SIPA | SUPPORT TO VIET NAM FOR THE IMPLEMENTATION OF THE PARIS AGREEMENT

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On behalf of:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

Vietnam NDC Sectoral Report

Industrial Processes and Product Use

Published by the
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

As of
June 2020

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On behalf of the
German Federal Ministry for Environment, Nature Conservation, and Nuclear Safety (BMU).

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Acronyms and abbreviations Report

ACFTA	ASEAN-China Free Trade Area
AR4	The Fourth Assessment Report of the IPCC
BAT	Best Available Technique
BATP	Best Available Techniques Practice
BAU	Business-As-Usual
BF TGR	Blast Furnace Top Gas Recycling
BFG	Blast Furnace Gas
BMU	German Ministry for the Environment, Nature Conservation, and Nuclear Safety
BOF	Basic Oxygen Furnace gas
CCF	Carbon Content Factor
CMA	Conference of the Parties to the Paris Agreement
COG	Coke Oven Gas
COP	Conference of the Parties
CSI	Cement Sustainability Initiative
DAP	Diammonium Phosphate
EAF	Electric Arc Furnace
EDC	Ethylene Dichloride
EF	Emissions Factor
FTA	Free Trade Agreement
GBFS	Granulated Blast Furnace Slag
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GL 2006	The 2006 Guidelines on National GHG Inventory of the IPCC
GWP	Global Warming Potential
HFC	Hydrofluorocarbons
HPG	Hoa Phat Group
HRC	Hot-rolled Coil
HSG	Hoa Sen Group
INDC	Intended Nationally Determined Contributions

IPCC	Inter-governmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IZ	Industrial Zone
LULUCF	Land Use, Land Use Change and Forestry
MICCO	Vinacomin-Mining Chemical Industry Holding Corporation Ltd.
MOC	Ministry of Construction
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MRV	Measurement, Reporting and Verification
NACAG	The Nitric Acid Climate Action Group
NAMA	Nationally Appropriate Mitigation Actions
NDC	Nationally Determined Contribution
NDF	Nordic Development Fund
NKG	Nam Kim Group
ODS	Ozone Depleting Substances
OHF	Open Hearth Furnace technology
PCB	Portland Cement Blended
PCF	Perfluorocarbons
PMR	Partnership for Market Readiness
TGR	Top Gas Recycling
UNDP	United Nations Development Programme
UNFCCC	United Nations Convention Framework on Climate Change
USA	The United States of America
VCM	Vinyl Chloride Monomer
VCUFTA	Vietnam – Eurasia Economic Union Free Trade Agreement
VKFTA	Vietnam-Korea Free Trade Agreement

Executive Summary

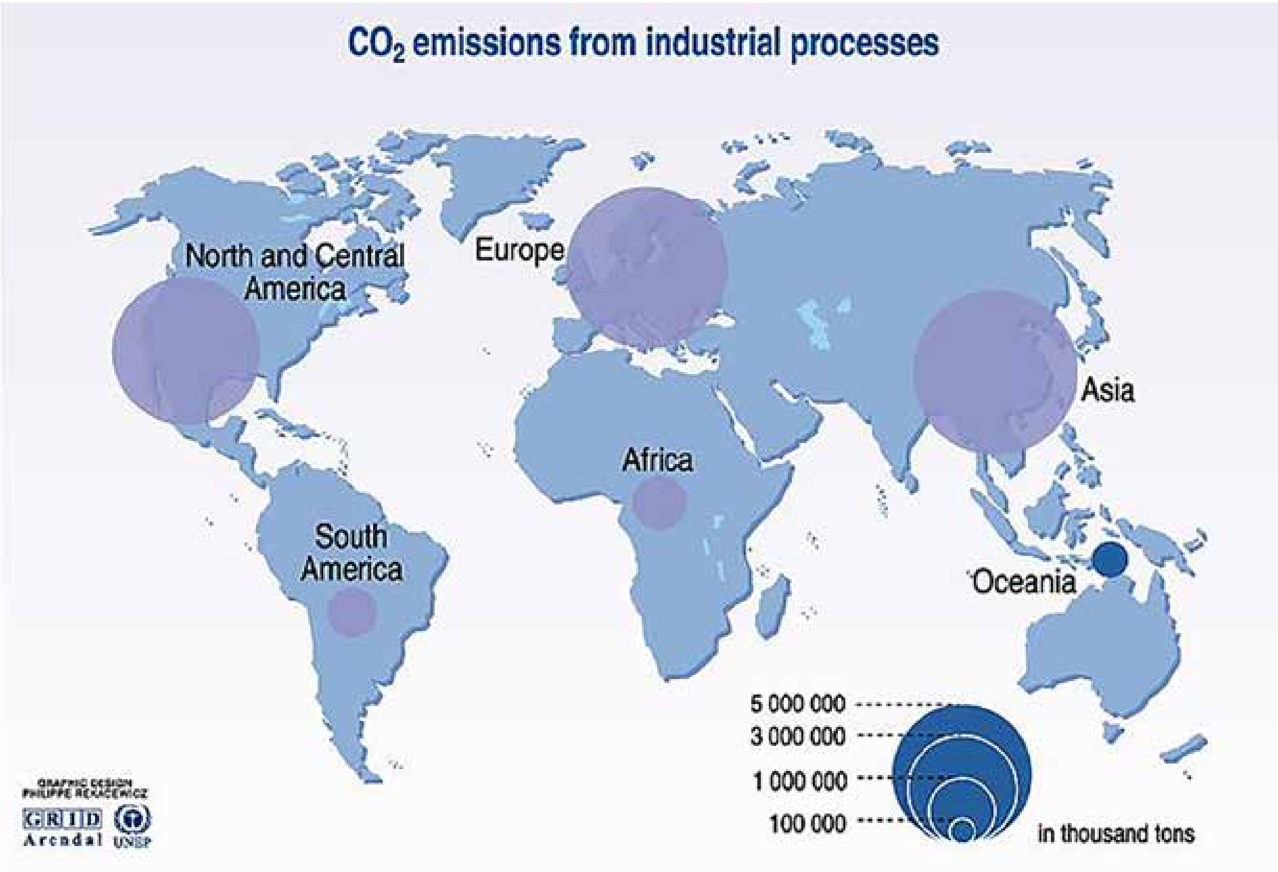
The following paper is part of a five-report series, produced in the context of the 2017-2020 revision and update of Vietnam's Nationally Determined Contribution (NDC).

