤ جيغاغرام من مكافئ ثاني أكسيد الكربون. أما المصادر الأساسية لانبعاثات الغازات الناجمة عن القطاع الصناعي في العام ٢٠١١ فكانت ثاني أكسيد الكربون وثاني أكسيد الكبريت الناجم عن صناعة الإسمنت وبحجم ٢،٥٧٨ جيغاغرام و٢ جيغاغرام على التوالي، وثاني أكسيد الكربون الناجم عن إنتاج الجير (٣ جيغاغرام) وثاني أكسيد الكربون الناجم عن استخدام رماد الصودا (٤ جيغاغرام) والمركبات العضوية المتطايرة غير الميثانية الناجمة عن التسقيف وتعبيد الطرق بمادة الإسفلت ومجالات إنتاج المأكولات والمشروبات، والتي تمثّل مجتمعةً ٤١ جيغاغرام (الشكل أ).

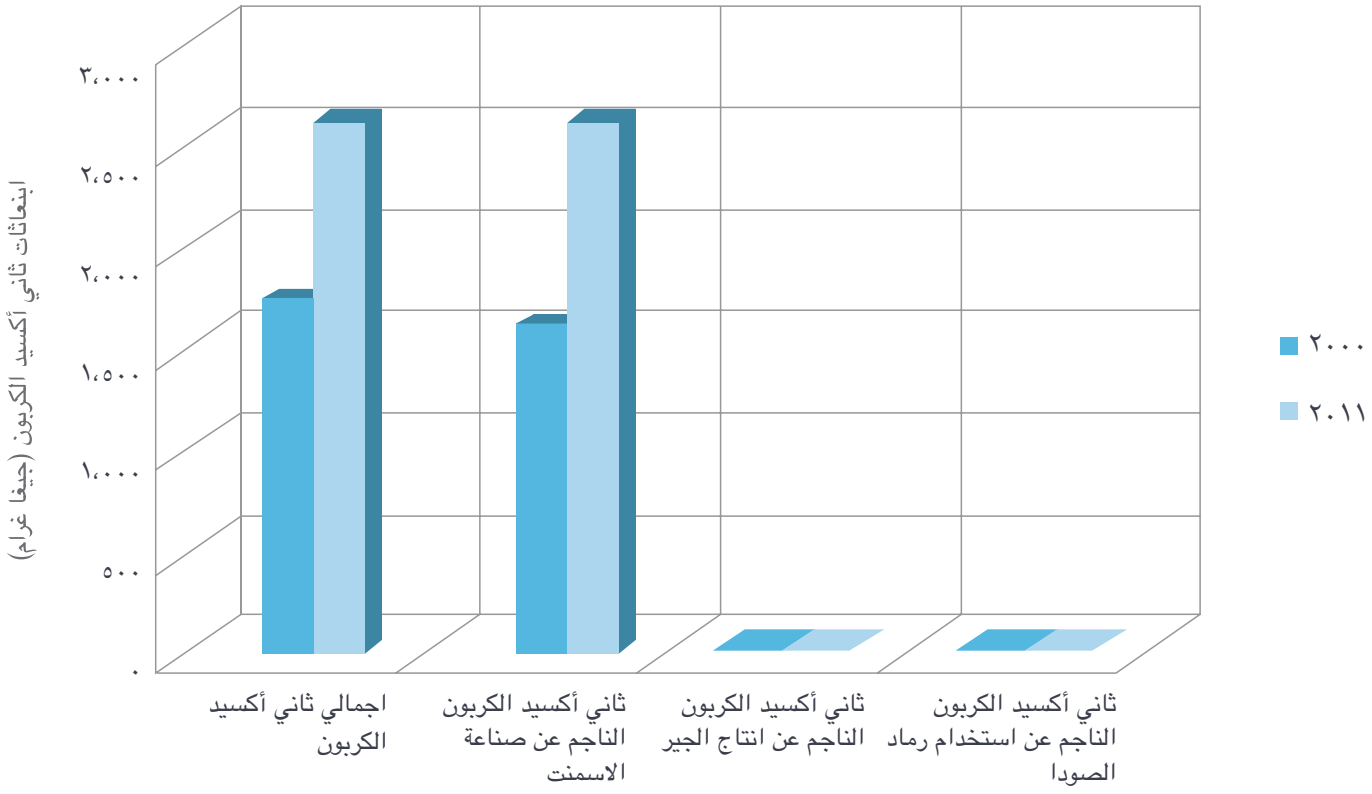


	انتاج الاسمنت	انتاج الجير	استخدام رماد الصودا	إنتاج الإسفلت للتسقيف	إنتاج الإسفلت لسطح الطريق	إنتاج المأكولات والمشروبات
CO_2	٢،٥٧٨	٣	٤			
SO_2	٢					
NMVOCs				٠،٠٤	٢٨،٥	١٣
CO				٠		

الشكل أ: توزيع انبعاثات الغازات من العمليات الصناعية بحسب الفئة وبحسب الغاز للعام ٢٠١١

في العام ٢٠١١، شكّل ثاني أكسيد الكربون الناجم عن صناعة الإسمنت نسبة ٩٩,٧٦٪ من ثاني أكسيد الكربون المنبعث من القطاع الصناعي. وأما مساهمة إنتاج الجير في الانبعاثات الصناعية لثاني أكسيد الكربون فكانت بنسبة ٠,١٢٪ فقط.

بشكل عام، ارتفعت الانبعاثات الناجمة عن القطاع الصناعي في العام ٢٠١١ مقارنة بالعام ٢٠٠٠. وارتفع إجمالي انبعاثات ثاني أكسيد الكربون الناجمة عن القطاع الصناعي بنسبة ٣١,٧٪ من العام ٢٠٠٠ وحتى ٢٠١١. وأما صناعة الإسمنت فكانت المساهم الأساسي في زيادة انبعاثات ثاني أكسيد الكربون. وحتى العام ٢٠١١، ارتفعت انبعاثات ثاني أكسيد الكربون الناجمة عن صناعة الإسمنت بنسبة ٣٦,٥٪ من العام ٢٠٠٠، وذلك نتيجة لازدهار أنشطة البناء في لبنان. وارتفعت انبعاثات ثاني أكسيد الكربون الناجمة عن إنتاج الجير بنسبة ٣٣,٣٣٪ خلال الفترة ذاتها (الشكل ب).



