CAMBODIA CLIMATE CHANGE ALLIANCE

The Project: Demonstration of
RECP, EMS, and GHG Mitigation and
Adaptation In Industrial and Handicraft Sectors

GHG INVENTORY IN THE INDUSTRIAL PROCESSES AND PRODUCT USE SECTOR







Prepared by: **The Ministry of Industry and Handicraft**

Phnom Penh, December 2018

Table of Contents

List of Tables iii

List of Figure iii

Abbreviation ix

Executive Summary vii

1. Introduction 1

2. Demography and age cohort 1

3. Socioeconomic development 2

4. Labour 3

5. Poverty 3

6. Gender equality and women's empowerment 4

7. Education system and development 4

8. Energy development and management 5

9. Industrial Development 8

10. Climate change status and national responses 9

10.1 Climate change status 9

10.2 National responses to climate change 10

11. Obligations under the UNFCCC 11

12. National Steering committee for Climate Change Project in the Industry and Handicraft 12

13. Overview of GHG Emissions from Industrial Processes and Product Use 12

13.1 Definition of Industrial Processes 12

13.2 Overview of GHG emissions from the Industrial Processes and Product Use 13

13.3 Direct Carbon Emissions in Cement Factories 14

13.4 Indirect Carbon Emissions in Cement Factories 14

14. National Inventory of GHG emissions from the Industrial Processes and Product Use ... 14

14.1 Objectives 14

14.2 Methodology 15

14.2.1 Activity Data 15

14.2.2 Emission Factor 17

14.2.3 Data collection 17

14.2.4 Training courses 18

14.2.5 Global warming potential 18

15. Results of GHG emissions in the Industrial Processes and Production Use 18

16. Conclusions and Recommendation 19

16.1 Conclusions 19

16.2 Recommendation 20

Reference 21

Annex 1: List of CDM projects 24

Annex 2: Classification of industrial process emissions by the IPCC 27

Annex 3: Agenda and list of participants for the first training 29

Annex 4: Agenda and list of participants for the second training 32

Annex 5: Agenda and list of participants for the third training 35

Annex 6: Global warming potential 38

List of Tables

Table 1: Trend in Dependency Ratio 2
Table 2: Share and Growth of Agriculture, Industry and Service Sector (%) (at constant price) 3
Table 3: Power generation by sources from 2003 to 2015 6
Table 4: Electricity generation by sources from 2010 to 2015 6
Table 5: Electricity consumption by final users from 2003 to 2015 8
Table 6: Power development plan in Cambodia 8
Table 7: GHG emissions in Cambodia 10
Table 8: Default emission factors from the IPPC 17
Table 9: List of industrial products 18
Table 10: GHG emissions by sectors in the IPPU sector 19

List of Figure

Figure 1: Map of Cambodia 1

Abbreviation

AR	Assessment Report
AR5	Fifth Assessment Report
BaU	Business As Usual
CMDG	Cambodia Millennium Development Goals
CIDP	Cambodia Industrial Development Policy
CCCSP	Cambodia Climate Change Strategic Plan
CDM	Clean Development Mechanism
CFSP	Fuel-wood Saving Project
CIDP	Cambodia Industrial Development Policy
CKD	Cement Kiln Dust
DNA	Designated National Authority
EEZ	Exclusive Economic Zone
EMS	Environmental Management System
GSSD	General Secretariat of the National Council for Sustainable Development
GDP	Gross Domestic Product
GHG	Green House Gas
INDC	Intended Nationally Determined Contribution
IPPU	Industrial Processes and Product Use
KOC	Kingdom of Cambodia
KP	Kyoto Protocol
LUCF	Land Use Change and Forestry
MoP	Ministry of Planning
MoWAs	Ministry of Women's Affairs
MIH	Ministry of Industry and Handicraft
MoEYS	Ministry of Education, Youths, and Sport
MoEF	Ministry Economy and Finance
MME	Ministry of Mines and Energy
NSDP	National Strategic Development Plan
NSPGG	National Strategic Plan on Green Growth
NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Program of Action
NCCC	National Climate Change Committee
NIS	National Institute of Statistics
NCSD	National Council for Sustainable Development
NBP	National Bio-digester Program
RECP	Resource Efficiency and Cleaner Production
RGC	Royal Government of Cambodia
RFB	Reference Food Basket
SRESB1	Special Report on Emissions Scenarios
SRESA2	Special Report on Emissions Scenarios
SNC	Second National Communication
SMEs	Small and Medium Enterprises
TFEC	Total Final Energy Consumption
TPES	Total Primary Energy Supply

UNTAC	United Nations Transitional Authority of Cambodia
UNFCCC	United Nations Framework Convention on Climate Change
UN	United Nations
VERs	Voluntary Emission Reductions projects
WCS	Wildlife Conservation Society

Chemical Compound

$BaCO_3$	Barium Carbonate
$CaCO_3$	Calcium Carbonate
CaC_2	Calcium carbide
CaO	Calcium Oxide
C_2H_4O	Ethylene Oxide
CO_2	Carbon Dioxide
CH_4	Methane
HNO_3	Nitric Acid
K_2CO_3	Potassium Carbonate
Li_2CO_3	Lithium Carbonate
N_2O	Nitrous Oxide
NH_3	Ammonia
$NaHCO_3$	Sodium Bicarbonate
NH_4NO_3	Ammonium Nitrate
PFCs	Perfluorocarbon
$SrCO_3$	Strontium Carbonate

Unit

GWh	Gigawatt Hour
Gg	Gigagram
$GtCO_2$	Gigatonne of Carbon Dioxide
$MtCO_2$	Metric tons of Carbon Dioxide
tCO_2	Ton of Carbon Dioxide
kgoe	Kilogram of Oil Equivalent
kWh	Kilowatt hour
$ktCO_2$	Kilotonne of Carbon Dioxide
$ktCO_2eq.$	Kilotonne of Carbon Dioxide Equivalent
ktoe	Kilotonne of Oil Equivalent
Mtoe	Megatonne of Oil Equivalent
MWh	Megawatt-hour
t	Tonne

Conversion:

GWh	10^3 MWh
MWh	10^3 KWh
Gg	10^9 Grams
Gg	10^3 t

Mtoe	10^3 ktoe
ktoe	10^3 toe
toe	10^3 Kgoe
$GtCO_2$	10^3 $MtCO_2$
$MtCO_2$	10^3 $ktCO_2$
$ktCO_2$	10^3 tCO_2
tCO_2	10^3 $kgCO_2$
$kgCO_2$	10^3 gCO_2

Executive Summary

The Cambodian population was about 15.85 million in 2017 and is projected to increase to about 18.39 million in 2030 and about 21.96 million in 2050. The government has made an utmost effort to rebuild the society, economy, and infrastructure and subsequently opened a market framework. The poverty rate fell sharply from 48% in 2007 to 14% in 2014, which far exceeded the CMDG goal of 20% by 2015. The country had been ranked as one of the most rapid economic growth countries among the developing world. Besides, the government has aspired to develop the economy to reach the status of an upper-middle income country by 2030 and a high-income level by 2050.

The industrial sector is expected to contribute to about 30% to the GDP by 2025; therefore, the government is planning to upgrade the diversification of manufacturing base and to promote further development of small and medium enterprises and also to encourage a rapid transformation of industrial structure to move from a labor-intensive and low productivity industry to a more broad-based, high-tech and high-skilled one. However, the government realizes that the stable and steady economic growth is largely attributed to the continued good performance of the agricultural sector through increasing the value added of milled rice production for export and other high value agriculture products. Energy supply and demand are expected to increase substantially due to increases of population, economy, outputs of industries, national grid, and reducing electricity tariffs.

The government has achieved remarkable progress, including enhancing the quality and living conditions of the people as reflected in significant improvement in social and economic indicators in education, technical and vocational training, health and employment. The government also aspires to develop human resources to ensure competitiveness in an increasingly open regional labor market.

Addressing economic and social development by taking climate change into account will assist the country in reducing vulnerability to potential climate risks, improving air quality and mitigating GHG emissions. In this regards, the government has mainstreamed climate change into the National Strategic Development Plan and approved Cambodia Climate Change Strategic Plan (2014-2023) as well as development of sectoral climate change responses, for instance, the Climate Change Action Plan for Industry and Handicraft Sectors (2015-2018).

There is a limited study and research on GHG emissions from the IPPU sector, only the Initial National Communication was included this sector with GHG emissions of about 50ktCO_2 in 1994. This study found that total GHG emissions from the IPPU sector is 1,626.03ktCO_2 in 2016; among them the cement sector shares about 97%, followed by the pulp and paper sector (2.5%). GHG emissions in the IPPU sector in Cambodia in 2016 is much smaller than that of Viet Nam in 1994 (21,172 ktCO_2) and that of Thailand in 2000 (15,400 ktCO_2).

1. Introduction

Cambodia is an agricultural country, covering 181,035km^2 and shares her 2,428km land border with Thailand to the northwest, Lao PDR to the northeast, and Vietnam to the east and the south (see Figure 1). The country has the coastline of 440 km and Exclusive Economic Zone (EEZ) up to 200 nautical miles along the Gulf of Thailand. The total area of the Tonle Sap catchment is 85,790 km^2. When the level of the Mekong River is high, the flow of the Tonle Sap River reverses, which water is pushed into the lake and raises its level by up to 10 meters and increases its area between 2,000-3,000 km^2 in the dry season and between 10,000-16,000 km^2 in the rainy season.

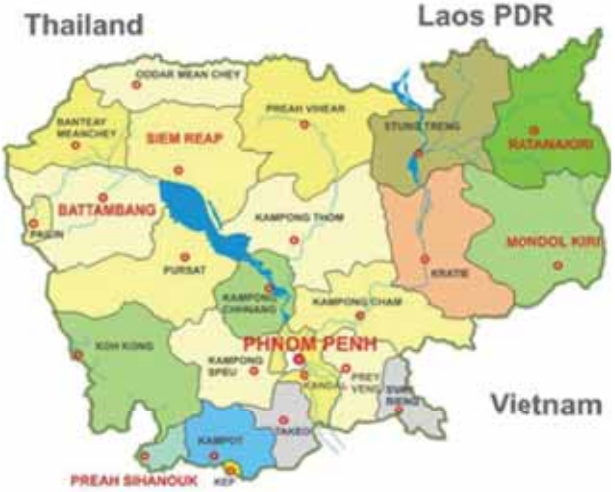

Figure 1: Map of Cambodia

Cambodia is influenced by the tropical monsoons with distinct rainy and dry seasons. The rainy season extends from May to October, while the dry one ranges from November to April. The average annual rainfall is about 1,400 mm on the central plain and increases to 3,800 mm in the mountains and along the coast. The average annual temperature is about 27°C with the maximum mean temperature of about 28°C and the minimum mean temperature of about 22°C. The country is far from the direct impacts of tropical cyclones and typhoons because of her surrounding mountains and highlands. The Kingdom of Cambodia (KoC) was granted her independence in 1953, which marked the end of 90 years of French protectorate rule. From 1975 to 1979, Khmer Rouge, headed by Pol Pot led the country during which the entire population were evacuated the city leaving a once vibrant capital in ruin and decay. However, the KoC has become a democratic, stable, and peaceful country after the United Nations Transitional Authority of Cambodia (UNTAC) supervised the first general election in 1993.

2. Demography and age cohort

The Cambodian population increased from about 13.95 million in 2010 (NIS, 2012) to about 15.85 million in 2017 (RGC, 2018). Among them, 29% are at the age cohort of 0-14 years old, 67% from 15-64 years old, and 5% from 65+ years old (See Table 11 Trend in Dependency Ratio) (RGC, 2018). In 2017, there were more than 12 million living in rural areas and about 3.7 million living in urban areas (NIS, 2017). The population is projected to increase to about 18.39 million in 2030 and about 21.96 million in 2050 (UN, 2011 and 2013).

The RGC has formulated the National Population Policy (2016-2030) with the overall strategic objective to contribute to steady improvements in the quality of life of the people and poverty alleviation with an emphasis on inclusive development, which can be achieved through concerted efforts in ensuring sustainable and equitable economic growth, social development, and environmental protection within the national and global development framework (RGC, 2016).

Table 1: Trend in Dependency Ratio

Age cohort/year (%)	1998	2008	2017	2018	2028	2030	2038	2048	2050
0-14	42.8	33.7	28.7	28.5	25.9	25.8	22.1	20.8	20.8
15-64	53.7	63	66.5	66.5	67.3	67.3	68.8	67.9	67.9
65+	3.5	4.3	4.8	5	6.8	6.9	9.1	11.3	11.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: NIS (2012 and 2017) and UN (2011 and 2013)

3. Socioeconomic development

The RGC has adhered to the principle of national solidarity to rally all Cambodians, inside and outside the country, from all walks of lives and political tendencies, with the objective to build and protect the nation and social achievements, while ensuring the country's independence, integrity, sovereignty, peace, democracy, and progress. The political stability, which had not been prevailing for years, has enabled Cambodia to carry out its reform measures in all sectors in order to build institutional capacity, improve socio-economic infrastructure, and create favorable environment to attract both domestic and foreign investments, with the aim of ensuring high rate of economic growth and poverty reduction.