Each of these works addresses a different sector, covering agriculture, energy, industrial processes and product use (IPPU), land use, land-use change and forestry (LULUCF), and waste. They all provide extensive trend analyses of a sector's projected greenhouse gas (GHG) emissions for the period of 2014-2030, which take current policy measures into consideration and assume no major changes moving ahead (*business-as-usual scenario*, BAU). On the basis of selected mitigation options, each paper outlines feasible *mitigation scenarios* that would see signification GHG emission reductions for the respective sector until 2030, as well as associated marginal abatement costs.

These five reports have informed the Government of Vietnam's updated and revised NDC, which is available at UNFCCC, https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Viet%20Nam%20First/Viet%20Nam_NDC_2020_Eng.pdf. A technical background report, published by the Ministry of Natural Resources and Environment (MONRE), comprises more information.

In this study for IPPU, the 2006 Guidelines on the National GHG Inventory of the IPCC (GL 2006) were both applied to develop the BAU scenario and mitigation scenario for the IPPU sector in the period 2020-2030. The values of Global Warming Potential (GWP) of GHG for 100 years in the IPPC AR4 Report were used in the development of the BAU and mitigation scenario for the IPPU sector. According to the BAU scenario, GHG emissions from the IPPU sector will reach 80.53 $MtCO_2e$ (2020), 116.15 $MtCO_2e$ (2025), and 140.28 $MtCO_2e$ (2030).

Mitigation options are selected based on the following criteria: availability of technology, mitigation potential, and economic efficiency and co-benefits. Mitigation in the IPPU sector was proposed for two sub-sectors: cement production and nitric acid production. Regarding cement production, four mitigation options were proposed, including: 1. GBFS grinding to replace clinker in cement component; 2. Fly ash grinding to replace clinker in cement component; 3. Pozzolana grinding to replace clinker in cement component; and 4. Limestone grinding to replace clinker in cement component. In nitric acid production, the application of BAT



Source: United Nations framework convention on climate change (UNFCCC).

technology was proposed to reduce N_2O emissions.

As a result, with international and voluntary mitigation measures, the amount of CO_2 emissions has been significantly reduced compared to the BAU scenario. For the voluntary mitigation scenario, in 2030 CO_2 emissions in the mitigation scenario totals 133.07 million tons, which is 7.21 million tons CO_2e lower than the BAU scenario, equivalent to a reduction of 5.14%. Regarding the mitigation scenario with international support, in 2030 CO_2 emissions will total 131.07 million tons, which is 8.32 million tons CO_2e lower than the BAU scenario, equivalent to a reduction of 5.92%.

The study also analysed barriers and needs in terms of policy, technology, finance and capacity building in the implementation of mitigation options in the IPPU sector. Regarding financial barriers, the total amount of domestic funding needed is USD 713.85 million to achieve the GHG reduction of 5.14% of the total BAU GHG emissions by 2030. An additional USD 198.84-201.1million would need to be mobilized from international sources in order to achieve the total GHG emissions reduction of 5.92% of total BAU scenario GHG emissions by 2030. The total financial need for voluntary options and international support ranges from USD 912.7 to 914.9 million.

01. Introduction

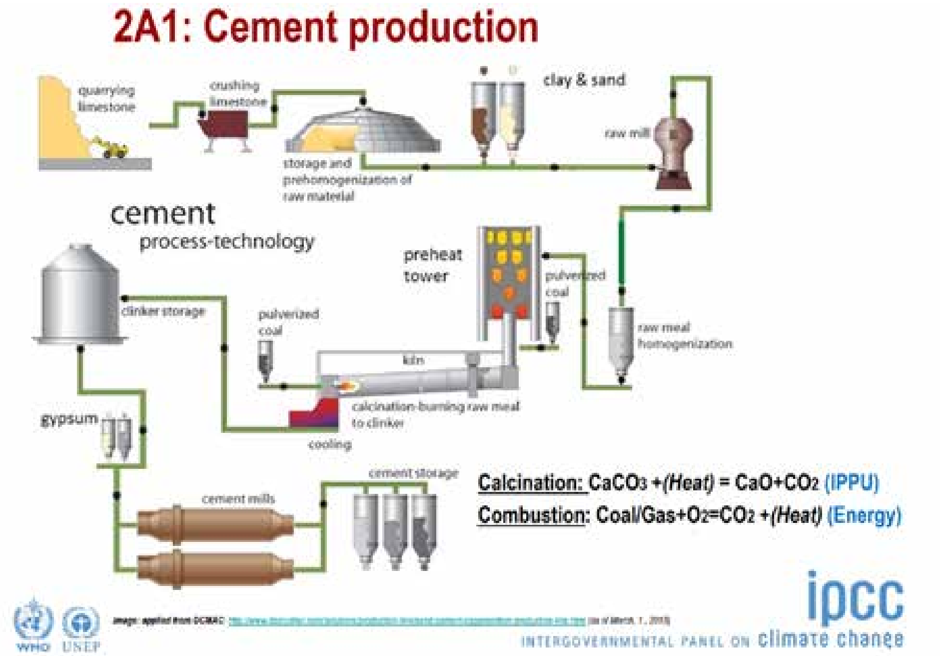


Photo Caption @ GIZ 2020

1.1. Background Information on the Paris Agreement and NDCs

The Paris Agreement on Climate Change was adopted by the states in COP 21 as the first global legal document regulating responses to climate change. The focus of the Paris Agreement is on the introduction of regulations concerning the responsibility for developing and implementing a Nationally Determined Contribution (NDC) of each of the Parties to the United Nations Convention Framework on Climate Change (UNFCCC). So far, the Agreement has been signed by 195 countries, ratified by 179 parties, and officially entered into force on 4 November 2016.