الشكل ب: تطوّر انبعاثات ثاني أكسيد الكربون الناجم عن العمليات الصناعية بين العام ٢٠٠٠ والعام ٢٠١١

1. Scope

As a Non-Annex I party to the United Nations Framework Convention on Climate Change (UNFCCC), Lebanon should periodically communicate its national inventory of Greenhouse Gas (GHG) emissions by source and removals by sink. Lebanon submitted its first GHG Inventory report through the Initial National Communication (INC) to the UNFCCC in 1999, and updated it through the Second National Communication (SNC) in 2011. The present report is published as part of the Third National Communication (TNC) to the UNFCCC project funded by the Global Environment Facility (GEF), implemented by the Ministry of Environment (MoE) and with the technical support of the United Nations Development Programme (UNDP). The report updates Lebanon's GHG inventory of the industrial processes sector for the third time for the period 2006-2011.

2. National circumstances

2.1. Overview

In the year 2007, a national industrial survey conducted by the Ministry of Industry (MoI) in collaboration with the United Nations Industrial Development Organization (UNIDO) identified 4,033 establishments with a workforce of a minimum of 5 workers, an Electricité du Liban (EDL) connection of a minimum of 50 Amperes or equivalent and benefiting from industrial certificates issued by the MoI. Out of these establishments, 61.7% were established between 1990 and 2007, making the Lebanese industrial sector a relatively new one (MoI/ALI/UNIDO, 2010). Figure 1 depicts the total number of the industrial establishments between the years 1950 and 2007 (EFL, 2013).

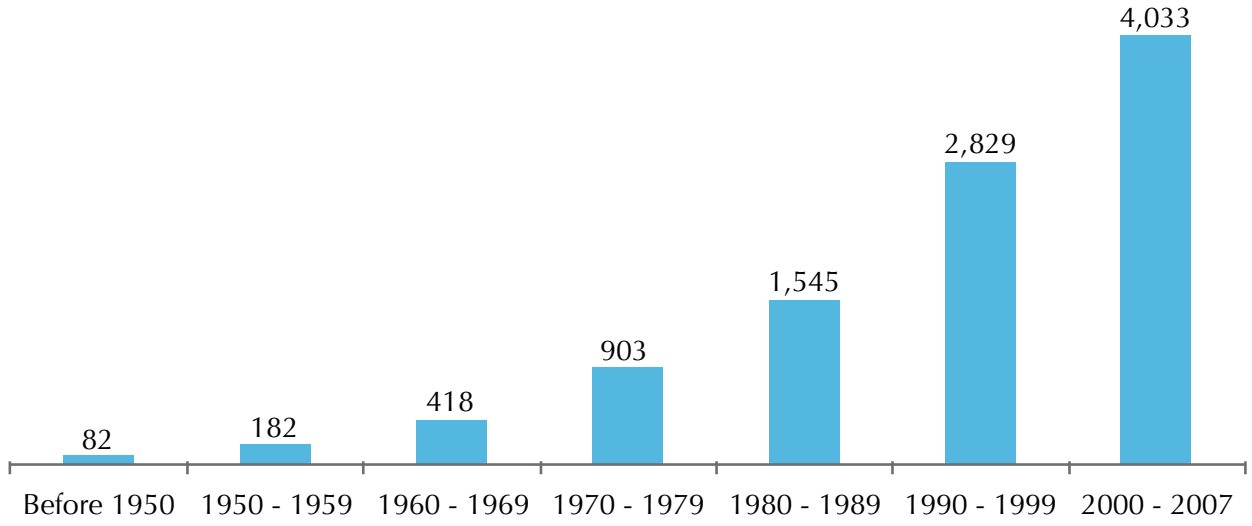


Figure 1: Total number of industrial establishments in Lebanon per decade between the years 1950 and 2007

2.2. Economic significance

The Lebanese industrial sector is relatively narrowed to 15 different subcategories from which 10 subcategories represent 86.1% of the total sector. The major industrial sectors are the food and beverage, the non-metallic mineral products (including cement and cement products and stones

shaping), and the fabricated metal products sectors. Other active sectors include the chemical sector, furniture manufacturing and electrical machinery manufacturing.

In 2007, the 10 major sectors generated 90.7% of the total value added of the industrial sector, employed 87.3% of the workforce and achieved 94.6% of the yearly industrial investments (EFL, 2013).

The food and beverage industries represent around 18.2% of the total industrial establishments, employing around 24.9% of the total industrial workforce and generating more than 26.9% of the value added of the sector. The non-metallic mineral products sector represents around 15.1% of the industrial establishments and employing around 13.3% of the workforce (MoI/ALI/UNIDO, 2010). Figure 2 and Figure 3 represent the distribution of establishments by economic activity and the distribution of workforce by economic activity respectively (MoI/ALI/UNIDO, 2010).