In recent years, Cambodia has experienced significant developments not only in political and security aspect but also in economic and social one. Such environments of political stability, peace, and safety are the prerequisites for Cambodia to make use of her socio-economic potentials. In addition, the government is committed to implementing fundamental principles that can lead the country for prosperity. Furthermore, in order to sustain the socioeconomic growth and environmental sustainability, the Government has formulated the National Strategic Development Plan (NSDP) (RGC, 2009 and 2014), which focused on improving natural resources management, building peace, political and social stability, and promoting socioeconomic development. The RGC has made an utmost effort to rebuild the society, economy, and infrastructure and subsequently opened a market framework and the country is gradually advancing the economic development and social stability and the country was ranked as one of the most rapid economic growth countries among the developing world (RGC, 2012).

The highest contributor to the GDP was the service sector (42%) with the tourism sector as the main contributor, followed by the industrial sector of 33% (mainly contributed by the construction sector), while the agriculture sector was only 25% in 2017 (https://www.indexmundi.com/cambodia/ economy profile.html). The industrial sector experienced average annual growth rate of around 10% from 2013 through to 2017, while the agriculture sector decreased from 2% in 2013 to 1% in 2017 and the service sector decreased from around 9% in 2013 to around 7% in 2017 (RGC, 2018a). Table 2 shows the share of sectors to the GDP from 2013 to 2017. It can be noted that Cambodia experienced an average annual economic growth rate of around 7% from 1994 through to 2017, while per capita GDP increased from 216USD in 1992 to more than 1,435USD in 2017 (RGC, 2018). In addition, the RGC set the target to reach the status of an upper-middle income country by 2030 and a high-income level by 2050 (RGC, 2013).

Table 2: Share and Growth of Agriculture, Industry and Service Sector (%) (at constant price)

Share by sector (%)	**2013**	**2014**	**2015**	**2016**	**2017**
Agricultural sector	24.2	22.7	21.2	26.3	24.9
Crop	13.1	12.3	11.5	11.3	13
Industrial sector	29.9	30.7	32.1	31.3	32.9
Textile	17.7	17.6	18.1	18.0	18.0
Construction	5.7	6.5	7.2	7.7	7.7
Service sector	39	39.6	39.6	42.4	42.2
Hotel & Restaurant	5.4	5.4	5.1	5.1	5.1
Growth by sector (%)					
Agricultural sector	1.6	0.3	0.2	1.4	1.7
Crop	0.6	0.5	0.3	0.2	0.2
Industrial sector	10.7	10.1	11.7	11.8	11.8
Textile	10.7	6.6	9.8	10.6	10.6
Construction	13.7	21.4	19.2	15.0	15.0
Service sector	8.7	8.7	7.1	7.1	7.1
Hotel & Restaurant	13.8	6.1	2.4	7.0	7.0

Source: NSDP (2016), MAFF (2017), and RGC (2018a)

4. Labour

Employment rate is the share of the employed in relation to the working age population and unemployment rate is the unemployment in relation to the labour force. The persons who currently work to contribute to their own households and who operate their own enterprise (e.g. farmers cultivating their own land, small shop keeper or small restaurants) without payment or income of any kind are classified as own account worker or self-employed. The labour force participation rate was about 84%-- about 79% for women and 89% for men in 2016 (NIS, 2017).

In terms of employment by sectors, the agriculture sector decreased from around 54% in 2010 to 42% in 2015. In contrast, the workforce in the industrial sector increased from 16% to 26% in 2015. Similarly, the workforce in the service sector increased from 30% in 2010 to 33% in 2015 (MAFF, 2018). Besides, it is noted that Cambodians are not only employed in the country but also abroad in order to increase incomes and gain experience. About 619,359 people were working overseas including: Thailand (533,707), Malaysia (38,633), South Korea (44,330), Japan (2,288), and Singapore (401), etc. (NSDP, 2016).

5. Poverty

Poverty has been widespread and created a serious social and development problem in Cambodia. The food poverty line is defined as the cost of purchasing food equivalent to 2,200 Kilocalories in a Reference Food Basket (RFB) designed to reflect food consumption patterns in the lowest 5th-30th quintiles, by consumption distribution from the bottom. The poverty rate fell sharply from 48% in 2007 to 19% in 2012 and to 14% in 2014, which far exceeded the CMDG goal of 20% by 2015 (NSDP, 2016).

In 2015, as much as half of rural household incomes was from salary and wage, compared to only 30% a decade ago. With continued expansion of textile and apparel exports, and the recovery of the

tourism and agricultural sectors, especially with a gradual uptick in agricultural commodity prices, have had the positive effect on income of poor households. The minimum wage of the garment and footwear sector was officially raised to US$170 per month in 2018-- an increase of 11% from 2017 and wages in the public sector are also increasing. As income rises, purchasing power increases, leading to more consumption and spending in the rural areas. Successfully implementing social assistance and social security programs, envisaged by the 2016-2025 Social Protection Policy Framework, can help prevent rural households from falling back into poverty (WBG, 2018).

6. Gender equality and women's empowerment

Women's economic empowerment is widely recognized as one the critical foundations for promoting gender equality and women's empowerment. Women have historically played a critical role in Cambodia's economic development; however, they remain economically disadvantaged, particularly with respect to access and control over economic resources, opportunities for increasing their skills, decision-making and higher-level employment opportunities. Women are generally lower-secondary school drop-outs with limited skills and career prospects. Women are exposed to domestic violence (physical, psychological, and sexual) and rights over the property and inheritance remain to be further improved.

The Government has achieved remarkable progress, including enhancing the quality and living conditions of the people as reflected in significant improvement in social and economic indicators in education, technical and vocational training, health and employment. The Ministry of Women's Affairs (MoWAs) developed a Strategic Plan for Neary Rattanak IV, which aims to support the reform process of the MoWAs to move from project-based activities to a Program-Based Approach, and promoting MoWAs' role in providing effective gender analysis, institutional advocacy and policy advice across the entire Government (MoWAs, 2014).

The RGC has set a number of priority actions to promote gender equity and women's empowers including: (1) further developing human resources with focus on strengthening quality, ability and work ethic standards through implementing a variety of interconnected measures in related sectors such as education, research, science, technology, technical and vocational training, and health; (2) promoting the role of women and youth in the economy through strengthening vocational training programs, equipping them with technical and entrepreneurial skills, and empowering women and youth; (3) promoting the role of women in the public sector through increasing the gender ratio in line ministry management and strengthening their ability to pursue leadership both at management and technical levels; (4) promoting the implementation of "National Action Plan to Prevent Violence Against Women"; (5) further strengthening law enforcement to be more effective in measures against human trafficking and sexual exploitation of women and children; and (6) further mainstreaming gender in government initiatives and responding to the needs of youth in national policy and the development plans in all sectors and at every level.

7. Education system and development

The education sector plays an important role in the national development in which the children, youths, and adults will receive education and lifelong learning services with high quality, which are relevant and responsive to the labor market demand (MoEYS, 2014). The Ministry of

Education, Youths, and Sport (MoEYS) intends to establish and develop human resources of the very highest quality and ethically sound in order to develop a knowledge-based society.

The Government aspires to develop human resources to ensure competitiveness in an increasingly open regional labor market through: (1) training of skilled and productive labor to meet market demand and increase value added; (2) building educational and vocational training institutions and developing regulatory frameworks; (3) encouraging private sector participation; and (4) strengthening the quality of education and promoting scientific research, technology development and innovation (RGC, 2013). The Government has also adhered to the policy **"Education for All"** in order to ensure equal access to education services, further promoting the quality and effectiveness of education services at all levels, as well as further developing the capacity of educational institutions and staff.

The MoEYS formulated a Policy on Higher Education Vision 2030 so as to ensure comprehensive equity and access for students, efficient and smooth coordination and management of higher education, necessary mechanisms to support higher education system, and development of human resources who will contribute fully to national development plan. The policy has a vision to build a quality higher education system that develops human resource with excellent knowledge, skills and moral values in order to work and live within the era of globalization and knowledge-based society. The goal of this policy is to develop a good governance system and higher education mechanisms to ensure that qualified students have an opportunity to access higher education programs which respond to the needs of socio-economic development and labour market (MoEYS, 2014).

8. Energy development and management

Cambodia's rapid economic growth was accompanied by a steady increase in energy demand, with peak demand rising by an annual average of over 20% between 2003 and 2008 (JICA, 2012). The access to sustainable energy service, which is seen as an important element to reduce fuel-wood dependency and poverty is included in the CMDGs and the NSDP. Per capita consumption of electricity had increased from around 15Kwhs/year in 1993 to 268Kwhs/year in 2013 and to 335Kwhs/year in 2015 (RGC, 2014 and MME-CERIAEA, 2016). Energy supply and demand are expected to increase substantially in the future due to increases of population, economy, outputs of industries, national grid, and reducing electricity tariffs (RGC, 2013). The industrial sector, which is identified as a key dynamic indicator for industrialization and modernization of Cambodia's economy, is a key sector consuming more electricity. Besides, residential and commercial sectors are also expected to consume large amount of electricity.

The Total Final Energy Consumption (TFEC) increased at an average annual growth rate of around 7% from 2,449 ktoe and 3,413 ktoe in 2010 and 2015, respectively (MME-CERIAEA, 2016). Consumption of coal grew the fastest at 21% per year, followed by electricity at 18% per year. Consumption of petroleum products and biomass, the major fuel consumed, grew at an annual average rate of 7% and 4%, respectively. Electricity supply increased on average by 20% per year from 2,515 Gwh and 6,186 Gwh in 2010 and in 2015, respectively, while electricity imports from neighboring countries (Viet Nam, Thailand, and the Lao PDR) accounted for 61% of total supply in 2010 and 25% in 2015. The amount decreased slightly from 1,546 Gwh and 1,541 Gwh in 2010 and in 2015, respectively (MME-CERIAEA, 2016).

Hydropower plants contributed about 43% of the domestic generation in 2015, while the share was only 3% in 2010. Coal also had the same share as hydropower in 2010, but the share increased to 51% in 2015, indicating a faster growth than that of hydropower. Increased generation from both hydropower and coal power plants is in accordance with the plan to reduce generation from oil-based power plants. Generation from oil-based power plants was dominant in 2010, accounting for 93% of total generation; in contrast, its share was reduced to 5% in 2015. Table 3 shows power generation by sources from 2003 to 2015, while Table 4 shows electricity generation by sources from 2010 to 2015.

Table 3: Power generation by sources from 2003 to 2015

Power Generation by Source (Gwh)				
Year	**Hydro**	**Coal**	**Diesel/HFO**	**Wood & Biomass**
2003	40.51	-	595.38	-
2004	28.42	-	714.81	-
2005	43.54	-	835.71	0.12
2006	50.61	-	1,034.82	1.68
2007	49.71	-	1,294.36	5.25
2008	46.28	23.36	1,409.94	4.53
2009	47.43	28.03	1,152.65	6.49
2010	31.73	32.08	898.73	5.82
2011	51.52	46.50	908.61	11.91
2012	517.37	37.42	856.56	11.75
2013	1,015.54	168.75	578.99	6.68
2014	1,851.60	863.02	326.97	16.79
2015	2,000.38	2,376.49	227.62	40.47

Source: MME-CERIAEA (2016)

Table 4: Electricity generation by sources from 2010 to 2015

Electricity Generation (Gwh)						
Year	**Hydro**	**Coal**	**Diesel/HFO**	**Biomass**	**Import**	**Total**
2010	32	32	899	6	1,546	2,515
2011	52	47	909	12	1,830	2,848
2012	517	37	857	12	2,104	3,527
2013	1,016	169	579	7	2,282	4,052
2014	1,852	863	327	17	1,803	4,861
2015	2,000	2,376	228	40	1,541	6,186

Source: MME-CERIAEA (2016)

The total primary energy supply (TPES) increased from 3,350 kilotons of oil equivalent (ktoe) in 2010 to 4,761 ktoe in 2015 at an average annual growth of around 7%. Coal and hydropower had the highest increase over the 2010-2015 period because electricity demand had been increasing rapidly during that time. Electricity imports increased from 133 to 192 ktoe in 2010-2013;

however, it declined to about 133 ktoe in 2015 due to the increase of domestic power generation. On the other hand, petroleum products and biomass have a total share of more than 90% over the 2010-2015 period.

By 2015, the electricity consumption of the final sectors increased to 5,201GWh at an average rate of 18% per year. The service sector's consumption increased at a faster rate of 23% per year as more hotels, hospitals, schools, and other commercial buildings were being constructed. The industrial sector's electricity consumption increased at an annual average rate of 18% per year, while that of the residential and other sectors increased at 12% per year. Table 5 shows electricity consumption by final users from 2003 to 2015

The Government adopted the "Law on Electricity" in 2000, which covered all activities related to the supply, provision of services and use of electricity, and other associated activities of the power sector. The law helps reform the current electricity sector, and was endorsed to boost private investors in the power sector in a fair, just, and efficient manner for the benefit of the society. The RGC also specified the development of the energy sector in the NSDP with the prioritized aims of increasing electricity supply capacity and reducing tariff rates to an appropriate level, while strengthening institutional mechanism and management capacity. The Government also identified the best alternative options to introduce more constant, reliable, and affordable sources of energy and reiterated that the country has available capacity and facilities to build hydropower dams, which have potential capacities of more than 10,000MW. However, Hydropower generation usually declines during the dry seasons due to the lack of water. Table 6 shows the detail list of power development plan.