Although countries had submitted NDCs by the end of 2015, even if all NDCs are fully implemented the global average temperature may still increase by 2.9°C to 3.4°. Achieving a target of 1.5°C will require zero global GHG emissions between 2060-2080 and around 2080-2090 for the 2°C target. Therefore, Decision No. 1/CP21 of the Paris Agreement on Climate Change requires all parties to review and update their NDCs at least every five years with the expectation of increasing their ambition to contribute to mitigating GHG emissions. All

States are required to submit their NDC (new or updated) by 2020 and every five years thereafter at least 9-12 months prior to the Conference of the Parties to the Paris Agreement (CMA). Consequently, countries are required to continually review their NDCs in order to identify options to raise ambition and mitigate the current contribution. The UNFCCC requires the parties to submit a revised NDC for the first time by 2020. The NDC revisions should consider a medium-term plan as well as a long-term plan to reduce GHG emissions. In addition, Article 13 of the Paris Agreement on Climate Change requires States to develop a transparent framework that requires parties to regularly submit GHG inventory reports and provide information on the NDC implementation process, support, and adaptation efforts. Technical assessments will be made for all parties to analyse the consistency of the information, identify areas in need of improvement, and strengthen capacity. The parties will also participate in facilitative, multilateral considerations of progress with respect to the respective implementation and achievement of their NDC's goals.

Recently, Vietnam planned to review and update its NDC with a view to submitting an updated NDC to UNFCCC in 2019. Thereby, Vietnam is fulfilling a requirement of the Paris Agreement – outlined in decision 1/CP21). Reviewing and updating its NDC is also an official requirement of the Vietnam Government. In 2016, the Prime Minister approved the Plan for the implementation of the Paris Agreement on Climate Change. In that plan, task No. 1 requires updating of the NDC's mitigation component and task No. 17 requires updating the NDC's adaptation component.

1.2. Overview of the Industrial Processes and Product Use Sector in Vietnam

1.2.1. Mineral industry

a) Cement production

Currently, Vietnam's cement industry is the fifth biggest producer of cement in the world. The country currently has 74 cement production factories with a total design capacity of more than 77.36 million tons. Cement exports have so far been seen as a temporary solution for Vietnam's cement industry.

The development of Vietnam's cement industry can be divided into the following stages:

» From 2000 to 2004

In 2000, Vietnam produced and consumed 13.29 million tons of domestic cement, ranking outside the world's top 20 cement-producing countries. In 2004, Vietnam produced and consumed 25.32 million tons domestically, ranking 17th in the world. In the period from 2000 to 2004, Vietnam production and consumption of cement grew at about 9-10% annually, importing about 4-4.5 million tons of clinker.

» The period from 2005-2009

In 2005, Vietnam produced and consumed 28.8 million tons of cement domestically. In 2009, Vietnam produced and consumed 45.5 million tons of domestic cement. Vietnam was ranked 8th in the world. In the period of 2005-2009, Vietnam's cement production and consumption grew at about 12-16% annually, importing about 3.5-4.5 million tons of clinker.

» The period from 2010 to the present

In 2010, Vietnam produced and consumed 50.2 million tons of cement domestically. For the first time, Vietnam produced enough cement to meet domestic demand and began exporting. The country imported 1 million tons of clinker (in the southern region) and exported 1.2 million tons (in the northern region). At the beginning of 2011, due to the impact of the economic recession, the growth of construction lost momentum and slowed down. Domestic cement consumption from 2011-2013 decreased compared to 2010.

In 2012, Vietnam had 67 rotary kiln cement lines in production with a total designed capacity of 68 million tons/year, producing and consuming 53.61 million tons. Production reached 80% of capacity.

In 2014, the situation was better, with total cement consumption reaching 71 million tons, an increase of 15%; and domestic consumption reaching 50.6 million tons, an increase of 10% compared to 2013. Vietnam stood fifth among cement-producing countries in the world (after China, India, Iran, and the USA). Currently, the country has 74 factories in operation with a total designed capacity of 77.36 million tons.

Table 1: Cement production and consumption in the period 2015-2014 and expected in 2015

Unit: Million tons

	Clinker production output	Cement production output	Consumption (cement + clinker)				
			Domestic	Export		Import	Total
				Cement	Clinker		
2005		24.1				4.5	28.8
2006		28.1				3.62	32.4
2007		32.4				3.79	36.8
2008		39.2				3.7	39.6
2009		45.5				3.56	45.1
2010	40.08	50.6	49.6	0.6	0.6	1	50.2
2011	41.83	49.6	44.95	2.2	3.3	1.15	49.3
2012	49.55	53.81	45.5	1.6	6.5	0.8	53.61
2013	57.19	50.54	46.05	4.04	11.06	-	61.15
2014	60	55.34	50.6	4.74	15.66	-	71
2015	63	62	54		20	-	74

b) Lime production

The lime industry in Vietnam is still very primitive; it is mostly produced by manual firing technology. The production facilities are professional and modest. The country only has 6 to 7 facilities, with a design capacity of about 150 tons to 200 tons/day for each furnace. The rest are mostly manual kilns with a capacity of 5 to 7 tons/ batch or from 15 to 20 tons/day. The consumption of lime in Vietnam is also very modest and the industry is mainly based on exports.