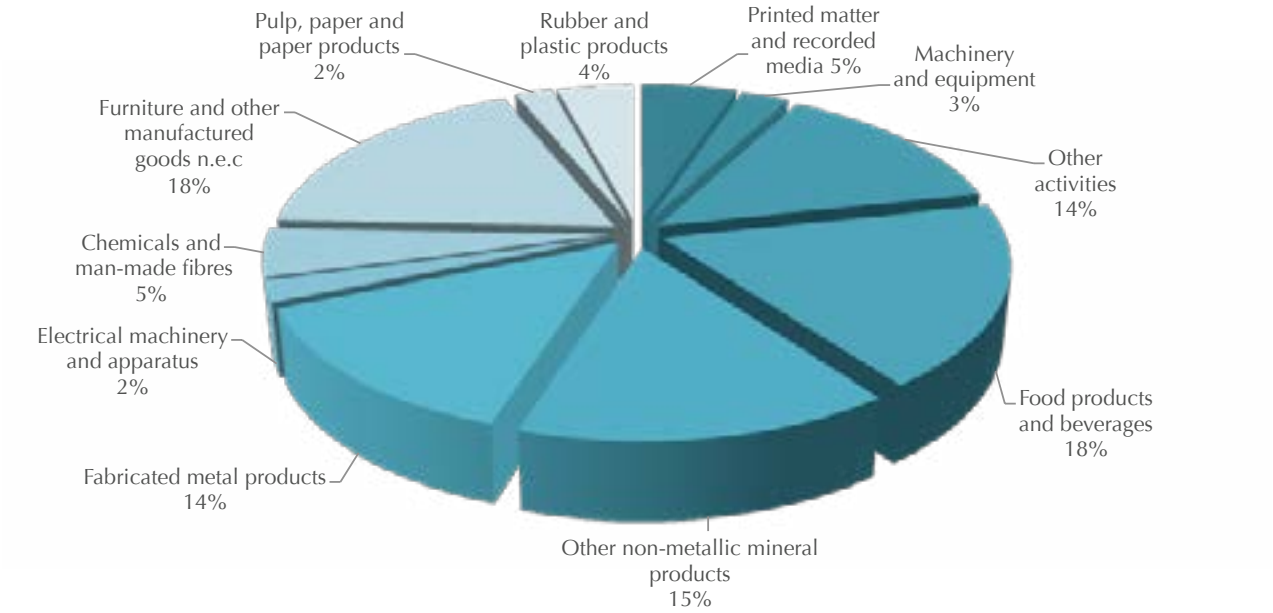


Figure 2: Distribution of industrial establishments by economic activity in 2007

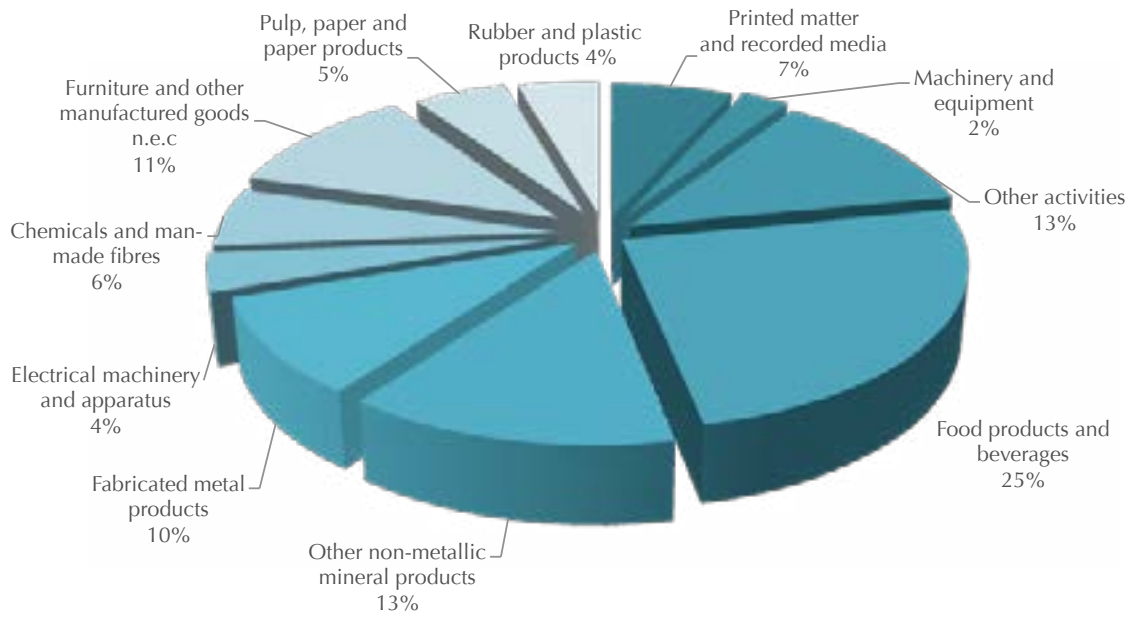


Figure 3: Distribution of workforce in the industrial sector by economic activity in 2007

The industrial output of the 4,033 industrial establishments reached USD 6.8 billion[1] in 2007. The food and beverage industry was the leading sector, followed by the other non-metallic mineral products sector, with total shares of 25.7% and 11.7% respectively. The total share of the fabricated metal products sector was 10.9%.

In a similar industrial survey conducted in 1998, the industrial survey comprised 5,802 industrial establishments employing more than 4 workers with a total industrial output of USD 3.1 billion. The gross industrial output increased by 115% between 1998 and 2007. The higher efficiency of the industrial activities along with the price inflation and the depreciation of the American Dollar and Lebanese Pound with respect to other currencies (Euro, Yen) during the same period played key roles in the increase of the gross industrial output. However, the shares of the food and beverage and the other non-metallic mineral products sectors decreased from 1998 to 2007 (28% and 14.8% respectively in 1998) (MoI/ALI/UNIDO, 2010).

Despite the noticeable increase in the gross industrial output, the industrial growth rate and the contribution of the industrial sector in the Gross Domestic Product (GDP) declined over the years 1995 to 2010. Due to the political instability in the region in 2010, the industrial growth rate decreased to 3% compared to a rate of 13% in 2007. Similarly, the industrial contribution to the GDP reduced from 12.5% in 1997 to 7.2% in 2010 (EFL, 2013).

2.3. Geographical distribution

The industrial establishments are unevenly distributed over the Lebanese territory (MoI/ALI/UNIDO, 2010). According to the MoI census of 2007, the majority of the industries, mainly the manufacturing industries that need large areas for their operation, were located in rural and remote areas. The largest industries were located outside the Mohafaza of Beirut and Mount Lebanon, mainly in Bekaa and North Lebanon (MoI/ALI/UNIDO, 2010). Figure 4 presents the distribution of the industrial establishments by Mohafaza.

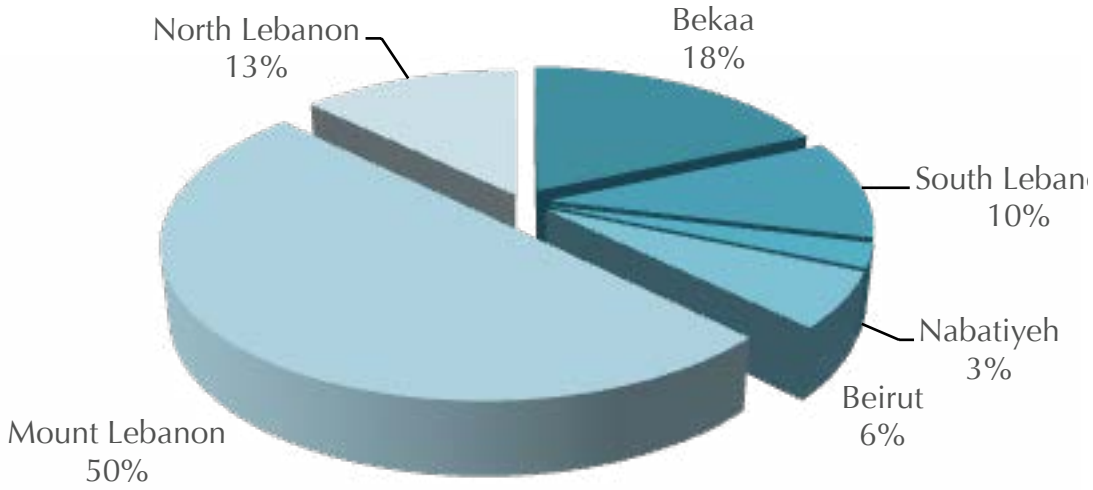


Figure 4: Distribution of the industrial establishments in Lebanon by Mohafaza

[1] The industrial establishments generate electricity for their consumption. The value of the electricity generated accounts for 2.8% of the total output (USD 192.3 million).