The Government set two main energy development targets--the first is to achieve the 100% level of village electrification (47% level as an intermediate target of household electrification) by 2020; and the second is to achieve 70% level of household electrification with grid quality electricity by 2030 (JICA, 2006). The Government prepared a power sector master plan, indicating that the fuel mix of power generation in 2030 comprises natural gas (40%), hydropower (35%), coal (15%), import (6%), oil (3%), and renewable energy (1%) (MME, 2014).

It has been investigated that in order to reduce energy demand and CO_2 emissions in the future and simultaneously to provide reliable and affordable energy services to all of the end users in the most sustainable manner, the Government declared a circular on the "implementation of electricity saving measures" that required all Government ministries and public institutions to participate in a program on "electricity saving consumption" in 2008 so as to save the national budget and to ensure the effective and efficient use of electricity. The government developed National Energy Efficiency Policy in 2018 in order to: (1) improve the management and maintenance of existing infrastructure (e.g. buildings) and industrial processes (e.g. for the use of fuel wood) for increased energy efficiency; and (2) increase the transfer and adoption of energy efficient technology (e.g. fuel efficient vehicles and light bulbs) to reduce energy intensity (RGC, 2018b). The policy also set the overarching target to reduce energy demand by 20% in 2035 relative to the business as usual scenario.

Table 5: Electricity consumption by final users from 2003 to 2015

Electricity Consumption by Final Users (Gwh)					
Year	**Residential**	**Commercial**	**Industrial**	**Other**	**Total**
2003	292.17	229.86	76.46	0.55	599.04
2004	325.19	270.74	105.93	0.46	702.31
2005	365.84	348.03	143.76	0.72	858.36
2006	388.83	449.22	215.98	3.13	1,057.16
2007	458.25	548.91	338.61	3.35	1,349.12
2008	575.40	694.41	389.62	4.96	1,664.40
2009	682.03	778.15	388.59	4.72	1,853.50
2010	869.08	892.89	489.88	2.19	2,254.04
2011	854.16	1,082.45	629.87	6.26	2,572.74
2012	1,079.28	1,275.90	900.32	10.31	3,256.81
2013	1,186.58	1,539.47	820.04	6.50	3,552.59
2014	1,223.08	1,639.29	1,054.35	127.39	4,144.12
2015	1,527.15	2,530.31	1,136.84	7.18	5,201.49

Source: MME-CERIAEA, 2016

Table 6: Power development plan in Cambodia

No.	Generation Expansion Plan	Fuel	MW	Year
1	Kamchay Hydro Power Plant	Hydro	193.2	2011
2	200 MW Coal Power Plant (I) in Sihanouk Ville -Phase 1	Coal	100	2011
3	Kirirom III Hydro power Plant	Hydro	18	2012
4	Atay Hydro Power Plant	Hydro	110	2012
5	200 MW Coal Power Plant (I) in Sihanouk Ville -Phase 2	Coal	100	2012
6	Tatay Hydro Power Plant	Hydro	246	2013
7	Lower Stung Rusey Chhrum Hydro Power Plant	Hydro	338	2013
8	700 MW Coal Power Plant (II) in Sihanouk Ville -Phase 1	Coal	100	2013
9	700 MW Coal Power Plant (II) in Sihanouk Ville -Phase 2	Coal	100	2014
10	700 MW Coal Power Plant (II) in Sihanouk Ville -Phase 3	Coal	100	2015
11	700 MW Coal Power Plant (II) in Sihanouk Ville -Phase 4	Coal	100	2016
12	Lower Sesan II + Lower Srepok II	Hydro	400	2016
13	Stung Chay Areng Hydro Power Plant	Hydro	108	2017
14	700 MW Coal Power Plant (II) in Sihanouk Ville -Phase 5	Coal	100	2017
15	700 MW Coal Power Plant (II) in Sihanouk Ville -Phase 6	Coal	200	2018
16	Steung Treng Power Plant	Hydro	980	2018
17	Sambor Hydro Power Plant	Hydro	2600	2019
18	Coal Power Plant (III) or Gas Power Plant	Coal/NG	450	2020

Source: MME-CERIAEA, 2016

9. Industrial Development

Over the last 10 years, Cambodia has had an average economic growth of 7%, which is attributed to the rapid expansion of investment in all sectors such as construction, tourism, agriculture, agro-industry, and garment industry. The industrial sector played an important role with its share to the GDP increased from 13% in 1993 and 33% in 2017 (RGC, 2018). It was reported that there were 1,579 factories registered at the Ministry of Industry and Handicraft (MIH) in 2016, or a 174% increase compared to 2012. The growing sectors were the food and beverage (135 factories), the garment (1,079 factories), the pulp and paper (43 factories), the non-metal mine (31 factories), the

chemical/rubber/plastic (110 factories), the metal processing (111 factories), the furniture (34 factories), and other industries (36 factories). The total labour demand in the industrial sector was 921,858 in 2017 or 165% growth from 2012. The total labour demand in the garment and footwear sector, and other sectors were 798,815 and 123,043, respectively, in 2017 (MIH, 2017).

Cambodia has also witnessed rapid infrastructure development, which is translated into the increase of demand for construction materials among others. The government approved 1,523 projects nationwide during the first half of 2017, compared with 1,183 projects for the same period of 2016 (B2B Cambodia, 2017). The RGC aims at converting industrial structure into a knowledge-based industry by 2025 (RGC, 2015). In this regard, the industry sector is going to be a major economic pillar for many years to come. The Government will also upgrade the diversification of manufacturing base and promote further development of Small and Medium Enterprises (SMEs). The Government is encouraging a rapid transformation of industrial structure to move from a labor-intensive and low productivity industry to a more broad-based, high-tech and high-skilled one (RGC, 2015).

10. Climate change status and national responses

10.1 Climate change status

The warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia (IPCC, 2013). It went on to stress that the atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of GHGs have increased. The report highlighted that among the total world GHG emissions of 49GtCO_2eq./year in 2010, the energy sector contributed by about 35%, the AFOLU sector by 24%, industry by 21%, transport by 14%, and buildings by 6% (IPCC, 2013). The share of GHG emissions from the AFOLU sector had decreased from around 31% in 2004 to 24% in 2010 (IPCC, 2007 and Smith *et al*., 2014) largely due to increases of emissions in the energy sector.

Southeast Asia has faced increasing threats from climate change, with increasing loss of human lives and significant damage to economic development and natural resources. We have all observed the alarming trends of more frequent and intensified floods, droughts, saline intrusion, and extreme weather events, especially over the last decades. As for Cambodia, the temperature has increased and this trend is predicted to continue with mean temperatures increase between 0.013^{o}C to 0.036^{o}C per year by 2099 (GSSD, 2015). The rate of temperature increase is higher in low altitude areas than in high altitude areas. It was assumed that under elevated CO_2, rainfall levels and variability will change in Cambodia. Rainfall variability in some regions may decrease and increase in others depending on the time horizons. Under elevated CO_2 with low rate of emission scenarios (Special Report on Emissions Scenarios-SRESB1), it is quite likely that the wet season rainfall will continue to increase in the future and then might decrease again after 2050s; however, under high emission scenario (Special Report on Emissions Scenarios-SRESA2), the direction of change will reverse. Indeed, Cambodia has witnessed floods and droughts resulting in considerable economic losses, infrastructure damages and fatalities. An assessment released that if no appropriate measures taken Cambodia is projected to affect around 3.5% of the total national GDP by 2050.

In terms of GHG emissions, Cambodia is regionally and globally insignificant with per capita GHG emissions of about 0.23tCO_2 eq./year in 2000 and expected to increase to 1.3tCO_2eq./year in 2050 (GSSD, 2015); however, a study found that per capita GHG emissions were projected to increase to about 1.1 and 5.5tCO_2eq./year in 2030 and 2050, respectively (Mao et al, 2016).

According to the Second National Communication (SNC), the highest contributor of GHG emissions was Land Use Change and Forestry (LUCF), which accounted for about 51%, followed by agriculture (45%), energy (4%), and waste (less than 1%). However, the country had changed from a net carbon sink in 1994 (MoE, 2002) to a net emitter in 2000 (GSSD, 2015). The result of the assessment showed that GHG emissions is projected to increase about 2 times and 3 times in 2030 and 2050, respectively, compared to 2010 (GSSD, 2015). Table 7 shows GHG emissions in Cambodia. It is noted that GHGs emissions from the Industrial Processes and Industrial Use (IPPU) sector have not been considered because of its insignificant contribution, while GHG emissions from the waste was insignificant (MoE, 2002 and GSSD, 2015). The country has also potential mitigation options such as energy efficiency measures, solar power, rice husk gasification with combined heat and power, electric vehicles, efficient cook-stoves, and ceramic water filters, etc. The country also developed Energy Efficiency National Appropriate Mitigation Action (NAMA) in the Garment Industry in 2015 in order to improve efficiency in the industrial sector and to build capacity in the field of energy efficiency.

Table 7: GHG emissions in Cambodia

Sector/year	2000	2010	2030	2050	2030/2010	2050/2010
Residential	948	936	1,287	1,890	1.4	2.02
Commercial	68	142	311	682	2.2	4.80
Energy industry	385	1,453	3,539	8,888	2.4	6.12
Manufacturing	320	689	1,144	1,766	1.7	2.56
Transport	709	2,000	4,631	10,816	2.3	5.41
AFOLU	(8,882)	15,689	25,504	34,112	1.6	2.17
Total (MtCO2eq.)	**(6,452)**	**20,909**	**36,416**	**58,154**	**1.7**	**2.78**

Source: GSSD (2015)

10.2 National responses to climate change

Although Cambodia's GHG emissions are negligible, the participation of Cambodia as a member of the UNFCCC should partially be important to contribute to the global effort to achieving the GHG emissions reduction target (UNFCCC, 1992, 1998, and 2015). The Government also realized that addressing economic and social development by taking climate change into account will assist the country in reducing vulnerability to potential climate risks, improving air quality, and mitigating GHG emissions. Cambodia has been working very closely and actively with the world communities by ratifying the UNFCCC on 18th December 1995 and acceded to the Kyoto Protocol on 04th July 2002. Cambodia also signed the Paris Climate Agreement on 22nd April 2016 and ratified accordingly.

In 2006, the Government adopted the National Adaptation Program of Action (NAPA), covering 39 adaptation projects including agriculture development, water supply, irrigation, health care, fighting malaria, malaria education, agro-forestry development, and coastal zones (NAPA, 2006). Cambodia established the National Climate Change Committee (NCCC), assisted by Climate Change Technical Team (CCTT) in 2006 as the policy and decision making body with the mandate to prepare, coordinate, and monitor the implementation of policies, strategies, legal instruments, plans and programs to address climate change issues. However, the NCCC was restructured to be the National Council for Sustainable Development (NCSD) on 09th May 2015, chaired by the Minister of Environment with the primary mandate to prepare, coordinate, and monitor policies, strategic and action plans, legal instruments, and programs related to climate change and sustainable development.

Additionally, Cambodia submitted the Intended Nationally Determined Contribution (INDC) to the UNFCCC in 2015 in order to indicate her contribution to the global effort to stabilising GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (RGC, 2015a). GHG emissions is expected to reduce a maximum of 27% by 2030 compared to the Business As Usual (BaU) level (RGC, 2015a). Cambodia also prepared National Strategic Plan on Green Growth (NSPGG) (2013-2030) in 2013, aiming to promote national economy with growth stability, reduction and prevention of environmental pollution, safe ecosystem, poverty reduction, and promotion of public health service, educational quality, natural resource management, sustainable land use, and water resource management to increase energy efficiency, ensure food safety, and glorify the national culture (NCGG, 2013). In addition, Climate change has been mainstreamed into the National Strategic Development Plan (NSDP) Update (2009-2013), aiming to build the capacity of the Government's institutions and to develop a strategy dealing with the anticipated impacts of climate change, and to strengthen disaster management capabilities and other development activities.

The RGC approved the first ever Cambodia Climate Change Strategic Plan (CCCSP) (2014-2023), aiming to develop the country towards a green, low-carbon, climate resilient, equitable, sustainable, and knowledge-based society (RGC, 2014a). The CCCSP covers eight main strategic objectives: (1) promote climate resilience through improving food, water, and energy security; (2) reduce sectoral, regional, gender vulnerability, and health risks to climate change impacts; (3) ensure climate resilience of critical ecosystems, biodiversity, protected areas, and cultural heritage sites; (4) promote low-carbon planning and technologies to support sustainable development; (5) improve capacities, knowledge, and awareness for climate change responses; (6) promote adaptive social protection and participatory approaches in reducing loss and damage due to climate change; (7) strengthen institutions and coordination frameworks for national climate change responses; and (8) strengthen collaboration and active participation in regional and global climate change processes. A sectoral climate change action plan was also developed; for instance, Climate Change Action Plan for Industry and Handicraft Sectors (2015-2018) in order to promote green industry for climate resilient low carbon production; to use renewable energy and energy diversification including promoting on-site renewable energy captive generation for industrial production processes; to introduce more path-breaking technologies for low-carbon production industries; and to enhance industrial waste management.

11. Obligations under the UNFCCC

Cambodia as a signatory party of both the UNFCCC (Articles 4 and 12) and the Kyoto Protocol (KP) must report GHG emissions by sources and removals, national mitigation and adaptation measures, and any other relevant achievement towards the objective of the Convention and the country must set up institutional arrangements for the national approval of the Clean Development Mechanism (CDM) under the KP.