According to survey data from Departments of Construction, Statistical Yearbooks of provinces in 2010-2012, and local construction material development plans, lime output in Vietnam is summarized in Table 2.

Table 2: Lime consumption in Vietnam in the period 2010-2012

	2010	2011	2012
Domestic consumption	1,628,606	1,689,193	1,150,000
Exports	300,000	450,000	2,000,000
Total lime consumption	1,928,606	2,139,193	3,150,000

Among lime exports, countries with high import demand include South Korea, Taiwan, India, Thailand, and Myanmar. The production and consumption of lime in Vietnam is mainly concentrated in the Red River Delta and North Central and Central Coastal regions.

c) Glass production

Vietnam is a country with great potential in developing glass manufacturing and processing industries. Vietnam has an abundant source of raw materials, such as quartz white sand on most beaches, with abundant sources of limestone, dolomite, and pegmatite.

Compared to other countries, Vietnam has experienced late investment in glass production technology, but has quickly gained access to the world's advanced technology in producing flat glass, such as advanced float glass technology. Currently, the technology for processing tempered laminated glass, laminated safety glass, tinted glass, and mirror glass is advanced. This is also the case for production operation capacity, and the technological mastery of staff and workers in glass production, which is also increasingly advanced (Nguyen Quang Cung, 2009).

The construction glass manufacturing industry has grown at a fast pace. In 2000, the whole country had only 2 glass factories with a total capacity of 32.8 million m²/year, which was unable to meet domestic demand. After just 5 years, by 2005, Vietnam had 7 glass factories with a total capacity of 84.4 million m²/year. By 2008, with the advent of VGI, Vietnam's glass production capacity was 112.4 million m²/year, leading to an oversupply. After Chu Lai (Quang Nam) and Trang An (Ninh Binh) float glass lines were put into production according to scheduled progress in 2010, Vietnam's glass production capacity reached 181.4 million m²/ year.

Table 3: Capacity and production of construction glass in Vietnam

Unit: million m²/year

	2000	2003	2005	2006	2007	2008	2009	2010
Production capacity of construction glass	32.8	62.8	84.4	84.4		112.4	131..4	181.4
Production of construction glass	30.71	38.35	74.76	81.31	77.5	71		

1.2.2. Chemical industry

Regarding the chemical industry, Vietnam has built on a large scale since 1954. With more than a decade of rapid development, the Vietnamese industry has become technologically and economically independent.

From 1980 to 1985, Vietnam's chemical industry was one of the industries that clearly demonstrated the primacy of the state-owned industry. State-owned enterprises were guaranteed 70% of the total industrial output. In 1985, it accounted for a significant proportion of the entire Vietnamese industry.

Starting from the renovation period in 1986, Vietnam's chemical industry has developed stably. The highest growth rate from 1991-1995 reached 20%/year. In the last years of the twentieth century, Vietnam's chemical industry grew in all economic sub-sectors.

The main products of the chemical industry in Vietnam are fertilizers, plant protection chemicals, detergents, basic chemicals, rubber products, plastics, electrochemistry, paints, and plastics.

Assessment of the characteristics of the chemical industry shows that technology is generally still outdated, and labour productivity is low. Some basic industries such as petrochemicals, and organic chemistry have not yet been formed or have just emerged. The chemical industry is still unable to meet the needs of other economic sectors. Many essential products of the chemical industry, such as soda, plastics, synthetic fibres or dyes are produced in Vietnam. Manufacturing industries that use these materials depend primarily on imports.

Vietnam's chemical industry accounts for 11.2%. of the country's industrial structure. However, this industry is still small compared with other developing countries in Southeast Asia.

Chemicals are essentially a key sector in a country's economy, but its role in Vietnam is limited. According to the Vietnam Chemical Industry Report in 2016, the chemical industry does not produce basic organic chemicals, such as chloroform, methanol, or ethanol.

1.2.3. Metal industry

a) Iron and steel

According to Nguyen Xuan Hung and Nguyen Nhat Hoang (2017), Vietnam's steel industry is in the development stage, with an average growth rate in steel output in the period 2012-2016 reaching 17.5%/year. Steel consumption per person is only about 180-190 kg, still lower than the world average, estimated at 217kg/person and the average in Asia, estimated at 267kg/person. In 2016, total domestic steel production reached 17.2 million tons and steel consumption 20.5 million tons.

The steel industry in 2016 accounted for about 5% of Vietnam's GDP. The total revenue of listed steel enterprises was about USD 4.7 billion in 2016. The steel industry is also the reason Vietnam's trade balance weakened. Specifically, in 2016, the country had a trade surplus of USD 2.68 billion but the import turnover of iron and steel was more than USD 8 billion.

The domestic steel industry value chain is closed in the long steel segment, but the flat steel segment has just started to process from hot-rolled coil (HRC) steel. Self-sufficiency for the steel industry's input materials is very low. The main materials such as iron ore, coke, and scrap steel must be imported. The manufacturing process in Vietnam accounts for a larger share than EAF technology, which is estimated at 60%, with the rest using BOF furnaces. Output by product structure in the Vietnam steel industry in 2016 included 48% of long construction steel, galvanized steel products accounted for 41%, with the remaining 11% steel pipes.