2.4. Professional affiliation

Up to the year 2007, around 45% of the Lebanese industrialists were not registered at any business or professional organization. The insufficient awareness of the Lebanese business community, along with the presence of numerous individual and family owned businesses, the preference to avoid taxes and the skeptical attitude of industrialists towards the professional organizations are the main reasons explaining the low ratio of professional affiliations.

The ratio of professional registration varies according to sector of activity, the size of the industry and the geographic location. According to the MoI, 84% of the chemical and paper industries, and 65% of the clothing and food industries, were registered in at least one association.

The professional organizations include the Chambers of Commerce, Industry and Agriculture (CCIA) with 50% of total industrial registrations, the Association of Lebanese Industrialists (ALI) with 14%, the regional industrial associations with 9.6% and the sectoral industrial organizations with 8.1%. The CCIAs were the most attractive to the industrialists due to their distribution in all the Lebanese Mohafazas and their various services namely obtaining certifications and exporting documents (MoI/ALI/UNIDO, 2010).

2.5. Legislation

Up to the year 2000, Lebanese establishments were classified as industrial or non-industrial by the decree 4917 dated 24-04-1994. The classification was based on criteria such as the size of the establishment, the number of workers, the availability of machineries and their horsepower, with little focus on the environment and the human health.

The decree 5243, dated 05-04-2001, modified the first decree by classifying the industrial establishments into 5 different categories based on strict environmental criteria such as the environmental risks, the production of odor and noise and the impacts on water, air and soil.

Category 1 is defined as the high-risk facilities. This category includes tanneries, cement, paper, fertilizers, ammunition production and gas products.

Categories 2 and 3 are defined as high to medium risk facilities. They are numerous, scattered in the Lebanese territory and often located in populated areas, therefore causing significant danger to human health and the environment. The industries in these categories lack the necessary awareness and resources to control their emissions (MoE/LEDO, 2001).

2.6. Environmental performance

Several environmental guidelines were developed by the MoE during the 2000-2002 period under the Strengthening the Permitting and Auditing System for Industries (SPASI) project financed by the European Union (EU). These guidelines resulted in the formulation of a policy note that addresses Industrial Pollution Management System (IPMS), prepared by the MoE in 2013, in partnership with the Environmental Fund for Lebanon (EFL), and later on to the establishment by the MoE of the

environmental compliance certification system (decree 8471-2012) which will enter into force in 2016. The IPMS consists of a set of processes and practices that would enable the polluting enterprises to control and reduce their pollution to an acceptable level, improve their environmental performance and promote the use of clean and efficient technologies.

Through the UNDP managed Lebanon Pollution Abatement Project (LEPAP) the government is currently providing technical assistance and financial incentives to prepare industries to the era of mandatory environmental compliance and build an enabling environment for sound environmental performance. For this, LEPAP offers free environmental audits (including environmental management plans) for companies interested in identifying their potential for improvement, in addition to near 0% interest loans (funded by the World Bank and the Banque du Liban) for industries willing to implement the environmental management plan in line with the guidelines of the environmental compliance decree.

This will make industries eligible to environmental certification which they can use to market their products.

3. Gaps and constraints identified in INC and SNC

The gaps and constraints for the calculation of GHG emissions from the industrial processes sector, including those identified in the previous greenhouse gas inventories are summarized in Table 1, along with the measures undertaken to tackle those gaps.

Table 1: Gaps and constraints for the calculation of GHG emissions

Gaps and constraints	Measures to overcome challenges
Activity data organization - Scattered data on fish, meat, chicken, lime, soda ash, asphalt, wine (customs, factories, ministries). - Lack of uniformity in data between different official sources (i.e. meat and poultry production). - Lack of sufficient documentation on data sources in both the Second National Communication (SNC) and Initial National Communication (INC).	**For current inventory:** - Collection of numbers and figures from various sources and research on detailed description of categories considered in each number. Most comprehensive data were adopted for the inventory. - Validation of available data through expert judgment. - Detailed archiving on sources of data. **Suggestions for future inventories:** - Centralization of data compilation management: cooperation initiated with Ministry of Industry in order to update industrial database and launch systematic data collection process from industries.

Gaps and constraints	Measures to overcome challenges
Activity data availability - Lack of data on bread, cakes and biscuits, and coffee beans. - Lack of data on halocarbons (HFCs and PFCs). - Lack of data for refining inventory to higher tier levels (except for cement).	**For current inventory:** - Wheat production is used to estimate production of bread, cakes and biscuits (based on ratios given by bakeries). - Emissions from HFCs and coffee beans were not estimated. - Higher tiers for categories other than cement were not used.
Activity data accessibility - Lack of institutional arrangements for data sharing. -Time delays in accessing and compiling data.	**Suggestions for future inventories:** - Establish protocols and effective networking with data providers (Memorandums of Understanding already signed with various institutions, including the Ministry of Industry).
Activity data compilation Emissions from poultry, meat, fish, bread and cakes and biscuits were calculated using only national production. Emissions from processing of imported poultry, meat fish and wheat were not included (as well as subtraction of exported production).	**For current inventory:** - Consider import and export in final activity data compilation for cakes and biscuits and bread. - Imported poultry and meat was not added to national production since important discrepancies were noted in national production figures of SNC and TNC. Adding import numbers would increase this discrepancy. It is noteworthy that since NMVOCs emitted from the food sector are not included in GHG trend analysis, this discrepancy is not projected to the final figures of the inventory.
National circumstances - Lack of sufficient, updated and homogeneous literature on the industrial sector in Lebanon. - Lack of academics and researchers in the industrial field.	**For current inventory:** - Reliance on personal communications with practitioners and ministry staff. **Suggestions for future inventories:** - Nationwide survey has been launched on a sample of 180 industries from each category in order to capture the general situation of the industrial sector in Lebanon.

4. Methodology

4.1. Adopting the IPCC guidelines

The GHG inventory of industrial processes in Lebanon is carried out based on calculation methodologies of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1997), and the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories 2000 (IPCC, 2000). Further descriptions of the methodologies used are detailed in Table 2.