The NCSD/MoE has been appointed as the national focal point for the UNFCCC and as a secretariat for the Designated National Authority (DNA) for the CDM. Twelve CDM projects were registered by the UN-CDM Executive Board, which can reduce million tons of GHG emissions (GSSD, 2015). Annex 1 shows list of CDM projects. Some local organizations have implemented voluntary carbon standards as viable alternatives to the CDM. There are two Voluntary Emission

Reductions (VERs) projects, including National Bio-digester Program (NBP) and Fuel-wood Saving Project (CFSP). The first covered 10,000 family-sized bio-digesters with the expected annual emissions reduction of around 59ktCO_2 eq./year, while the latter has been working on the improvement of cook stoves that consume about 20.0% less charcoal than traditional ones, and could reduce GHG emissions by about 160ktCO_2eq./year over the period of 2003-2012 (RGC, 2013a). The RGC in cooperation with Wildlife Conservation Society (WCS) has sold the first Carbon Credit of the Climate Change Reduction Project in the 292,690 ha wildlife protection area in Keo Seima, Mondulkiri province, to a U.S. firm, Disney. It is projected to reduce emissions of 14 million metric tons of CO_2eq. over the first 10 years period between 2010-2019. Furthermore, the government made a clear commitment in 2017 that there will be zero emissions of GHG in the forestry sector before 2040 (RGC, 2017)

12. National Steering committee for Climate Change Project in the Industry and Handicraft

In order to effectively implement the project on "Demonstration of Resource Efficiency and Cleaner Production (RECP), Environmental Management System (EMS) and Greenhouse Gases Mitigation and Adaptation", the Ministry of Industry and Handicraft (MIH) established a national steering committee for climate change project in the industry and handicraft on 20 December 2018. The chair of the committee is a secretary of state of the MIH with the participation of the representatives of the MIH and the General Secretariat of the National Council for Sustainable Development (GSSD). The committee has the following roles and responsibilities:

- To assist the Ministry of Industry and Handicraft for steering climate change project in the industry and handicraft;
- To monitor, evaluate, and decide on project action plan, report, and budget;
- To communicate with project director and management level about national priorities and produce quality outputs;
- To provide comments and improvement on the project implementation gaps; and
- To monitor and decide on the project implementation outputs.

13. Overview of GHG Emissions from Industrial Processes and Product Use

13.1 Definition of Industrial Processes

Industrial processes are procedures, involving chemical, physical, electrical, or mechanical steps to aid in the manufacturing of an item or items, usually carried out on a very large scale. The IPPU sector includes emissions generated from production processes, involving the use of carbonates (such as limestone and dolomite), carbon when used as a chemical reductant (such as iron and steel or aluminum production), chemical industry processes (such as ammonia and nitric acid production), the production and use of synthetic gases such as Hydrofluorocarbon (HFCs) or sulfur hexafluoride, combustion of lubricant oils not used for fuel and carbon dioxide (CO_2) generated in food production. GHG emissions from industrial processes and product use are primarily by products of production. The level of emissions is a factor of the process technology used and the level of industrial output. Industrial processes and product use emissions are non-energy related, while energy-related emissions are considered in the energy sector (Liu, 2016).

13.2 Overview of GHG emissions from the Industrial Processes and Product Use

GHG emissions can be generated by fossil fuel combustion, industrial production processes, waste treatment, and land use change (IPCC, 2006). It is invested that fossil fuel combustion and cement production are the most significant sources of human-induced carbon emissions (Le Quere, et al., 2013; Levin, 2012; Boden et al., 2013; and Oliver et al., 2014). The IPCC lists several types of industrial products (Annex 2), the chemical or physical production of which can release carbon emissions. For instance, global emissions from cement production were approximately 2,000 Mt CO_2 in 2013 (Oliver et al., 2014). Industrial activities generate GHG emissions in a variety of ways such as from the use of electricity and natural gas energy supplies to provide power and heat (indirect emissions). Industrial emissions also result from the processing of materials to manufacture items, including mineral aggregate products, chemicals, metals, refrigerants, electronics, and other consumer goods such as paper and food items (David, 2018). During these processes, many different GHGs, including CO_2, CH_4, N_2O, and Perfluorinated Compound (PFC), can be released (IPCC, 1996). Cement production in particular is the largest source of industrial production emissions and has widely been reported.

Carbon emissions from cement production refer to the direct emissions from the calcination process for clinker production (2A1 in IPCC classification). In the production of clinker, which is scorched at about 1450°C, the calcination of calcium carbonate ($CaCO_3$) releases CO_2 emissions, but CO_2 can also be released during the calcination of Cement Kiln Dust (CKD) (Liu, 2016). Clinker production is the most energy escalated step, speaking to around 80% of the energy used in cement manufacturing (Bakhtyar, 2017). By upgrading the energy efficiency in the clinker production process can lessen the energy consumption, related expenses, and CO_2 emissions. The cement-based approach represents changes in CO_2 emissions in cement production by incorporating modifications (blended) to the cement manufacturing process, while the clinker-based approach calculates CO_2 emissions based on the volume and composition of clinker produced and the amount of cement kiln dust not recycled to the kiln (Davis, 2002). Direct primary energy combustion and indirect electricity consumption also occur during this process and emissions from these processes can be categorized as emissions from energy combustion (1A2 in IPCC classification).

Total GHG emissions of the industrial production is mainly composed of two parts: energy related emissions and process related emissions. Energy related emissions are mainly from energy consumption; for example, direct emissions from combustion of fossil fuel and indirect emissions from consumption of electricity and heat (Liu et al., 2014). Almost all industrial sectors cause energy related emissions, while the followings cause process related emissions (DCCEE, 2010):

- **Metal production:** CO_2 and PFCs emissions from aluminum smelting and carbon dioxide, methane, and nitrous oxide emissions from iron and steel production;
- **Chemical industry:** N_2O emissions from the production of Nitric Acid (HNO_3) (largely used in production of Ammonium Nitrate-NH_4NO_3), CO_2 emissions from Ammonia (NH_3) production; and CH_4 emissions from the production of organic polymers and other chemicals;
- **Mineral products:** CO_2 emissions from cement clinker and lime production, the use of limestone and dolomite in industrial smelting processes, soda ash use and production, magnesia production, and the use of other carbonates (Sodium Bicarbonate-$NaHCO_3$, Potassium Carbonate-K_2CO_3, Barium Carbonate-$BaCO_3$, Lithium Carbonate-Li_2CO_3, and Strontium Carbonate-$SrCO_3$); and

- **Food and drink production:** CO_2 emissions from Ammonia (NH_3) production, CO_2 wells, Ethylene Oxide (C_2H_4O) production, and Sodium Bicarbonate ($NaHCO_3$) use.

13.3 Direct Carbon Emissions in Cement Factories

Direct emissions are emanations from sources that are possessed or controlled by the reporting organization. According to Vanderborght and Brodmann (2001), direct CO_2 emissions result from the accompanying sources; for instance, calcination of limestone in the raw materials, conventional fossil kiln fuels, and alternative fossil based kiln fuels, biomass kiln fuels, and non-kiln fuels in cement plants. Cement is known as the **"glue"** that holds the concrete and is utilized extensively in construction globally (IEA, 2007). Cement production is an energy-escalated process and energy consistently addresses to 20-40% of total production costs. The most extensively used is Portland cement type that contains 95% cement clinker. Ali et al. (2011) interpreted that emissions of CO_2 in a cement industry mainly come directly from the combustion of fossil fuels and calcination of the limestone into calcium oxide.

13.4 Indirect Carbon Emissions in Cement Factories

Indirect emissions are emissions caused by the activities of the reporting company; however, it happens at sources possessed or controlled by another corporation. For instance, emissions from the generation of network electricity ran through by a cement company will qualify as indirect (WBCSD, 2011). Utilization of electricity that is generated by burning fossil fuels is considered as energy-related CO_2 emissions and transmitting CO_2 indirectly. Zhu (2011) investigated that the share of CO_2 emissions from the power utilization is 5%, and CO_2 emissions are indirect since they are the aftereffect of the power utilization to work the plant.

Cement production uses much electricity for raw materials preparation, cement grinding, and catering for other electrical instrumentations (Ke et al., 2013). Amid the cement production process, CO_2 is emitted by four different sources. Combustion of fossil fuel in pyro-handling unit, producing 40% of total emanations, while another 10% is in consequence of crude materials transport and electricity generation consumed by electrical engines and facilities. Mahasenan et al. (2003) argued that the most noteworthy proportion of emissions of about 50% is discharged in the decomposition of $CaCO_3$ (Calcium Carbonate) and $MgCO_3$ (Magnesium carbonate) to produce CaO and MgO. CO_2 outflows in cement industry mostly from ignition of fossil fills and calcination of the limestone into calcium oxide. Ali et al. (2011) indicated that nearly 50% of CO_2 discharges originated from the combustion of fuels, and half of them are originated from the calcination of the limestone.

14. National Inventory of GHG emissions from the Industrial Processes and Product Use

14.1 Objectives

The main objectives of this report are to:

- Collect, compile, and quantify data of the Industrial Processes and Product Use (IPPU);
- Propose methodology for estimation of GHG emissions from the IPPU sector; and
- Estimate GHG emissions from the IPPU sector.

14.2 Methodology

Carbon emissions from the industrial production refer to the CO_2 released from the physical-chemical process of transforming raw materials into industrial products, while the fossil fuels used in this transformation stage are considered carbon emissions from fossil fuel combustion performed by the industrial sectors and are not considered as the industrial process emissions. Emissions from the calcination of calcium carbonate ($CaCO_3 => CaO + CO_2$) are considered as industrial process emissions; however, emissions from fossil energy usage during the calcination process are considered as energy-related emissions. According to the IPCC guideline 2006, three basic methodologies have been recommended to estimate industrial process emissions (IPCC, 2006).

1) **Tier 1** approach (a reference approach) is an output-based approach that estimates emissions based on the production volume and the default emission factors;
2) **Tier 2** approach (an output-based approach) estimates emissions based on production and country-specific information for correction emission factors. The calculation process in this approach is similar to the Tier 1 approach, except the global average emission factors are replaced by country-specific values; and
3) **Tier 3** approach (an input-based carbonate approach) estimates the emissions based on the carbon inputs. The calculation process requires a material flow analysis of the entire production supply chain. It requires the greatest volume of data.

Note: Because of data limitation, the Tier 1 approach is used for this purpose.

The general methodology, employed to estimate emissions associated with each industrial process involves the product of activity level data, e.g., amount of material produced or consumed, and an associated emission factor per unit of consumption/production. This general method represents the fundamental relationship to evaluate industrial process emissions. To estimate GHG emissions from the IPPU sector, the following equation is used:

Total Emission = Activity Data x Emission Factor

Where:

- Total Emission = Process emission (tonne) from the industrial sector
- Activity Data = Amount of activity or production of process material in the industrial sector
- Emission Factor = Emission factor associated with gas per unit of activity in the industrial sector (tonne/year)

(1)

14.2.1 Activity Data

Activity data are the amount of industry products at the national level (tons). The emission factors (ton CO_2/ton product) is the national average ratio of the amount of CO_2 released for each unit of product. The following equations are used to estimate emissions released during the production process:

a) **Glass Production:** When glass raw materials have been melted, the limestone ($CaCO_3$), dolomite $Ca(CO_3)$, $Mg(CO_3)$ and soda ash (Na_2CO_3) produce CO_2:

$$CaCO_3 \longrightarrow CaO + CO_2$$
$$MgCO_3 \longrightarrow MgO + CO_2 \quad (2)$$

b) **Soda Ash Production:** Soda ash comprises primarily sodium carbonate (Na_2CO_3). CO_2 is emitted during the production of Na_2CO_3, thus the carbon emissions can be estimated by multiplying the quantity of soda ash consumed by the default emissions factor for sodium carbonate:

$$2Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O = 3Na_2CO_3 + 5H_2O + CO_2 \quad (3)$$

c) **Ammonia Production:** Ammonia (NH_3) in the form of major industrial chemical products is synthesized H_2 (hydrogen) and N (nitrogen), while both the production processes will release CO_2 as a byproduct:

$$CH_4 + H_2O \longrightarrow CO + 3H_2$$
$$CO + H_2O \longrightarrow CO_2 + H_2 \quad (4)$$

HYDROGEN AND NITROGEN PRODUCTION:

$$CH_4 + Air \longrightarrow CO + 3H_2 + 2N_2 \quad (5)$$

AMMONIA SYNTHESIS:

$$N_2 + 3H_2 \longrightarrow 2NH_3 \quad (6)$$

d) **Calcium Carbide Production:** Calcium carbide (CaC_2) is created by heating calcium carbonate ($CaCO_3$) to produce calcium oxide (CaO) and the carbonization process of CaO. Both processes will release CO_2.

$$CaCO_3 \longrightarrow CaO + CO_2$$
$$CaO + 3C \longrightarrow CaC_2 + CO$$
$$2CO + O_2 \longrightarrow 2CO_2 \quad (7)$$

e) **Alumina Production:** During the alumina production process, CO_2 is emitted from the consumption of carbon anodes, while transforming alumina oxide into alumina metal:

$$2Al_2O_3 + 3C = 4Al + 3CO_2 \quad (8)$$

14.2.2 Emission Factor

The emissions factors refer to the emission amounts per production unit, which amounts vary depending on the production processes. The detail information on the default emission factors is shown in Table 8. For the purpose of this assignment, the emission factor will mainly be focused on (1) Cement Production, which CO_2 emitted during the cement production process represents the most important source of non-energy industrial process of global CO_2. Estimation of emissions from cement production is accomplished by applying an emission factor (tCO_2) released per ton of clinker produced to the annual clinker output; and (2) Soda Ash (Na_2CO_3), which is used as a raw material in a large number of industries, including glass manufacture, soap and detergents, pulp and paper production, and water treatment. Because of limited country information, the emission factors from the IPCC 2006 guidelines (IPCC, 2006) will be used.