The situation of supply and demand in the steel industry in general is always one of shortage; supply does not meet the demand, which increased sharply in the period 2011-2015. Supply of steel in the coming period is expected to increase sharply with investment from leading enterprises in both long and flat steel segments. Typically, in flat steel HSG increases by 66.7% and NKG by 228% in capacity; while the supply of long steel will increase sharply thanks to HPG (+ 200%), Formosa Ha Tinh, and Ca Na project. In addition, the last period witnessed the recovery of the real estate market – the construction market, housing demand, and infrastructure upgrading are strong drivers of growth for the construction materials industry in general and the steel industry in particular.

The business environment for Vietnam's steel industry is subject to outside influences, but is supported by the State. The government expressed its clear priority for the development of the steel industry through a policy banning the export of iron ore, anti-dumping policies for both long and flat steel, and prioritising domestic enterprises. Contrary to positive State policies, most of the FTAs Vietnam has recently signed have negatively affected the domestic steel industry. The most serious are ACFTA, VKFTA and VCUFTA. However, thanks to the protection of the government, domestic enterprises still have several years to prepare before these FTAs come into force.

b) Aluminium

Currently, Vietnam has only one aluminium factory, Daknong Aluminium Electrolysis Plant in Nhan Co Industrial Park, Dak R'Lap District, which is an investment of Tran Hong Quan Metallurgical Co., Ltd. The project is expected to come into operation by the end of 2018 with a capacity of 450,000 tons/year. Thus, by 2020, aluminium production is expected to be 450,000 tons/year. There are no data for aluminium production to 2030 but it is forecast that without the support of electricity prices, the development of the aluminium industry will face many difficulties and production in 2030 will not change compared to 2020.

1.3. Objectives and Scope of the Study

In 2015, under the leadership of the Ministry of Natural Resources and Environment (MONRE) and with support from the German Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) through Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the United Nations Development Programme (UNDP), Vietnam successfully submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC Secretariat. Vietnam's INDC proposed mitigation targets and options for relevant sectors, including the energy, agriculture, Land Use, Land Use Change and Forestry (LULUCF) and waste sectors. It can be seen that the IPPU sector was not included in Vietnam's first NDC. Therefore, the goal of this study is to develop a BAU and mitigation scenario for the IPPU sector in the period 2020-2030, which will input into the review and update of Vietnam's INDC.

According to IPCC, all sub-sectors of the IPPU sector include: Mineral industry (2A); Chemical industry (2B); Metal industry (2C); Non-Energy Products from Fuels and Solvent Use (2D); Electronics industry (2E); Product Uses as Substitutes for Ozone Depleting Substances (2F); Other Product Manufacture and Use (2G) and Other (2H). However, Vietnam is a developing country with limited industrial production, and not all IPPU sub-sectors in the above list exist in Vietnam.

For the mineral industry, the sectors that mainly release GHGs are cement, lime, and glass, of which cement production is the largest emitter of GHGs.

For the chemical industry, GHGs are mainly emitted from producing ammonia and producing petrochemical products.

However, at present, Vietnam has no petrochemical projects. After 2020, there will be petrochemical projects (such as methanol, EDC and VCM production) going into operation.

For the metal industry, Vietnam currently only has an iron and steel industry. By the end of 2018, the first aluminium factory with a capacity of 450,000 tons will come into operation. Vietnam has no factories producing magnesium, lead, or zinc.

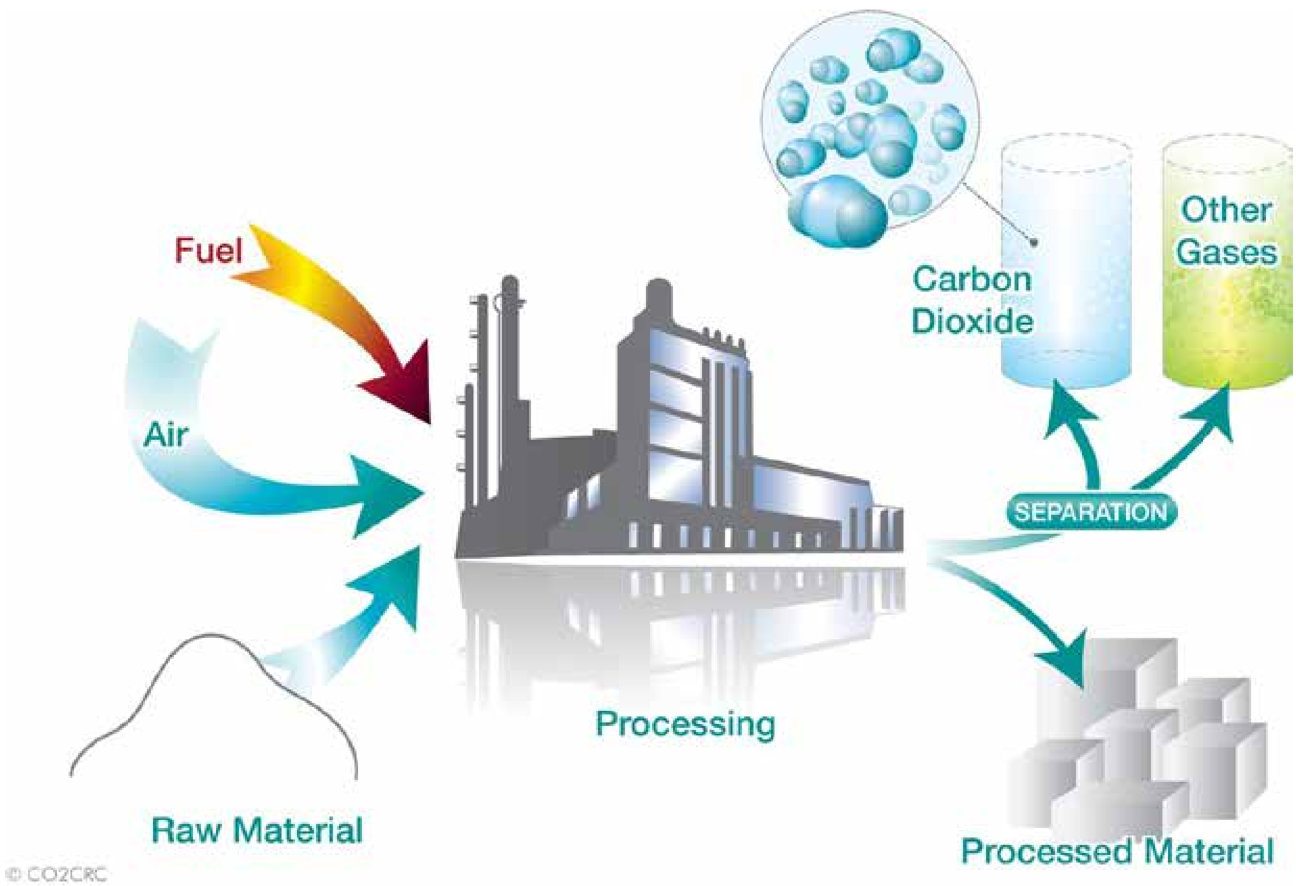
Non-energy products from fuels and solvents such as the electronics industry and other industries are not updated in this report due to a lack of sufficient data.