Table 2. Reporting categories investigated in the inventory of the Lebanese industrial processes sector

Reporting categories	Emitted gases	Methodology, description and remarks
Cement production	CO_2 SO_2	All cement industries in Lebanon are covered in this calculation. Cement manufacturing is a key category in Lebanon according to SNC. Tier 2 is adopted to calculate emissions from this category.
Lime production	CO_2	The only lime production plant in Lebanon is covered in this calculation. Lime is also produced in cement manufacturing, however it is already accounted for in clinker produced in cement industries.
Limestone use	CO_2	Limestone is mainly used in Lebanon in cement, glass and lime industries. Therefore emissions from limestone are already accounted for in each of these categories.
Soda ash production and use	CO_2	There is no soda ash production in Lebanon. Therefore all soda ash used is imported. Percentages of soda ash used for each type of industry (glass manufacturing, soap and detergents, water treatment etc.) are not available.
Production and use of miscellaneous mineral products	NMVOCs CO SO_2	**Asphalt use and production** Bitumen used for asphalt road paving in Lebanon is imported. It is assumed that all asphalt used for non-paving applications is produced by blowing process (IPCC, 1997). Therefore, the amount of asphalt blown was derived by subtracting cement asphalt for road paving from total bitumen imports. **Glass production** Glass production does occur in Lebanon, however production data could not be accessed. Therefore emissions from glass production are not estimated. **Concrete pumice stone production** There is no concrete pumice stone production in Lebanon. Therefore emissions are not occurring.
Ammonia production	CO_2 NMVOCs CO SO_2	There is no ammonia production in Lebanon. Therefore emissions are not occurring.
Nitric acid production	N_2O NO_x	There is no nitric acid production in Lebanon. Therefore emissions are not occurring.

Reporting categories	Emitted gases	Methodology, description and remarks
Adipic acid production	N_2O NO_x NMVOCs CO	There is no adipic acid production in Lebanon. Therefore emissions are not occurring.
Carbide production	CO_2 CH_4	There is no carbide production in Lebanon. Therefore emissions are not occurring.
Production of other chemicals	CH_4 NO_x NMVOCs CO SO_2	Phosphate fertilizers are reported to be produced in Lebanon. However, data from producing companies is inaccessible to any government agency. Therefore, emissions from this category are not estimated.
Metal production	CO_2 NO_x NMVOCs CO SO_2	There is no metal production in Lebanon. SNC reported production of Iron and Steel from the years 2000 to 2002. Then the only metal producing company in Lebanon closed. Besides emissions from this period, none have occurred for this category.
Pulp and paper industries	NO_x NMVOCs CO SO_2	In Lebanon, there is no pulp production in any of the paper industries. Pulp is imported. Therefore emissions are not occurring.
Food and drink	NMVOCs	Categories included in this module are: wine production, beer production, meat, fish and poultry production. Estimations were also made for bread and cake and biscuits production based on quantities of imported as well as locally produced wheat. Data on coffee, animal feeds and Arak (locally produced spirit) production could not be obtained, therefore emissions from these subcategories were not estimated.
Production of halocarbons and sulphur hexafluoride	HFCs PFCs	Halocarbons are not produced in Lebanon. Therefore, emissions from production are not occurring.
Consumption of halocarbons and sulphur hexafluoride	HFCs PFCs	There is no data available on consumption of halocarbons. Therefore, emissions from consumption of imported HFCs are not estimated.

4.2. Collection of activity data

Table 3: Source of activity data and methodology of calculations

Reporting categories	Activity data needed	Source of activity data
Cement production	Quantity of cement produced Quantity of clinker produced	The three cement industries in Lebanon
Lime production	Quantity of lime produced	The only lime producing company in Lebanon. Recalculation of SNC activity data for the years 2000 onward were performed based on revised numbers from the company.
Soda ash use	Soda ash used	Ministry of Economy and Trade - Recalculations of SNC activity data (which excluded soda ash used in glass production) for the years 2000 onward were performed based on activity data provided by the Ministry of Economy and Trade.
Production and use of miscellaneous mineral products	Asphalt for road paving	Ministry of Economy and Trade
	Asphalt for roofing – blowing process	Ministry of Economy and Trade for asphalt for road paving Ministry of Energy and Water for bitumen import (bitumen import – asphalt for road paving = quantity of asphalt blown*)
Food and drink	Wine production	Union Vinicole du Liban
	Beer production	The only beer producing company during the period covered by the inventory
	Fish production	Recalculations of SNC activity data for the years 2000 onward were performed based on activity data provided in Nader et.al, 2014.
	Meat production	Ministry of Agriculture (for locally produced meat)
	Poultry production	Ministry of Agriculture (for locally produced poultry)
	Bread production	Estimated from wheat import (Ministry of Economy and Trade) and production (Ministry of Agriculture). According to SNC, 50% of wheat is used for bread production, and 50% for cakes and biscuits.

Reporting categories	Activity data needed	Source of activity data
Food and drink	Bread production	The amount of wheat used for bread making was multiplied by a factor of 0.92 based on the fact that each tonne of wheat produces 920 kg of bread.
	Cakes and biscuits production	Estimated from wheat import (Ministry of Economy and Trade) and production (Ministry of Agriculture). According to SNC, 50% of wheat is used for bread production, and 50% for cakes and biscuits. The amount of wheat used for cakes and biscuits production was multiplied by a factor of 4 based on the fact that each tonne of wheat produces 4 tonnes of cakes/biscuits.

*The annual weight of asphalt binder (cutback) used in road paving is required to prepare estimates of maximum likely emissions of NMVOCs from this source. This amount is derived from asphalt cement consumption according to the following formulas:
Weight of Cutback Asphalt = Weight of Asphalt Cement + Weight of Diluent
Weight of Diluent = Volume of Diluent x Density of Diluent (0.7 kg/l)
Volume of Diluent = Volume of Cutback Asphalt x 0.45 (45% of diluent in Cutback Asphalt)
Volume of Cutback Asphalt = Volume of Asphalt Cement / 0.55 (55% Asphalt Cement in Cutback Asphalt)
Volume of Asphalt Cement = Weight of Asphalt Cement / Density of Asphalt Cement (1.1 kg/l)
Details of the calculation of activity data for each year are presented in Annex I.

Activity data for the various categories for the years 2006-2011 are presented in Table 4 to Table 10 below.