Table 8: Default emission factors from the IPPC

Category	**Emission factor**
Cement Production	0.52 t CO_2/t clinker
Lime Production	0.75 t CO_2/t lime
Glass Production	0.20 t CO_2/t glass
Ceramics	*Chapter 2.5*
Other Uses of Soda Ash	0.41 t CO_2/t soda ash
Non-Metallurgical Magnesia Production	0.52 t CO_2/t magnesite
Carbon Dioxide Contents Common Carbonate Species	**Emission Factor (tonne CO /tonne carbonate)**
CaCO	0.44
MgCO	0.52
CaMg(CO)	0.48
FeCO	0.38
Ca (Fe,Mg,Mn)(CO)	0.41-0.48
MnCO	0.38
Na CO	0.41

14.2.3 Data collection

Data and information on industrial products that can be used to estimate GHG emissions remain limited in Cambodia. Several institutions are visited to collect data; for instance, the Department of Industrial Affairs of the MIH (food and beverage, pulp and paper, glass); the Ministry of Mines and Energy (MME) for cement products; the National Institute of Statistics (NIS) of the Ministry of Planning (MoP) for the statistic year books, etc. In addition, the working group of the MHI and the national consultant visited to several companies (beer and food) to collect and verify data. The consultant also discussed with experts from respective ministries and institutions to clarify some collected data in order to make the result high quality and acceptable. Table 9 shows list of industrial products used to estimate GHG emissions from the IPPU sector.

Table 9: List of industrial products

Products (Ton/year)	2014	2015	2016	2017
Cement	-	1,389,880	3,034,231	3,406,716
Food	208,585	433,837	552,093	1,052,289
Beverages	564,577	711,321	804,722	971,910
Pulp and paper	66,762	76,576	91,259	147,053
Glass	-	-	39,564	47,690

Source: The Department of Industrial Affairs of the MIH

14.2.4 Training courses

One of the objectives of the project is to strengthen the Government, especially the staff of the MIH and industrial sector capacity and to raise awareness of low-carbon planning and technologies. In response, three training courses were organized subsequently. These three training courses were organized in Siemreap province. The first one was held on 27 April aiming to: (1) provide overview of climate change impacts and responsive measures; (2) introduce GHG calculation methodology for industrial process and product use; and provide conceptual framework for data collection and requirement. The agenda and list of participants is attached in the Annex 3. The second training course was held on 10 August 2018 with the main objectives: (1) to further enhance capacity of relevant stakeholders for GHG emissions estimation methodology; (2) to collect additional data to quantify and qualify the results of GHG emissions estimation; and (3) to discuss, verify, and validate the results of GHG emissions estimation. The agenda and list of participants is attached in the Annex 4. The last training course was held on 5 September 2018, aiming to: (1) enhance capacity of relevant stakeholders for GHG emissions estimation methodology; (2) collect further data to qualify the results of GHG emissions estimation; and (3) verify and validate the results of GHG emissions estimation. The agenda and list of participants is attached in the Annex 5. Additionally, an on job training was organized on 28 November 2018 at the MIH with the main objective to further enhance capacity of the MIH's staff, especially those who are assigned to visit relevant companies and enterprises. They become the trainers to train other relevant stakeholders for data collection and compilation and to train how to promote the efficient improvement of industrial processes and production use.

14.2.5 Global warming potential

When emissions source is not CO_2 the conversion to CO_2 equivalent is required. The detail information on global warming potential is shown in Annex 6. We use data of the Fifth Assessment Report (AR5) to conduct GHG emissions estimation.

15. Results of GHG emissions in the Industrial Processes and Production Use

In order to estimate GHG emissions from the IPPU sector, the excel spread sheet is created and used. Data of industrial processes and product use is very limited in Cambodia and most of data are available from 2014. Data used to estimate GHG emissions from the IPPU sector includes: food and beverage, pulp and paper, cement, and glass. According to the Initial National Communication (INC) in 2002 of Cambodia, GHG emissions are produced during the microbial fermentation process in the production of beer, wines and spirits; however, these activities are

assumed to give zero net CO_2 emissions since the CO_2 emitted is assumed to be reabsorbed during crop growth (MoE, 2002). In that sense, GHG emissions from the beverage are not included in this report. As all data are available from 2016, the comparison is made in this year.

The result shows that the cement sector shares the highest GHG emissions of about 97%, followed by the pulp and paper sector of 2.5%, while glass and food sectors share GHG emissions of about 0.5% and 0.01%, respectively, in 2016. Table 10 shows GHG emissions by sectors in the IPPU sector. The result shows that GHG emissions from the cement sector in 2016 is about 31 times higher than that of 1994 (about 50ktCO_2). The difference is because of the increase of cement factories and producing capacity. The result also illustrates GHG emissions in the IPPU sector in Cambodia in 2016 is much smaller than that of Viet Nam in 1994 (21,172 ktCO_2) (MoNRE, 2014) and that of Thailand in 2000 (15,400 ktCO_2) (ONREPP, 2015).

Table 10: GHG emissions by sectors in the IPPU sector

Emissions by sectors/year	2014	2015	2016	2017
Food	0.06	0.13	0.17	0.32
Pulp and paper	29.38	33.69	40.15	64.70
Cement		722.74	1,577.80	1,771.49
Glass			7.91	9.54
Total emissions (ktCO_2/year)	**29.44**	**756.56**	**1,626.03**	**1,846.05**

16. Conclusions and Recommendation

16.1 Conclusions

To achieve the aspiration of the Government shift to the status of an upper-middle income country by 2030 and a high-income level by 2050, the industrial sector contribution is utmost important. The industrial policy was set to reach 30% of its contribution to the GDP growth by 2025. In this regard, The Government will upgrade the diversification of manufacturing base and promote further development of Small and Medium Enterprises. The government is encouraging a rapid transformation of industrial structure to move from a labor-intensive and low productivity industry to a more broad-based, high-tech and high-skilled one. However, the government still realizes that the stable and steady economic growth is largely attributed to the continued good performance of the agricultural sector whereby the country is increasing the value added of milled rice production for export and other high value agriculture products. There is an implication that due to the ambiguous economic development plan, GHG emissions is expected to increase accordingly.

At the time of enjoying the economic growth, Cambodia has faced a lot of challenges of climate change where there is a need to take actions. The Government stressed that addressing economic and social development by taking climate change into account will assist the country in reducing vulnerability to potential climate risks, improving air quality and mitigating GHG emissions. In response, the government has mainstreamed climate change into the National Strategic Development Plan in order to build the capacity of the Government's institutions and to develop a strategy dealing with the anticipated impacts of climate change, and to strengthen disaster management capabilities and other development activities. The government also approved Cambodia Climate Change Strategic Plan (2014-2023) so as to develop the country towards a green, low-carbon, climate resilient, equitable, sustainable, and knowledge-based society. Also

sectoral climate change responses were developed, for instance, the Climate Change Action Plan for Industry and Handicraft Sectors (2015-2018), aiming to promote green industry for climate resilient low carbon production; to use renewable energy and energy diversification including promoting on-site renewable energy captive generation for industrial production processes; to introduce more path-breaking technologies for low-carbon production industries; and to enhance industrial waste management.

Cambodia has limited study and research on GHG emissions from the IPPU sector, only the Initial National Communication was considered this sector with GHG emissions of about 50ktCO_2 in 1994 (MoE, 2002). The Ministry of Industry and Handicraft with the support from the Cambodia Climate Change Alliance is implementing the project on "Demonstration of Resource Efficiency and Cleaner Production, Environmental Management System and Greenhouse Gases Mitigation and Adaptation" in which one of the activities is to conduct GHG inventory from the IPPU sector. This study found that total GHG emissions from the IPPU sector is 1,626.03ktCO_2 in 2016; among them the cement sector shares about 97%, followed by the pulp and paper sector (2.5%). The same study estimated that GHG emissions from this sector increased to 1,846.05ktCO_2 in 2017.

16.2 Recommendation

Cambodia realizes the importance of the contribution of GHG emissions from the IPPU sector to the total national emissions. The country has also jumped to another step of handing over the responsibilities of conducting GHGs inventory to the responsible institutions, in which the MoE had previously been responsible for. The project on "Demonstration of Resource Efficiency and Cleaner Production, Environmental Management System and Greenhouse Gases Mitigation and Adaptation" provides a window of opportunity to build capacity of staff of the MIH and other relevant stakeholders for GHGs inventory from the IPPU sector through conducting both theoretical and practical trainings. A number of challenges faced including: limited human resources and capacity, limited relevant industrial data for GHGs inventory, limited study and research in this sector in the country, limited financial support to conduct a regular and continuous inventory, limited cooperation and participation from the private sectors, etc.

In order to address these constraints, it is very important for the MIH and other relevant institutions to take the following suggestions into account:

- Promote human capacity development through nominating them to attend trainings and workshops related GHGs inventory from the IPPU sector;
- Raise awareness to relevant stakeholders, especially private sectors for data compilation and management, especially industrial production data, which will be used for GHGs inventory;
- Enhance cooperation and participation in sharing data and information required for GHGs inventory preparation;
- Conduct on job trainings to relevant stakeholders, including private sectors on how and what kind of data needed to/for GHGs inventory as well as train them on how to estimate GHG emissions;
- Mobilize resources (both human and financial resources) from different development partners and donor countries to continue the implementation of GHGs inventory, especially development of national emission factors and enhancement of the compilation and management of industrial activity data; and
- Translate the result of the study into real actions through implementing GHGs mitigation projects.

Reference

1. Ali, M.B., Saidur, R., Hossain, M.S., 2011. A review on emission analysis in cement industries. Renewable and Sustainable Energy Reviews, 15(5), 2252-2261
2. B2B Cambodia (Business2Business, 2017. Industry Overview: Construction and Maintenance. Retrieved from https://www.b2b-cambodia.com/industry-overviews/construction-maintenance/#146442112 6851-7f52d77a-0ce5, December 10th, 2017
3. Boden, T., Andres, R.J., Marland, G., 2013. Global, Regional, and National Fossil-Fuel CO_2 Emissions, vol. 2013. Oak Ridge (TN, USA): Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory
4. Bakhtyar, B., Kacemi, T., Nawaz, Md. A., 2017. A Review on Carbon Emissions in Malaysian Cement Industry. Universiti Utara Malaysia, Malaysia
5. Davis, G., 2002. General Reporting Protocol. California Climate Action Registry.
6. David, O., 2008. An Analysis of Regional Emissions and Strategies to Achieve AB 32 Targets. University of San Diego
7. Department of Climate Change and Energy Efficiency (DCCEE), 2010. Industrial Process Emissions Projections 2010 of the DCCEE: Caberra, Australian, 2010
8. General Secretariat of the National Council for Sustainable Development (GSSD), 2015. Cambodia's Second National Communication under the United Nations Framework Convention on Climate Change. The General Secretariat of the National Council for Sustainable Development/Ministry of Environment, the Kingdom of Cambodia, Phnom Penh
9. International Energy Agency (IEA), 2007. Tracking Industrial Energy Efficiency and CO2 Emissions. Paris, France: Organisation for Economic Co-operation and Development
10. IPCC, 2013. Summary for Policymakers. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to 5th Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge
11. IPCC, 2007. 4th Assessment Report. The Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge
12. Intergovernmental Panel on Climate Change (IPCC), 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3. Industrial Process and Product Use
13. Intergovernmental Panel on Climate Change (IPCC), 1996. The Science of Climate Change. Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press
14. Japan International Cooperation Agency (JICA), 2012. Data Collection Survey on Electric Power Sector in Cambodia. The Chugoku Electric Power Co., Inc., Japan
15. Japan International Cooperation Agency (JICA), 2006. The Master Plan Study on Rural Electrification by Renewable Energy in the Kingdom of Cambodia. Nippon Koei Co., Ltd. and Kri International Corp., Tokyo, Japan
16. Ke, J., McNeil, M., Price, L., Khanna, N.Z., Zhou, N., 2013. Estimation of CO 2 emissions from China's cement production: Methodologies and uncertainties. Energy Policy, 57, 172-181.
17. Liu, Z., 2016. National Carbon Emissions from the Industry Process: Production of Glass, Soda Ash, Ammonia, Calcium Carbide and Alumina. Harvard University, Cambridge, MA 02138, USA
18. Le Quéré, C., Andres, R.J., Boden, T., Conway, T., Houghton, R.A., House, J.I., 2013. The Global Carbon Budget 1959–2011. Earth System Science Data 2013; 5:165–86
19. Levin, I., 2012. Earth science. The balance of the carbon budget. Nature 2012; 488 (7409): 35–6.
20. Liu, Z., Dong, H., Geng, Y., Lu, C., and Ren, W., 2014. Insight into the Regional Greenhouse Gas Emission of Industrial Processes: A Case Study of Shenyang, China. Available at www.mdpi.com/journal/sustainability