Therefore, ***the scope*** of IPPC sub-sectors covered in this report is as follows:

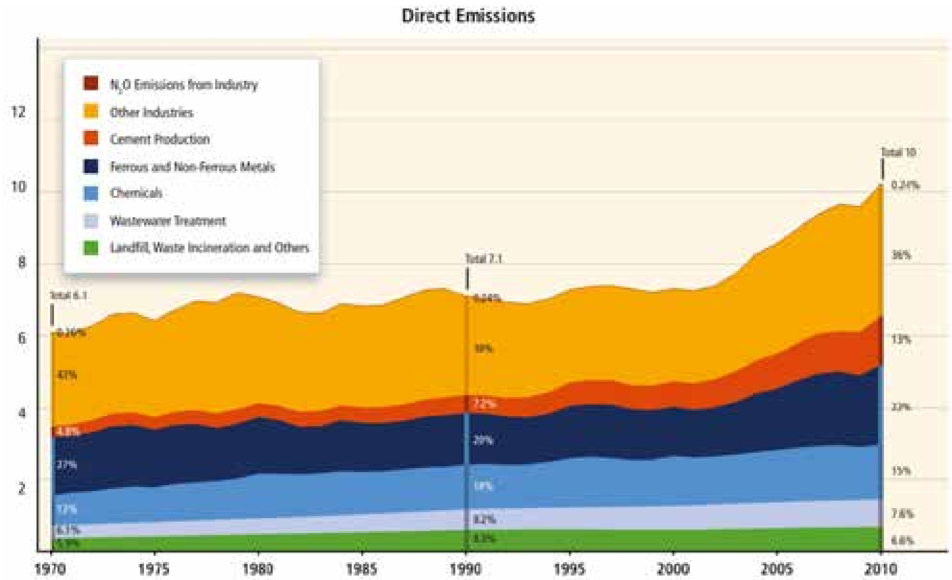
- 2A. Mineral industry, including: Cement production (2A1), Lime production (2A2), and Glass production (2A3).
- 2B. Chemical industry, including: Ammonia (2B1) and Petrochemicals (Methanol, EDC & VCM) (2B8).
- 2C. Metal industry, including Iron and steel (2C1) and Aluminium (2C3).

Base year: The year 2014 was chosen since this is the latest year for which national data was available for modelling.

Types of GHGs: This study includes Carbon dioxide (CO_2), Methane (CH_4) and Nitrous oxide (N_2O).



02. Mitigation efforts in the IPPU sector since INDC submission in 2015.



2.1. Policies

2.1.1. Cross-sectoral policies related to mitigation

Vietnam recognises that actively responding to climate change is one of the most important tasks of the whole political system. Since INDC submission in 2015, the Vietnamese Government has promulgated a number of policies to create a legal basis for research, development, and implementation of mitigation activities. These include the following:

» Decision No. 2053/QD-TTg dated October 28th, 2016 of the Prime Minister approving the Action Plan for Implementation of the Paris Agreement on climate change for the period 2016-2020 aims to: 1) review existing regulations and develop a Decree on the roadmap and modality for GHG emissions mitigation; (2) develop a carbon market within the country; piloting the system, policies, and market tools for mitigation of GHG emissions in potential sectors; and (3) develop and implement GHG mitigation and green growth proposals in accordance with national conditions for implementation of NDC.

» Decision No. 1670/QD-TTg dated October 31st, 2017 of the Prime Minister approving the Target Programme for climate change adaptation and green growth for the period 2016-2020. One of the main objectives of the programme is to reduce GHG emissions, contributing to the implementation of NDC after 2020.

» Resolution No.120/NQ-CP dated November 17th, 2017 of the Government of Vietnam on sustainable development in the Mekong River Delta region with a vision to 2050. The Mekong Delta region will be on a more advanced development level compared to the country as a whole, with an advanced social structure; with per capita income higher than the national average, and with people's livelihoods secured; the proportion of ecological agriculture and high-technology agriculture to be 80% and the proportion of forest coverage to be increased to over 9% (compared to 4.3% now), along with efforts to preserve and develop important natural ecosystems.

» Decision No. 1085/QD-BKHDT dated July 16th, 2018 of the Minister of Planning and Investment promulgating the guidelines on classification of public investment for climate change and green growth.