Table 4: Cement production - Worksheet: 2-1

Year	2006	2007	2008	2009	2010	2011
Quantity of clinker produced (t)	3,868,051	4,261,477	4,845,337	4,839,191	4,971,936	4,955,079
Quantity of cement produced (t)	4,043,357	4,649,998	5,215,860	5,697,469	5,755,311	5,771,074

Table 5: Lime production - Worksheet: 2-2

Year	2006	2007	2008	2009	2010	2011
Quantity of lime produced (t)	2,500	3,500	3,500	3,500	3,500	3,500

Table 6: Soda ash used - Worksheet: 2-4

Year	2006	2007	2008	2009	2010	2011
Quantity of soda ash used (t)	14,601	8,685.526	10,458.65	11,646.25	7,103.462	9,122.62

Table 7: Asphalt roofing production - Worksheet: 2-5

Year	2006	2007	2008	2009	2010	2011
Quantity of asphalt roofing produced (t) - blowing process	20,222	32,058	37,385	44,937	61,887*	16,205*

* extrapolation

Table 8: Road paving with asphalt - Worksheet: 2-5

Year	2006	2007	2008	2009	2010	2011
Quantity of road paving material used (t)	35,940.83	61,924.65	55,557.07	65,941.10	172,694	89,124.88

Table 9: Food and drink - alcoholic beverage production - Worksheet: 2-13

Year	2006	2007	2008	2009	2010	2011
Quantity of beer produced (hl)	158,740	166,308*	173,876*	181,444	213,147	211,587
Quantity of wine produced (hl)	43,356	50,000	54,000	60,000	54,000	70,000

* interpolation

Table 10: Food and drink - food production - Worksheet: 2-13

Year	2006	2007	2008	2009	2010	2011
Quantity of meat produced (t)	18,916	47,250	47,250	47,250	47,307	51,401
Quantity of fish produced (t)	8,090	8,360	6,490	6,050	9,070	9,113*
Quantity of poultry produced (t)	129,999	NA**	26,868,127	30,229,846	31,544,031	32,099,986
Quantity of bread produced (t)	177,758	239,646	239,142	292,480	260,336	263,733
Quantity of cakes and biscuits produced (t)	772,862	1,041,939	1,039,748	1,271,654	1,131,897	1,146,668

* extrapolation

** Not Available. No interpolation was performed because of the discrepancy between the two sets of data before and after 2007.

4.3. Choice of emission factors and other parameters

Emission factors adopted in this report are presented in Table 11 below.

Table 11: Emission factors and other parameters adopted in the national greenhouse gas inventory

Reporting categories	Emission factor and other parameters	Source of emission factor
Cement production	0.51 t CO_2/t clinker produced	Nationally developed emission factor, SNC (MoE/UNDP/GEF, 2011)*
	Correction factor for cement kiln dust (CKD): 1.02*	IPCC Good Practice Guidance and Uncertainty Management, p.3.12
	0.3 kg SO_2/t cement produced	Revised 1996 IPCC guidelines, reference manual, p.2.7
Lime production	0.79 t CO_2/t quicklime produced	Revised 1996 IPCC guidelines, reference manual, p.2.9
Soda ash use	415 kg CO_2/t soda ash used	Revised 1996 IPCC guidelines, reference manual, p.2.13
Production and use of miscellaneous mineral products	320 kg NMVOCs/t road paving material used	Revised 1996 IPCC guidelines, reference manual, p.2.14
	2.4 kg NMVOCs/t asphalt roofing produced	Revised 1996 IPCC guidelines, reporting instructions, p.2.9
	0.095 kg CO/t asphalt roofing produced	Revised 1996 IPCC guidelines, reference manual, p.2.13
Food and drink	0.08 kg NMVOCs/hl wine produced	Revised 1996 IPCC guidelines, reference manual, p.2.41
	0.035 kg NMVOCs/hl beer produced	Revised 1996 IPCC guidelines, reference manual, p.2.41
	0.3 kg NMVOCs/t fish processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	0.3 kg NMVOCs/t meat processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	0.3 kg NMVOCs/t poultry processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	8 kg NMVOCs/t bread processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	1 kg NMVOCs/t cakes and biscuits processed	Revised 1996 IPCC guidelines, reference manual, p.2.42

* Details of calculation of a national emission factor for clinker and a correction factor for cement kiln dust are presented in Annex II.

5. Results and discussion

5.1. GHG inventory for the years 2006 to 2011

Emissions from the industrial processes sector in Lebanon for each of the years extending from 2006 to 2011 are presented in Table 12 and Figure 5. Greenhouse gas emissions primary entail the CO_2 gas from the cement and lime production sectors, with the largest contributor being the cement production. NMVOCs and/or SO_2 and/or other precursors are also emitted from the remaining categories. Details of emissions per category are presented in section 5.2.

Table 12: Emissions from the industrial processes sector for the years 2006 to 2011

Year	Emissions of CO_2 (Gg)	Emissions of SO_2 (Gg)	Emissions of NMVOCs (Gg)
2006	2,020	1	14
2007	2,223	1	23
2008	2,528	2	29
2009	2,525	2	34
2010	2,592	2	68
2011	2,584	2	41

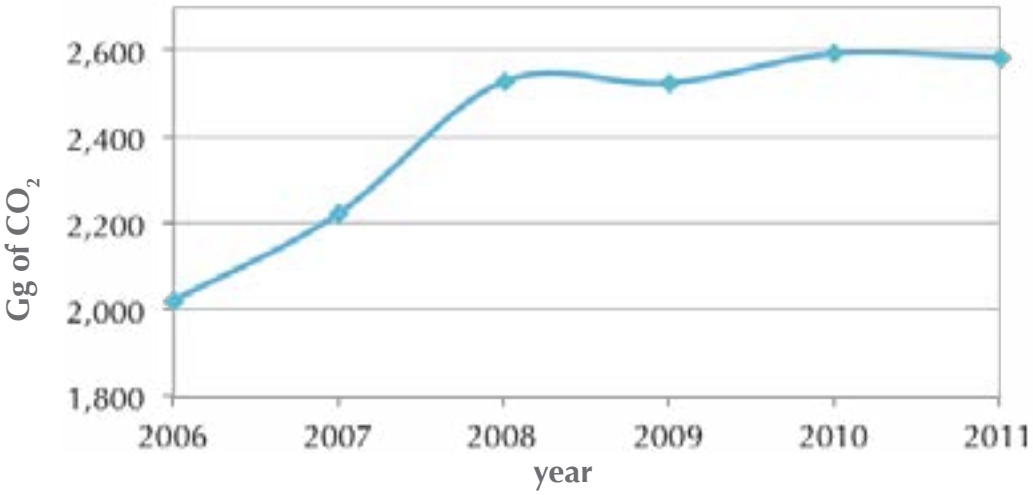


Figure 5: CO_2 emissions from the industrial processes sector in Lebanon for the years 2006 to 2011

Recalculated CO_2 emissions from the industrial sector for the year 2000 resulted in a value of 1,765 Gg. The total CO_2 emissions from the industrial sector increased by 31.7% from the year 2000 to 2011. The cement industry was the major contributor to the increase of the CO_2 emissions, since CO_2 emitted from the cement industry accounted for 99.76% of the CO_2 emitted from the industrial sector in 2011. Up until 2011, the CO_2 emitted from the cement industry increased by 36.5% from the year 2000 (Figure 6), due to the booming in the construction activities in Lebanon. Indeed, according to data from the Lebanese Order of Engineers and Architects (provided by Banque du Liban), the surface area of new construction permits reached 16.5 million m^2 in 2011, constituting an increase of 144.8% from 6.7 million m^2 in 2000.