21. Ministry of Women's Affairs (MoWAs), 2014. Neary Rattanak IV: Five Year Strategic Plan for Gender Equality and Women's Empowerment 2014-2018. Phnom Penh, Cambodia
22. Ministry of Industry and Handicraft (MIH), 2017. Industry and Handicraft's Implementation Results 2016. Retrieved from http://www.mih.gov.kh/File/UploadedFiles/4_20_2017_3_16_25.pdf, on December 10th, 2017
23. Ministry of Education, Youths, and Sport (MoEYS), 2014. Education Strategic Plan 2014-2018. Phnom Penh, Cambodia
24. Ministry of Agriculture, Forestry and Fisheries (MAFF), 2018. Annual Report 2017 and its target 2018. Phnom Penh, Cambodia
25. Ministry of Mines and Energy, Cambodia and Economic Research Institute for ASEAN and East Asia (MME-CERIAEA), 2016. Cambodia National Energy Statistics 2016. Phnom Penh, Cambodia
26. Ministry of Mines and Energy (MME), 2014. Power Development Master Plan in the Kingdom of Cambodia. Mitsubishi Research Institute, Japan
27. Ministry of Environment (MoE), 2002. Initial National Communication. Phnom Penh, Cambodia
28. Ministry of Natural Resources and Environment (MoNRE), 2014. The Initial Biennial Updated Report of Viet Nam. The Socialist Republic of Viet Nam.
29. Mao, H., Matsuoka, Y., Hasegawa, T., and Gomi, K., Hoa, N. T., (2016). A Design of Low Carbon Development Plan towards 2050 in Cambodia. Kyoto, Japan
30. Mahasenan, N., Smith, S., Humphreys, K., Kaya, Y., 2003). The cement industry and global climate change: Current and potential future cement industry CO2 emissions. In: Greenhouse Gas Control Technologies-6th International Conference. Vol. 2. Elsevier. p995-1000
31. National Strategic Development Plan (NSDP), 2016. Mid-term Review of the National Strategic Development Plan of the Royal Government of Cambodia. Phnom Penh, Cambodia
32. National Institute of Statistics (NIS), 2017. Cambodia Socio-Economic Survey 2016 of the NIS of the Ministry of Planning. Phnom Penh, Cambodia
33. National Institute of Statistics (NIS), 2012. Cambodia Socio-Economic Survey 2010 of the NIS of the Ministry of Planning. Phnom Penh, Cambodia
34. National Council for Green Growth (NCGG), 2013. National Strategic Plan on Green Growth (2013-2030). Phnom Penh, Cambodia
35. NAPA, 2006. The National Adaptation Programme of Action to Climate Change of the Ministry of Environment, Cambodia
36. Olivier, J.G., Janssens-Maenhout G., Peters, J.A., 2014. Trends in Global CO_2 Emissions: 2014 Report. PBL Netherlands Environmental Assessment Agency
37. Office of Natural Resources and Environmental Policy and Planning (ONREPP), 2015. Thailand's First Biennial Update Report. The Kingdom of Thailand.
38. Royal Government of Cambodia (RGC), 2018. Summary of the Royal Government of Cambodia's Achievement within 2013-2017 of the Council of Ministers. Phnom Penh, Cambodia
39. Royal Government of Cambodia (RGC), 2018a. Rectangular Strategy Phase IV (2018-2023) of the Council Ministers. Phnom Penh, Cambodia
40. Royal Government of Cambodia (RGC), 2018b. National Energy Efficiency Policy (2018-2035). The Ministry of Mines and Energy. Phnom Penh, Cambodia
41. Royal Government of Cambodia (RGC), 2017. Notification No. 1211, s.j.n.k.s. dated 28 Nov, 2017 on "Zero emission of GHGs in Forestry Sector before 2040", Phnom Penh, Cambodia
42. Royal Government of Cambodia (RGC), 2016. National Population Policy 2016-2030. The Ministry of Planning. Phnom Penh, Cambodia
43. Royal Government of Cambodia (RGC), 2015. Industrial Development Policy 2015-2025. The

Ministry of Industry and Handicraft. Phnom Penh, Cambodia
44. Royal Government of Cambodia (RGC), 2015a. Intended Nationally Determined Contribution of the Ministry of Environment. Phnom Penh, Cambodia
45. Royal Government of Cambodia (RGC), 2014. National Strategic Development Plan (2014-2018). Phnom Penh, Cambodia
46. Royal Government of Cambodia (RGC), 2014a.Cambodia Climate Change Strategic Plan (CCCSP) of the MoE. Phnom Penh, Cambodia
47. Royal Government of Cambodia (RGC), 2013. Rectangular Strategy Phase III (2014-2018) of the Council Ministers. Phnom Penh, Cambodia
48. Royal Government of Cambodia (RGC), 2013a. Technology needs assessment and technology action plans for climate change mitigation. Phnom Penh, Cambodia
49. Royal Government of Cambodia (RGC), 2012. Cambodian Government's achievements and future direction in sustainable development: national report for Rio+20 United Nations Conference on Sustainable Development. Phnom Penh, Cambodia
50. Royal Government of Cambodia (RGC), 2009. National Sustainable Development Strategy updated (2009-2013). Phnom Penh, Cambodia
51. Rogier, V. M., 2011. The Solar Roadmap for Cambodia. Phnom Penh, Cambodia.
52. Smith P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E. A., Haberl, H., Harper, R., House, J., Jafari, M., Masera, O., Mbow, C., Ravindranath, N. H., Rice, C. W., Robledo Abad, C., Romanovskaya, A., Sperling, F., and Tubiello, F., 2014. AFOLU. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to 5th Assessment Report of the IPCC. Cambridge University Press, Cambridge, United Kingdom and New York
53. Vanderborght, B., Brodmann, U., 2001. The Cement CO_2 Protocol: CO_2 Emissions Monitoring and Reporting Protocol for the Cement Industry. World Business Council for Sustainable Development
54. UNFCCC, 2015. The Paris Climate Agreement of United Nations Framework Convention on Climate Change. https://unfccc.int/sites/default/files/english_paris_agreement.pdf
55. UNFCCC, 1998. United Nations Framework Convention on Climate Change. Available at http://unfccc.int/resource/ docs/convkp/kpeng.pdf
56. UNFCCC, 1992. United Nations Framework Convention on Climate Change. Available at http://unfccc.int/resource/ docs/convkp/conveng.pdf
57. UN, 2011 and 2013. World Population Prospects: The 2010 and 2012 Revision. Vol. I: Comprehensive Tables. Department of Economic and Social Affairs of the United Nations, New York City, U.S.A
58. World Bank Group (WBG), 2018. Cambodia Economic Update: Recent Economic Developments and Outlook April 2018
59. WBCSD, 2011. CO_2 and Energy Accounting and Reporting Standard for the Cement Industry. World Business Council for Sustainable Development
60. Zhu, Q., 2011. CO_2 Abatement in the Cement Industry. IEA Clean Coal Centre. Research Report CCC/184

Annex 1: List of CDM projects

No.	Company	Other Parties	Project	Methodology	Registered	Period	Address
1	Siang Phong		W2E Siang Phong Biogas Project Cambodia	AMS-III.H. ver. 14 AMS-I.F. AMS-I.C. ver. 17	07 Apr 11		#157 St.118 Sangkat Phsar Chas, Khan Daun Penh +855 23 215 397
2	China Huadian Lower Stung Russei Chrum Hydro-Electric Project (Cambodia) Co., Ltd.	Switzerland	Lower Stung Russei Chrum Hydro-Electric Project	ACM0002 ver. 12	21 Aug 12	01/01/2013-31/12/2019	No. 57, St.596, Sangkat Boeung Kok , II Khan Toul Kork, Phnom Penh, Cambodia. +855 23 990 529 Email: duanchao-wen@chdhk.com
3	MH Bio-Energy Co., Ltd		Biogas Project at MH Bio-Ethanol Distillery, Cambodia	AMS-III.H. ver. 16 AMS-I.C. ver. 18	16 Feb 12	01 Apr 12 - 31 Mar 19	5 National Road, Duoing village , Preak Phnouv Commune +855 23-351-404 017-402-010
4	1.Sinohydro Kamchay Hydroelectric Project Co., Ltd. 2. CF Carbon Fund II Limited	Netherlands	Kamchay Hydroelectric BOT Project	ACM0002 ver. 13	08 Oct 13	01/09/2013-31/08/2020	No.49, St.310, Sangkat Boeung Keng Kang 1,Khan chamkar Mon Phnom Penh Cambodia +855 23-726665 John_shu@vip.163.com fund@cf-partners.com
`5	1. T.T.Y Agricultural Plant Development and IMEX Co. Ltd 2. Carbon Bridge Pte Ltd		TTY Cambodia Biogas Project	AM0022 ver. 4	03 Sep 08	July 2008-June 2015	210 Street 63 Sangkat Boeng Keng Kang I +855 23 220 942 ttysengtouch@online.com.kh bmcintosh@carbon-bridge.com
6	Angkor Bio Cogen Co., Ltd (Cambodia),	Japan Sweden	Angkor Bio Cogen Rice	AMS-I.A. ver. 7 AMS-III.E. ver.	10 Aug 06	20/04/2011-	Angsnoul District, Kandal Province +855 23-369218

	Mitsubishi UFJ Morgan Stanley Securities Co., Ltd (Japan), Asian Development Bank as Trustee of the Future Carbon Fund, Swedish Energy Agency (Sweden)		Husk Power Project	7 AMS-I.D. ver. 18			angkorrice@hotmail.com
7	Samrong Thom Animal Husbandry	Japan	Methane fired power generation plant in Samrong Thom Animal Husbandry, Cambodia	AMS-III.D. ver. 13 AMS-I.A. ver. 12	03 Dec 08		Phum Prek Treng, Khum San Rong Thom, Srok Kean Svay +855 23-211-709 +855 511-564-173 leng.rafael@hotmail.com
8	C.H.D (Cambodia) Hydropower Development Co.,Ltd.	Sweden	Cambodia Stung Atay Hydropower Project	ACM0002 ver. 12	19 Dec 12	01/03/2013-29/02/2020	St.606, Khan ToulKork +855 858 608 85 516902389@qq.com moe@tricorona.com
9	Kampot Cement Company	Denmark	Kampot Cement Waste Heat Power Generation Project (KCC-WHG)	AMS-III.Q. ver. 2	17 Apr 09	2009-2019	No. 100 National Road No. 2 Sangkat Chak Angre Leu Khan Meanchey + 855 23 996 839
10	Cambodian Tatay Hydropower Limited	Netherlands	Stung Tatay Hydroelectric Project	ACM0002 ver. 12	14 Dec 12	01/09/2013-31/08/2020	No. 16, Street 592, Sangkat Beungkok, Khan Toul Kok, Phnom Penh +855 888-888 978 cthl.kh@gmail.com

11	Nexus Carbon for Development Lt		Wast to energy using biomass Gasification in South East Asia LDCs programme of activities in Cambodia		29 Feb 2016		LoA approved on 29 Feb 2016 #33 Sothearos boulevard, P.O. Box 956 +855 23 990 591 contact@nexus-c4d.org
12	International Water Purification Programme		Water Kiosks in Cambodia – CPA 3		05 Sep 2015		Pure Water Ltd, T echnoparktrasse 1 8005 Zurich Switzerland

Annex 2: Classification of industrial process emissions by the IPCC

IPCC classification							
2. Industrial process	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halo-genated Gases
2A: Mineral industry							
2A1: Cement production	X	*					
2A2: Lime Production	X	*					
2A3: Glass Production	X	*					
2A4: Other process use of carbonates							
2A4a: Ceramics	X	*					
2A4b: Other Uses of Soda Ash	X	*					
2A4c: Non Metallurgical Magnesia Production	X	*					
2A4d: Other	X	*					
2A5: Other process	X	*	*				
2B: Chemical industry							
2B1: Ammonia production	X	*	*				
2B2: Nitric acid production	*	*	X				
2B3: Adipic acid production	*	*	X				
2B4: Caprolactam, glyoxal and glyoxylic acid production	*	*	X				
2B5: Carbide production	X	X	*				
2B6: Titanium dioxide production	X	*	*				
2B7: Soda ash production	X	*	*				
2B8: Petrochemical and carbon black production							
2B8a: Methanol	X	X	*				
2B8b: Ethylene	X	X	*				
2B8c: Ethylene Dichloride and Vinyl Chloride Monomer	X	X	*				
2B8d: Ethylene Oxide	X	X	*				
2B8e: Acrylonitrile	X	X	*				
2B8f: Carbon black	X	X	*				
2B9: Fluorides production							
2B9a: By-product Emissios				X	X	X	X
2B9b: Fugitive Emissions				X	X	X	X
2B10: Other	*	*	*	*	*	*	*
2C: Metal industry							
2C1: Iron and steep production	X	X	*				
2C2: Ferroalloys production	X	X	*				
2C3: Aluminum production	X	*			X		
2C4: Magnesium production	X			X	X	X	X
2C5: Lead production	X						
2C6: Zinc production	X						
2C7: Other	*	*	*	*	*	*	*
2D: Non-energy products from fuels and solvent use							
2D1: Lubricant use	X						
2D2: Paraffin wax use	X	*	*				
2D3: Solvent use							
2D4: Other	*	*	*				
2E: Electronic industry							
2E1: Integrated Circuit or Semiconductor	*		*	X	X	X	X
2E2: TFT Flat Panel Display				X	X	X	X
2E3: Photovoltaics				X	X	X	X
2E4: Heat Transfer Fluid							X
2E5: Other	*	*	*	*	*	*	*