2.1.2. Policies related to mitigation in the industrial sector

At present, the industry and trade sector has no specific targets for reducing GHG emissions in the industrial processes sector. In order to implement the National Action Plan on Green Growth for the period 2014 - 2020 approved by the Prime Minister in Decision No. 403/QD-TTg of March 20, 2014, the ministries also issued their own Action Plans on Green Growth. A summary of policies related to mitigation in the field of industrial processes is shown in Table 4.

Table 4: Policy on GHG emissions reduction in the field of industrial processes

Policy	Decision No.	Year published	Sector
Action Plan on Green Growth for the Industry and Trade sector in the period 2015-2020.	13443/QD-BCT	2015	Chemicals; iron and steel industry
Action plan on Climate change response for the Construction Industry in the period 2016-2030.	811/QD-BXD	2016	Cement; construction glass industry
Action plan for the Construction Industry on Green Growth to 2020, with orientation to 2030.	419/QD-BXD	2017	Cement industry
Action plan to reduce GHG emissions in the cement industry to 2020, with orientation to 2030.	802/QD-BXD	2017	Cement industry

A summary of the objectives and strategies in the decisions outlined in Table 4 is as follows:

The Ministry of Industry and Trade issued the Action Plan on Green Growth for the industry and trade sector in the period 2015-2020 according to Decision No. 13443/QD-BCT dated December 8, 2015 with three related objectives, including:

» Reduce GHG emissions intensity in the industry and trade sector by 8-10% compared to 2010 levels;

» Reduce the amount of GHG emissions in the field of chemical fertilizer production from 9% to 15% compared to the normal development plan, of which the voluntary level is about 9%, and the level with international assistance is 6%;

» Reduction of GHG emissions in the steel industry from 10% to 20% compared to the normal development plan, of which the voluntary level is about 10%, and the level with international assistance is 10%.

The Ministry of Construction issued the Action Plan for the Construction industry on green growth to 2020, with orientation toward 2030 under Decision No. 419/QD-XD dated May 11, 2017, which details the tasks of reviewing, adjusting, and building the Vietnam Cement Industry Development Plan for the period 2017-2025 with orientation to 2035 (replacing Master Plan 1488).

Specifically for the cement manufacturing sub-sector, the Ministry of Construction issued the "Action Plan to reduce GHG emissions in the cement industry to 2020, with orientation to 2030" under Decision 802/QD-BXD with the specific targets of reducing 20 million tons of CO_2e by 2020 and reducing 164 million tons of CO_2e by 2030 compared to the BAU scenario.

In Decision 811/QD-BXD dated August 18, 2016, the Ministry of Construction set specific targets and action plans to respond to climate change and sea level rise.

2.2. Mitigation Actions

Based on reference reports and data in this report, it can be seen that the two sectors with the most potential to contribute to mitigation of GHG emissions are the mining industry (mainly the cement manufacturing industry) and the metallurgical industry (mainly the iron and steel manufacturing industry).

For the cement industry, the Ministry of Construction and the Ministry of Industry and Trade are planning to use materials such as blast furnace slag (GBFS), fly ash, pozzolana, limestone, and gypsum residue from the DAP factory to replace the clinker component in cement to protect the environment and reduce GHG emissions.

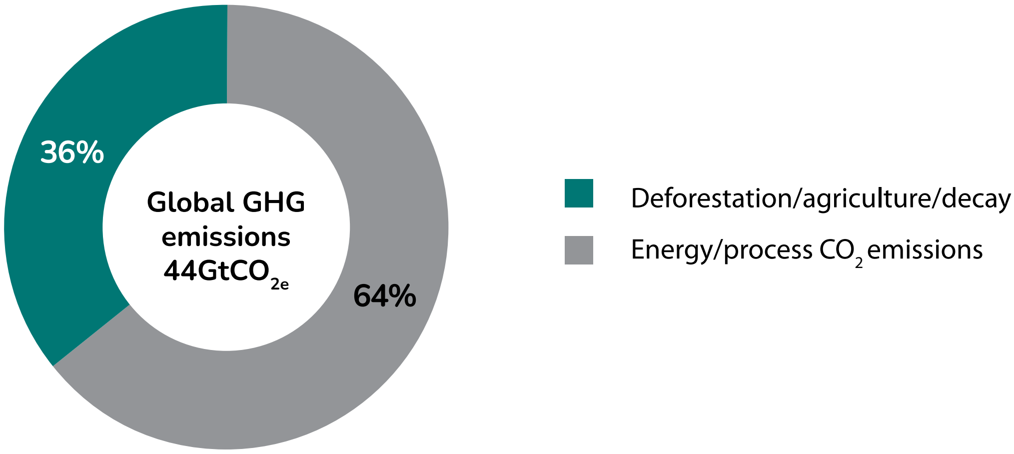
For the steel industry, according to Decision 694/QD-BCT dated 2013, by 2020, cast iron factories, steel billets, and steel rolling lines with small capacity will be basically eliminated (except blast furnaces to produce cast iron for mechanical engineering, and specialized furnaces for casting mechanical details, stainless steel and high-quality rolling lines). From 2013 onwards, no investment will be granted for new projects with outdated technologies, environmental pollution, or high energy consumption. Investment projects must comply with the national technical regulation on technologies and equipment for iron and steel production, which is prescribed by the Ministry of Industry and Trade. These solutions will contribute to the overall reduction of GHG emissions in the steel industry in terms of both energy and industrial processes