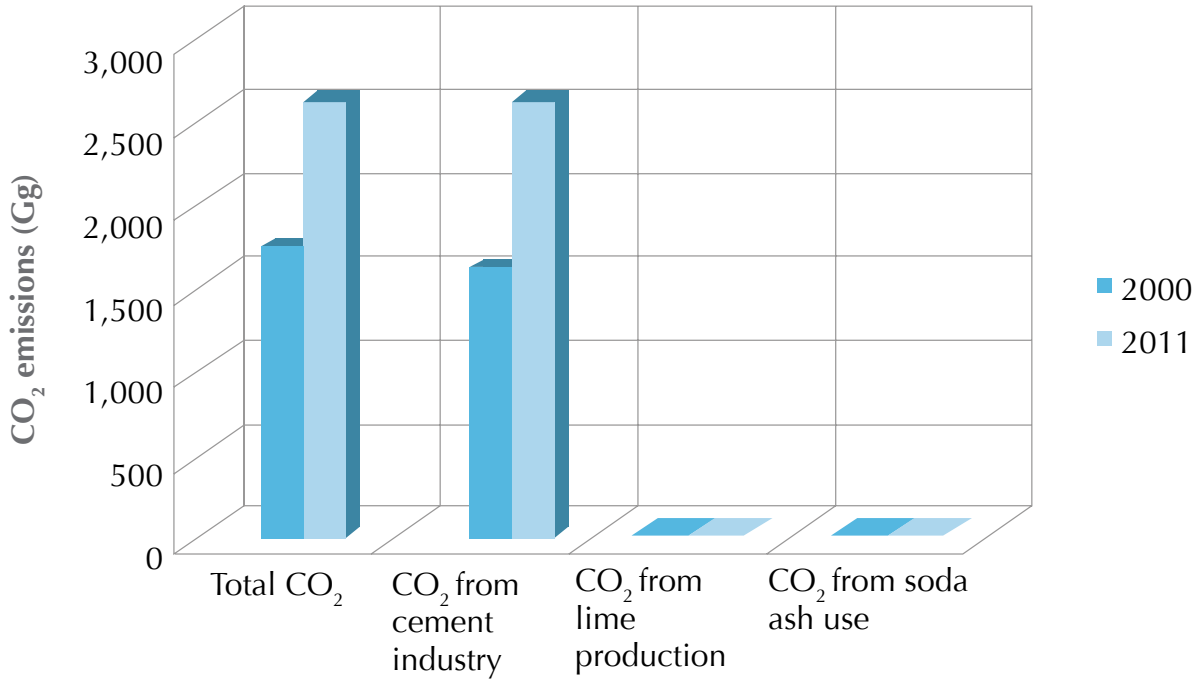
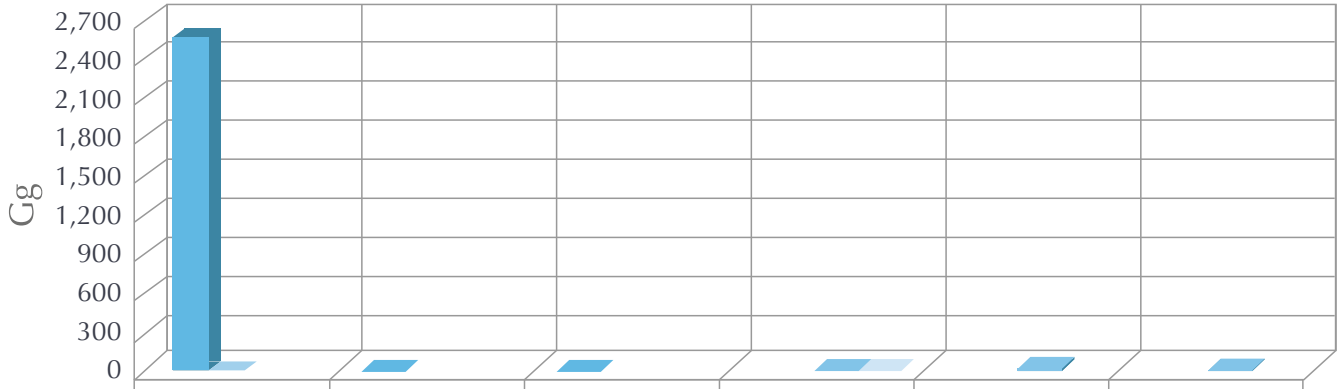


Figure 6: Evolution of emissions of CO_2 from industrial processes between 2000 and 2011

5.2. Emissions from industrial processes per category

In 2011, total GHG emissions from the industrial sector in Lebanon amounted to 2,584 Gg of CO_2eq. The major sources of GHG emissions from the industrial sector in 2011 were CO_2 and SO_2 from the cement industry with 2,578 Gg and 2 Gg respectively, CO_2 from lime production (3 Gg), CO_2 from use of soda ash (4 Gg) and NMVOCs from the asphalt roofing, the road paving (use of asphalt for road surface) and the food and beverages production industries, all together accounting for 41 Gg. Figure 7 below illustrates emissions of direct and indirect greenhouse gases per category for the year 2011.



	Cement production	Lime production	Use of soda ash	Production of asphalt roofing	Use of asphalt for road surface	Food and beverages production
CO_2	2,578	3	4			
SO_2	2					
NMVOCs				0.04	28.5	13
CO				0		

Figure 7: Emissions of direct and indirect greenhouse gases per category per gas for the year 2011

5.2.1. Cement production

The CO_2 emission estimates from the cement production sector for years 2006 to 2011 are presented in Table 13.