2F Product Uses as Substitutes for Ozone Depleting Substances							
2F1: Refrigeration and Air Conditioning							
2F1a: Refrigeration and Stationary Air Conditioning	*			X	X		*
2F1b: Mobile Air Condioning	*			X	X		*
2F2: Foam Blowing Agents	*			X	*		*
2F3: Fire Production	*			X	X		*
2F4: Aerosols				X	X		*
2F5: Solvents				X	X		*
2F6: Other Applications	*	*	*	X	X		*
2G: Other Production Manufacture and Use							
2G1: Electrical Equipment							
2G1a: Manufacture of Electrical Equipment					X	X	*
2G1b: Use of Electrical Equipment					X	X	*
2G1c: Disposal of Electrical Equipment					X	X	*
2G2: SF6 and PFCs from other product uses							
2G2a: Military Applications					*	X	*
2G2b: Accelerators					*	X	*
2G2c: Other					X	X	*
2G3: N_2O from Product Uses							
2G3a: Medical Applications			X				
2G3b: Propellant for Pressure and Aerosol Products			X				
2G3c: Other			X				
2G4: Other	*	*		*			*
2H: Other manufacturing							
2H1: Pulp and Paper Industry	*	*					
2H2: Food and Beverages Industry	*	*					
2H3: Other	*	*	*				

Annex 3: Agenda and list of participants for the first training

Ministry of Industry and Handicraft

GREEN HOUSE GAS INVENTORY TRAINING WORKSHOP
Venue: Hotel, Siemreap, 27 April 2018

Tentative Agenda		
Time	**Description**	**Responsible**
08:00 - 08:30	Registration	Admin officer
08:30 - 08:35	National Anthem	All Participants
08:35 - 08:50	Welcome speech	**H.E. Dr. TUNG Ciny,** Under Secretary State of the MIH and Project Director
08:50 - 09:00	**Photo Session**	All Participants
09:00 - 10:00	**Session I:** Global and National Information on Climate Change and Responsive Measures (Q&A)	**Dr. HAK Mao**
10:00 - 10:20	**Coffee and Tea break**	
10:20 - 12:00	**Session II:** Initial framework for GHG emissions calculation methodology for industrial process and production use (Q&A)	**Dr. HAK Mao**
12:00-13:30	**Lunch Break**	All Participants
13:30 - 15:00	Conceptual framework for data collection and requirement (Q&A)	**Dr. HAK Mao**
15:00 - 15:15	**Coffee and Tea break**	
15:15-16:00	Group discussion	All Participants
16:00-16:30	Group presentation	Group leader
16:30-16:45	Wrap-up	**Mr. VEN Keahak**, Deputy Director General of Industry and Project Manager
16:45-16:55	Closing remarks	**H.E. Dr. TUNG Ciny,** Under Secretary State of the MIH and Project Director

Note:

- All times listed are estimated only!
- The Agenda is subjected to be changed without prior notice.

List of participants for the first training

ល.រ No	ឈ្មោះ Name	តំណែង Position	អង្គភាព Origanize	លេខទូរសព្ទ Phone Number
1	ឯកឧត្តម ទឹង ស៊ីនី	អនុរដ្ឋលេខាធិការ	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	012 429 406
2	លោក វ៉ែន គៀហាក់	អគ្គនាយករង	អគ្គនាយកដ្ឋានឧស្សាហកម្ម	012 595 860
3	លោក ហេង អៀង	ប្រធានមជ្ឈមណ្ឌល	មជ្ឈមណ្ឌលផលិតភាពជាតិ	012 867 906
4	លោក សារិ ផល្លា	ប្រធាននាយកដ្ឋាន	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	012 3000 87
5	លោក ចុង ប៊ូ	អនុប្រធាននាយកដ្ឋាន	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	012 83 52 60
6	លោក ផន យិនយ៉ា	អនុប្រធាននាយកដ្ឋាន	ន.ដ្ឋានផែនការ ស្ថិតិ សហប្រតិបត្តិការ និងការងារអាស៊ាន	010 558 998
7	លោក ហ៊ឹម ផានិត	អនុប្រធានមជ្ឈមណ្ឌល	មជ្ឈមណ្ឌលផលិតភាពជាតិ	077 36 9007
8	លោកស្រី លាង ធារី	អនុប្រធាននាយកដ្ឋាន	នាយកដ្ឋានកិច្ចការសិប្បកម្ម	011 777 445
9	លោក ហឿង គឹមសាយ	ប្រធានការិយាល័យ	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	077 977 727
10	លោកស្រី ស៊ឺ សោភា	ប្រធានការិយាល័យ	មជ្ឈមណ្ឌលផលិតភាពជាតិ	097 5 2222 86
11	កញ្ញា សាង សុគន្ធី	ប្រធានការិយាល័យ	នាយកដ្ឋានសហគ្រាសធុនតូច និងមធ្យម	012 37 24 76
12	លោក សុិន រិទ្ធី	អនុប្រធានការិយាល័យ	មជ្ឈមណ្ឌលផលិតភាពជាតិ	098 24 61 41
13	លោក ពៅ សំបៀន	អនុប្រធានការិយាល័យ	មជ្ឈមណ្ឌលមន្ទីរពិសោធន៍ឧស្សាហកម្មកម្ពុជា	012 877 564
14	លោក ស្រ៊ុន លឺ	អនុប្រធានការិយាល័យ	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	095 96 51 72
15	លោក ឌី ដារិន	អនុប្រធានការិយាល័យ	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	012 96 96 89
16	លោក ប៉ុក ពន្លក	អនុប្រធានការិយាល័យ	នាយកដ្ឋានសហគ្រាសធុនតូច និងមធ្យម	070 80 47 57
17	លោកស្រី អ៊ឹង សុគន្ធនារី	អនុប្រធានការិយាល័យ	នាយកដ្ឋានកិច្ចការសិប្បកម្ម	095 737 567
18	លោក អ៊ី ប៊ុនលាន	មន្ត្រី	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	092 204 555
19	លោក យឹម រិទ្ធី	មន្ត្រី	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	012 881 607
20	លោក អុល ភារិទ្ធ	មន្ត្រី	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	090 5 9999 4

21	លោក ស៊ីវ សុវណ្ណ	មន្ត្រី	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	081 40 2 444
22	លោក នី សុខរស្មី	មន្ត្រី	នាយកដ្ឋានសហគ្រាសធុនតូច និងមធ្យម	077 777 850
23	កញ្ញា លី ចាន់ថុល	មន្ត្រី	មជ្ឈមណ្ឌលផលិតភាពជាតិ	012 72 4007
24	លោក ជួន មុនី	មន្ត្រី	នាយកដ្ឋានកិច្ចការសិប្បកម្ម	
25	កញ្ញា សុវណ្ណ សូនីតា	មន្ត្រី	នាយកដ្ឋានកិច្ចការសិប្បកម្ម	093 399 359
26	លោក ខាន់ ប៊ុនណ្ណារិទ្ធ	មន្ត្រី	នាយកដ្ឋានរដ្ឋបាល	
27	លោក ហាក់ ម៉ៅ	ទីប្រឹក្សា	គម្រោងការប្រែប្រួលអាកាសធាតុសិស័យឧស្សាហកម្ម និងសិប្បកម្ម	078 996 479
28	លោក លៀង សុផល	ប្រធានការិយាល័យ	ក្រសួងបរិស្ថាន	096 46 25 300
29	លោក ឆេង ភីរុណ	អ្នកសម្របសម្រួលគម្រោង	គម្រោងការប្រែប្រួលអាកាសធាតុសិស័យឧស្សាហកម្ម និងសិប្បកម្ម	012 704 231
30	កញ្ញា ស ដានី	មន្ត្រីរដ្ឋបាល និងហិរញ្ញវត្ថុ	គម្រោងការប្រែប្រួលអាកាសធាតុសិស័យឧស្សាហកម្ម និងសិប្បកម្ម	012 288 164

Annex 4: Agenda and list of participants for the second training

Ministry of Industry and Handicraft

GREEN HOUSE GAS INVENTORY TRAINING WORKSHOP
Venue: Hotel, Siem Reap; August 10, 2018

Time	Description	Responsible
08:00 - 08:30	Registration	Admin officer
08:30 - 08:35	National Anthem	All Participants
08:35 - 08:50	Welcome Remark by Project Manager	**Mr. VEN Keahak,** Deputy Director General of Industry, the MIH
08:50 - 09:05	Opening speech by Representative of Senior Minister, Minister of Industry and Handicraft	**H.E. Dr. TUNG Ciny,** Under Secretary State of the MIH
09:05 - 09:15	**Photo Session**	All Participants
09:15 - 09:45	**Coffee and Tea break**	
09-45:12:00	Introduction of GHG emissions and reduction from the energy sector of the industrial sector (Q & A)	**National Consultant**
12:00 - 13:30	**Lunch Break**	All Participants
13:30 - 15:00	Review of GHG emissions and estimation in the IPPU sector (Q&A)	**National Consultant**
15:00 - 15:15	**Coffee and Tea break**	
15:15 - 16:45	Exercise on GHG emissions estimation: Excel spreadsheet (computer)	All Participants
	Group discussion & Group presentation	
16:45 - 17:00	Closing Remarks by Representative of Senior Minister, Minister of Industry and Handicraft	**H.E. Dr. TUNG Ciny,** Under Secretary State of the MIH

Note:

- All times listed are estimated only!
- The Agenda is subjected to be changed without prior notice.

List of participants for the second training

ល.រ No	ឈ្មោះ Name	តំណែង Position	អង្គភាព Origanize	លេខទូរសព្ទ Phone Number
1	ឯកឧត្តម ទឹង ស៊ីនី	អនុរដ្ឋលេខាធិការ	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	012 429 406
2	លោក វ៉ែន គៀហាក់	អគ្គនាយករង	អគ្គនាយកដ្ឋានឧស្សាហកម្ម	012 595 860
3	លោក ឈុន ម៉ារឌី	មន្ត្រី	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	017 31 22 99
4	លោកស្រី ស៊ឺ សោភា	ប្រធានការិយាល័យ	មជ្ឈមណ្ឌលផលិតភាពជាតិ	097 5 2222 86
5	លោក តុប ធឿន	អនុប្រធានមន្ទីរ	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តសៀមរាប	012 92 18 40
6	លោក ហ៊ឹម ផានិត	អនុប្រធានមជ្ឈមណ្ឌល	មជ្ឈមណ្ឌលផលិតភាពជាតិ	077 36 9007
7	លោកស្រី ឃីម ណារី	ប្រធាន	ទឹកកកអនាម័យ ផប អាយ	012 755 494
8	លោក សារិ ផល្លា	ប្រធាននាយកដ្ឋាន	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	012 3000 87
9	លោក យឹម រិទ្ធី	មន្ត្រី	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	012 881 607
10	លោក ប៊ិន តារា	មន្ត្រី	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តសៀមរាប	096 6 333 559
11	លោក រឿយ សំបុល	មន្ត្រី	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តសៀមរាប	086 230 769
12	លោក នេត វីរៈ	មន្ត្រី	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	081 82 83 90
13	លោក ឌី ដារិន	អនុប្រធានការិយាល័យ	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	012 96 96 89
14	លោក ពៅ សំបៀន	អនុប្រធានការិយាល័យ	មជ្ឈមណ្ឌលមន្ទីរពិសោធន៍ឧស្សាហកម្មកម្ពុជា	012 877 564
15	លោក ហ៊ាន សីហា	អនុប្រធានការិយាល័យ	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	015 55 04 33
16	លោក ហាក់ ម៉ៅ	ទីប្រឹក្សា	គម្រោងការប្រែប្រួលអាកាសធាតុវិស័យឧស្សាហកម្ម និងសិប្បកម្ម	078 996 479
17	កញ្ញា ស ដានី	មន្ត្រីរដ្ឋបាល និងហិរញ្ញវត្ថុ	គម្រោងការប្រែប្រួលអាកាសធាតុវិស័យឧស្សាហកម្ម និងសិប្បកម្ម	012 288 164
18	លោក អុល ភារិទ្ធ	មន្ត្រី	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	090 5 9999 4
19	លោក ញឹក សុវណ្ណតារា	មន្ត្រី	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តបាត់ដំបង	086 76 96 66
20	កញ្ញា ឃឿម សុផានី	មន្ត្រី	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តបាត់ដំបង	098 61 62 60

21	កញ្ញា ប៊ុន ទិត្យាវី	មន្ត្រី	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តបាត់ដំបង	069 47 41 39
22	លោក អ៊ួង សុងអ៊ី	បុគ្គលក្រុមហ៊ុន	Honly Food & Beverage	086 888 226
31	លោក ហេង អៀង	ប្រធានមជ្ឈមណ្ឌល	មជ្ឈមណ្ឌលផលិតភាពជាតិ	012 867 906
24	លោក ហឿង គឹមសាយ	ប្រធានការិយាល័យ	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	077 977 727
25	លោក ស៊ូ វ៉ាន់នី	អគ្គនាយករង	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	078 41 52 15
26	លោក ឆេង ភីរុណ	អ្នកសម្របសម្រួលគម្រោង	គម្រោងការប្រែប្រួលអាកាសធាតុវិស័យឧស្សាហកម្ម និងសិប្បកម្ម	012 704 231
27	លោក ខាន់ ប៊ុនណ្ណារិទ្ធ	មន្ត្រី	នាយកដ្ឋានរដ្ឋបាល	099 428 797
28	លោក យិន រឹង	តំណែង	សិប្បកម្មផលិតទុយោ(ខេត្តបាត់ដំបង)	087 98 59 85
29	លោក ស្រ៊ុន លឺ	អនុប្រធានការិយាល័យ	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	095 96 51 72
30	លោក កែ សុធា	មន្ត្រី	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	093 88 07 88
31	លោក ផន យិនយ៉ា	អនុប្រធាននាយកដ្ឋាន	ន.ដ្ឋានផែនការ ស្ថិតិ សហប្រតិបត្តិការ និងការងារអាស៊ាន	010 558 998

Annex 5: Agenda and list of participants for the third training

Ministry of Industry and Handicraft

GREEN HOUSE GAS INVENTORY TRAINING WORKSHOP
Venue: Hotel, Siem Reap, September 05, 2018

Time	Description	Responsible
08:00 - 08:30	Registration	Admin officer
08:30 - 08:35	National Anthem	All Participants
08:35 - 08:50	Welcome Remark by Project Manager	**Mr. VEN Keahak,** Deputy Director General of Industry, the MIH
08:50 - 09:05	Opening speech by Representative of Senior Minister, Minister of Industry and Handicraft	**H.E. Dr. TUNG Ciny,** Under Secretary State of the MIH
09:05 - 09:15	**Photo Session**	All Participants
09:15 - 09:45	**Coffee and Tea break**	
09-45:12:00	Introduction of GHG emissions and reduction from the energy sector of the industrial sector (Q & A)	**National Consultant**
12:00 - 13:30	**Lunch Break**	All Participants
13:30 - 15:00	Review of GHG emissions and estimation in the IPPU sector (Q&A)	**National Consultant**
15:00 - 15:15	**Coffee and Tea break**	
15:15 - 16:45	Exercise on GHG emissions estimation: Excel spreadsheet (computer)	All Participants
	Group discussion & Group presentation	
16:45 - 17:00	Closing Remarks by Representative of Senior Minister, Minister of Industry and Handicraft	**H.E. Dr. TUNG Ciny,** Under Secretary State of the MIH

Note:

- All times listed are estimated only!
- The Agenda is subjected to be changed without prior notice.

List of participants for the third training

ល.រ No	ឈ្មោះ Name	តំណែង Position	អង្គភាព Origanize	លេខទូរសព្ទ Phone Number
1	ឯកឧត្តម ទឹង ស៊ីនី	អនុរដ្ឋលេខាធិការ	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	012 429 406
2	លោក ហឿង គឹមសាយ	ប្រធានការិយាល័យ	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	077 977 727
3	លោក លៀង សុផល	ប្រធានការិយាល័យ	ក្រសួងបរិស្ថាន	096 46 25 300
4	លោក អ៊ុ ប៊ុនលាន	មន្ត្រី	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	092 204 555
5	លោក ស៊ិន ទិត្យផល្គុន	មន្ត្រី	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	012 707 198
6	កញ្ញា ស ដានី	មន្ត្រីរដ្ឋបាល និងហិរញ្ញវត្ថុ	គម្រោងការប្រែប្រួលអាកាសធាតុវិស័យឧស្សាហកម្ម និងសិប្បកម្ម	012 288 164
7	កញ្ញា សុង លក្ខិណា	មន្ត្រីគម្រោង	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	070 225 365
8	លោក ហ៊ឹម ផានិត	អនុប្រធានមជ្ឈមណ្ឌល	មជ្ឈមណ្ឌលផលិតភាពជាតិ	077 36 9007
9	លោក កើង សុខខេង	ប្រធានការិយាល័យ	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តបាត់ដំបង	012 46 92 31
10	លោក ញឹក សុវណ្ណតារា	មន្ត្រី	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តបាត់ដំបង	086 76 96 66
11	លោក រឿយ សំបុល	មន្ត្រី	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តសៀមរាប	086 230 769
12	លោក ប៊ិន តារា	មន្ត្រី	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តសៀមរាប	096 6 333 559
13	កញ្ញា សាង សុគន្ធី	ប្រធានការិយាល័យ	នាយកដ្ឋានសហគ្រាសធុនតូច និងមធ្យម	012 37 24 76
14	លោក យឹម រិទ្ធី	មន្ត្រី	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	012 881 607
15	លោក តូន ឈួន សេរីទ្ធ	ប្រធានមន្ទីរ	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តបាត់ដំបង	012 83 50 63
16	លោក តុប ធឿន	អនុប្រធានមន្ទីរ	មន្ទីរក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តសៀមរាប	012 92 18 40
17	លោកស្រី ហូដានី	អនុប្រធានមន្ទីរ	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តបាត់ដំបង	012 58 95 45
18	លោកស្រី ផាន សុគី	អនុប្រធានការិ-ទឹកស្អាត	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្មខេត្តបាត់ដំបង	012 93 82 63
19	លោក អុល ការិទ្ធ	មន្ត្រី	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	090 5 9999 4
20	លោក នេត វីរៈ	មន្ត្រី	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	081 82 83 90

21	លោក ស៊ូ វ៉ាន់នី	អគ្គនាយករង	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	078 41 52 15
22	លោកស្រី ស៊ឺ សោភា	ប្រធានការិយាល័យ	មជ្ឈមណ្ឌលផលិតភាពជាតិ	097 5 2222 86
23	លោក ឌី ដារិន	អនុប្រធានការិយាល័យ	នាយកដ្ឋានបច្ចេកទេស វិទ្យាសាស្ត្រ និងបច្ចេកវិទ្យា	012 96 96 89
24	លោក ពៅ សំបៀន	អនុប្រធានការិយាល័យ	មជ្ឈមណ្ឌលមន្ទីរពិសោធន៍ឧស្សាហកម្មកម្ពុជា	012 877 564
25	លោក ហ៊ាន សីហា	អនុប្រធានការិយាល័យ	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	015 55 04 33
26	លោក កែ សុធា	មន្ត្រី	ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម	093 88 07 88
27	លោក ហាក់ ម៉ៅ	ទីប្រឹក្សា	គម្រោងការពារប្រជ្រួលអាកាសធាតុវិស័យឧស្សាហកម្ម និងសិប្បកម្ម	078 996 479
28	កញ្ញា ឌីន ភារុណ	មន្ត្រី	ក្រសួងបរិស្ថាន	070 83 89 12
29	លោក ផន យិនយ៉ា	អនុប្រធាននាយកដ្ឋាន	ន.ដ្ឋានផែនការ ស្ថិតិ សហប្រតិបត្តិការ និងការងារអាស៊ាន	010 558 998
30	លោក វ៉ែន គៀហាក់	អគ្គនាយករង	អគ្គនាយកដ្ឋានឧស្សាហកម្ម	012 595 860
31	លោក ឆេង ភីរុណ	អ្នកសម្របសម្រួលគម្រោង	គម្រោងការពារប្រជ្រួលអាកាសធាតុវិស័យឧស្សាហកម្ម និងសិប្បកម្ម	012 704 231
32	លោក ហេង អៀង	ប្រធានមជ្ឈមណ្ឌល	មជ្ឈមណ្ឌលផលិតភាពជាតិ	012 867 906
33	លោក សារិ ផល្លា	ប្រធាននាយកដ្ឋាន	នាយកដ្ឋានកិច្ចការឧស្សាហកម្ម	012 3000 87
34	លោក ខាន់ ប៊ុនណ្ណារិទ្ធ	មន្ត្រី	នាយកដ្ឋានរដ្ឋបាល	099 428 797

Annex 6: Global warming potential

Industrial designation or common name	Chemical formule	GWP values for 100-year time horizon		
		Second Assessment Report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
Carbon dioxide	CO2	1	1	1
Methane	CH4	21	25	28
Nitrous oxide	N2O	310	298	265
Substances controlled by the Montreal Protocol				
CFC-11	CCl3F	3,800	4,750	4,660
CFC-12	CCl2F2	8,100	10,900	10,200
CFC-13	CCl2F2		14,400	13,900
CFC-113	CCl2FCClF2	4,800	6,130	5,820
CFC-114	CClF2CClF2		10,000	8,590
CFC-115	CClF2CF3		7,370	7,670
Halon-1301	CBrF3	5,400	7,140	6,290
Halon-1211	CBrClF2		1,890	1,750
Halon-2402	CBrF2CBrF2		1,640	1,470
Carbon tetrachloride	CCl4	1,400	1,400	1,730
Methyl bromide	CH3Br		5	2
Methyl chloroform	CH3CCl3	100	146	2
HCFC-21	CHCl2F			148
HCFC-22	CHCLF2	1,500	1,810	1,760
HCFC-123	CHCl2CF3	90	77	79
HCFC-124	CHClFCF3	470	609	527
HCFC-141b	CH3CCl2F	600	725	782
HCFC-142b	CH3CClF2	1,800	2,310	1,980
HCFC-225ca	CHCl2CF2CF3		122	127
HCFC-225cb	CHClFCF2CClF2		595	525
Hydrofluorocarbons (HFCs)				
HFC-23	CHF3	11,700	14,800	12,400
HFC-32	CH2F2	650	675	677
HFC-41	CH3F2	150		116
HFC-125	CHF2CF3	2,800	3,500	3,170
HFC-134	CHF2CHF2	1000		1,120
HFC-134a	CH2FCF3	1,300	1,430	1,300
HFC-143	CH2FCHF2	300		328
HFC-143a	CH3CF3	3,800	4,470	4,800
HFC-152	CH2FCH2F			16
HFC-152a	CH3CHF2	140	124	138
HFC-161	CH3CH2F			4
HFC-227ea	CF3CHFCF3	2,900	3,220	3,350
HFC-236cb	CH2FCF2CF3			1,210
HFC-236ea	CHF2CHFCF3			1,330
HFC-236fa	CF3CH2CF3	6,300	9,810	8,060
HFC-245ca	CH2FCF2CHF2	560		716
HFC-245fa	CHF2CH2CF3		1,030	858
HFC-365mfc	CH3CF2CH2CF3		794	804
HFC-43-10mee	CF3CHFCHFCF2CF3	1,300	1,640	1,650

Perfluorinated compounds Sulfur hexafluoride	SF6	23,900	22,800	23,500
Nitrogen trifluoride	NF3		17,200	16,100
PFC-14	CF4	6,500	7,390	6,630
PFC-116	C2F6	9,200	12,200	11,100
PFC-218	C3F8	7,000	8,830	8,900
PFC-318	c-C4F8	8,700	10,300	9,540
PFC-31-10	C4F10	7,000	8,860	9,200
PFC-41-12	C5F12	7,500	9,160	8,550
PFC-51-14	C6F14	7,400	9,300	7,910
PCF-91-18	C10F18		>7,500	7,190
Trifluoromethyl sulfur pentafluoride	SF5CF3		17,700	17,400
Perfluorocyclopropane	c-C3F6			9,200
Fluorinated ethers				
HFE-125	CHF2OCF3		14,900	12,400
HFE-134	CHF2OCHF2		6,320	5,560
HFE-143a	CH3OCF3		756	523
HCFE-235da2	CHF2OCHClCF3		350	491
HFE-245cb2	CH3OCF2CF3		708	654
HFE-245fa2	CHF2OCH2CF3		659	812
HFE-347mcc3	CH3OCF2CF2CF3		575	530
HFE-347pcf2	CHF2CF2OCH2CF3		580	889
HFE-356pcc3	CH3OCF2CF2CHF2		110	413
HFE-449sl (HFE-7100)	C4F9OCH3		297	421
HFE-569sf2 (HFE-7200)	C4F9OC2H5		59	57
HFE-43-10pccc124 (H-Galden 1040x)	CHF2OCF2OC2F4OCHF2		1,870	2,820
HFE-236ca12 (HG-10)	CHF2OCF2OCHF2		2,800	5,350
HFE-338pcc13 (HG-01)	CHF2OCF2CF2OCHF2		1,500	2,910
HFE-227ea	CF3CHFOCF3			6,450
HFE-236ea2	CHF2OCHFCF3			1,790
HFE-236fa	CF3CH2OCF3			979
HFE-245fa1	CHF2CH2OCF3			828
HFE 263fb2	CF3CH2OCH3			1
HFE-329mcc2	CHF2CF2OCF2CF3			3,070
HFE-338mcf2	CF3CH2OCF2CF3			929
HFE-347mcf2	CHF2CH2OCF2CF3			854
HFE-356mec3	CH3OCF2CHFCF3			387
HFE-356pcf2	CHF2CH2OCF2CHF2			719
HFE-356pcf3	CHF2OCH2CF2CHF2			446
HFE 365mcf3	CF3CF2CH2OCH3			<1
HFE-374pc2	CHF2CF2OCH2CH3			627
Perfluoropolyethers				
PFPMIE	CF3OCF(CF3)CF2OCF2OCF3		10,300	9,710
Hydrocarbons and other compounds - direct effects				
Chloroform	CHCl3	4		16
Methylene chloride	CH2Cl2	9		9
Methyl chloride	CH3Cl		8.7	12
Halon-1201	CHBrF2		13	376