Table 13: CO_2 emissions from the cement production sector for the years 2006 to 2011

Year	CO_2 emissions from cement production (Gg)
2006	2,012.16
2007	2,216.82
2008	2,520.82
2009	2,517.35
2010	2,586.40
2011	2,577.63

The SO_2 emission estimates from the cement production sector for years 2006 to 2011 are presented in Table 14.

Table 14: SO_2 emissions from the cement production sector for the years 2006 to 2011

Year	SO_2 emissions from cement production (Gg)
2006	1.21
2007	1.39
2008	1.71
2009	1.71
2010	1.73
2011	1.73

5.2.2. Lime production

The CO_2 emission estimates from the lime production sector (tier 1) for years 2006 to 2011 are presented in Table 15.

Table 15: CO_2 emissions from the lime production sector for the years 2006 to 2011

Year	CO_2 emissions from cement production (Gg)
2006	1.98
2007	2.77
2008	2.77
2009	2.77
2010	2.77
2011	2.77

5.2.3. Soda ash use

The CO_2 emission estimates from the use of soda ash (tier 1) for years 2006 to 2011 are presented in Table 16.

Table 16: CO_2 emissions from the use of soda ash for the years 2006 to 2011

Year	CO_2 emissions from soda ash use (Gg)
2006	6.06
2007	3.60
2008	4.34
2009	4.83
2010	2.95
2011	3.79

5.2.4. Asphalt production and use

The NMVOCs and CO emission estimates from the production of asphalt roofing (blowing process) and the use of asphalt for road surface for years 2006 to 2011 are presented in Table 17.

Table 17: CO and NMVOCs emissions from asphalt for roofing and for road surface for the years 2006 to 2011

Year	NMVOCs from production of asphalt roofing (Gg)	CO from production of asphalt roofing (Gg)	NMVOCs from use of asphalt for road surface (Gg)
2006	0.05	0.00	11.50
2007	0.08	0.00	19.82
2008	0.09	0.00	17.78
2009	0.11	0.00	21.10
2010	0.15	0.01	55.26
2011	0.04	0.00	28.52

5.2.5. Food and alcoholic beverages production

NMVOCs emissions from the national food and beverages production sector for the years 2006 to 2011 are presented in Table 18.

Table 18: NMVOCs emissions from the food and beverages production sector for the years 2006 to 2011

Year	NMVOCs emissions (Gg)
2006	2
2007	3
2008	11
2009	13
2010	13
2011	13

6. Conclusions

Most of the categories included in the industrial processes sector do not occur in Lebanon. From the main GHGs, only CO_2 is emitted, mainly from cement. Lime production and soda ash use have a very minimal contribution to CO_2 emissions in the sector. Emissions from these three categories have been increasing since the year 2000.

Other categories emit precursors, with NMVOCs being the highest emitted precursor, mainly from the food and beverage category.

While emissions from some categories were not estimated due to the absence of activity data (namely glass production and phosphate fertilizers), it is assumed that these will not highly impact overall GHG emissions from the sector, as the quantity produced is believed to be very minimal compared to the highest emitter, i.e., the cement sector. However, emissions from the consumption of halocarbons and SF_6, having a high global warming potential, may significantly affect the overall emissions from the sector in terms of CO_2 equivalent, even with small quantities.

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Annex I: Calculation of weight of asphalt binder (cutback) used in road paving

	A	B	C	D	E	F	G
	Weight of imported road paving material (kg)	Weight of imported road paving material (t)	Volume of imported road paving material (l)	Volume of cutback asphalt (l)	Volume of diluent (l)	Weight of diluent (t)	Weight of cutback asphalt (activity data in tonnes)
		B = A / 1,000	C = B / 1.1	D = C / 0.55	E = D x 0.45	F = E x 0.7	G = B + F
2006	23,634,896	23,634.896	21,486.26909	39,065.9438	17,579.67471	12,305.7723	**35,940.6683**
2007	40,722,193	40,722.193	37,020.17545	67,309.40992	30,289.23446	21,202.46412	**61,924.65712**
2008	36,534,814	36,534.814	33,213.46727	60,388.12231	27,174.65504	19,022.25853	**55,557.07253**
2009	43,363,446	43,363.446	39,421.31455	71,675.11736	32,253.80281	22,577.66197	**65,941.10797**
2010	113,565,075	113,565.075	103,240.9773	187,710.8678	84,469.8905	59,128.92335	**172,693.9983**
2011	58,609,298	58,609.298	53,281.18	96,874.87273	43,593.69273	30,515.58491	**89,124.88291**

The annual weight of asphalt binder (cutback) used in road paving is required to prepare estimates of maximum likely emissions of NMVOCs from this source. This amount is derived from asphalt cement consumption according to the following formulas:

Weight of Cutback Asphalt = Weight of Asphalt Cement + Weight of Diluent

Weight of Diluent = Volume of Diluent x Density of Diluent (0.7 kg/l)

Volume of Diluent = Volume of Cutback Asphalt x 0.45 (45% of diluent in Cutback Asphalt)

Volume of Cutback Asphalt = Volume of Asphalt Cement / 0.55 (55% Asphalt Cement in Cutback Asphalt)

Volume of Asphalt Cement = Weight of Asphalt Cement / Density of Asphalt Cement (1.1 kg/l)

Annex II : Calculation of a national emission factor for clinker and a correction factor for cement kiln dust

According to the IPCC Good Practice Guidance and Uncertainty Management, data on calcium oxide (CaO) content of the clinker (CaO_Clinker) is needed in order to generate a national emission factor for tier 2 method as per equation 3.3 p.3.12:

$EF_{clinker}$ = 0.785 x CaO_Clinker

0.785 is the molecular weight ratio of CO_2 to CaO in the raw material mineral calcite ($CaCO_3$) from which most or all the CaO in clinker is derived.

The value obtained from the three plants producing cement in Lebanon for CaO content of clinker is: 65%.

Therefore,

$EF_{clinker}$ = 0.785 x 0.65 = 0.51 t CO_2/t clinker

Cement Kiln Dust (CKD) is a mix of raw material and clinker that is produced by cement furnaces. It may be partly recycled to the furnace. Good practice is to correct for the CO_2 contained in the non-recycled, therefore lost calcined CKD because this CO_2 will not be accounted for by the clinker produced. The default CKD correction factor is 1.02 (i.e. add 2% to the CO_2 calculated for clinker).

Therefore, the emissions from the cement industries from clinker production as per the tier 2 method will be:

Emissions = clinker production x $EF_{clinker}$ x CKD correction factor