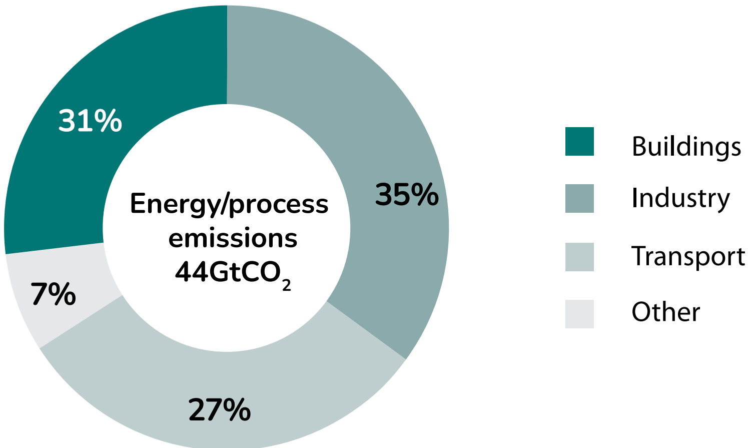
Some key mitigation actions in the IPPU sector (focusing on the mitigation actions which took place after Vietnam submitted the INDC) are summarized in Table 5.

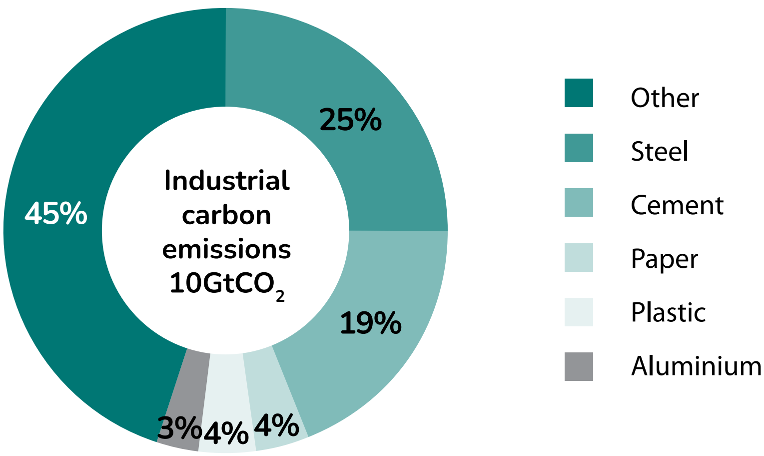
Table 5: Key mitigation actions in the IPPU sector

Mitigation action	Description	Implementation period	Budget	Quantitative goals
Vietnam Partnership for Market Readiness (PMR)	The project aims to strengthen the capacity of government agencies to develop, implement, and disseminate policies and tools for state management of NAMAs; formulate market-based instruments to reduce GHG emissions; pilot NAMAs in the fields of steel production and solid waste management; and develop a roadmap to participate in the domestic and international carbon market.	July 2015-June 2018	USD 3.6 million, of which USD 3.0 million is from the International PMR Programme and USD 0.6 million from counterpart State budgets and in-kind contributions from the co-implementing agencies	Concrete quantitative goals have yet to be identified
Capacity Building and Support for Development of GHG Emissions Reduction Action Plan for Cement Production in Vietnam	The project is supported by the Nordic Development Fund (NDF) and managed by MOC. The project aims to develop the NAMA Readiness Plan for the cement production sub-sector in Vietnam	2014 - 2016	USD 1.41 million from the NDF and USD 0.1 million from government counterpart co-financing for the capacity building activities. - Estimated funding need is USD 3 million for the readiness stage plus annual operational costs of about USD 0.3 million up to 2030. Funding for piloting the carbon-credit trade scheme is about USD 10 million	Estimated emissions reduction of 20 MtCO2e by 2020 and 164 MtCO2e by 2030

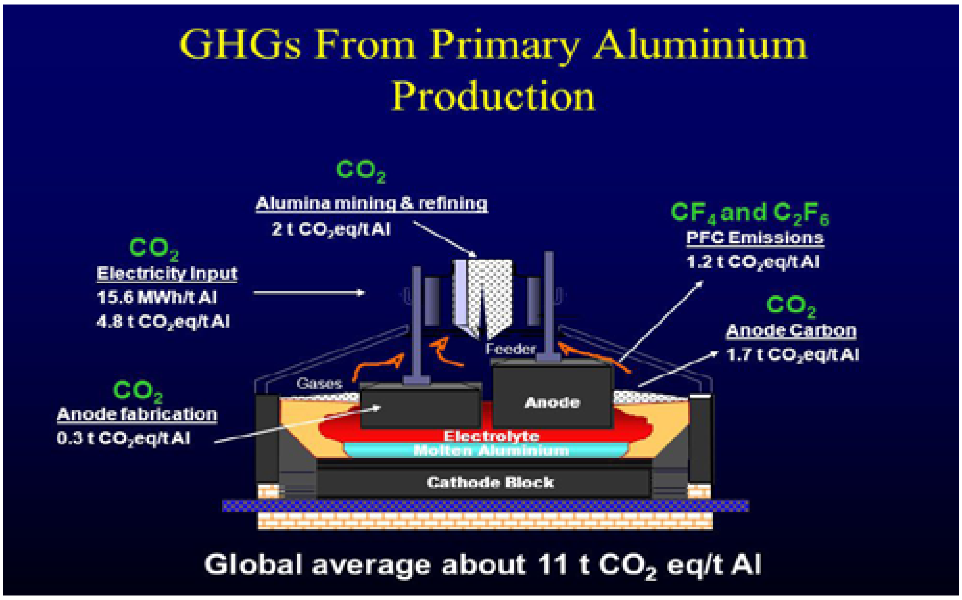
Source: Monre, 20170


Global GHG emissions $44GtCO_{2e}$
36%
64%
Deforestation/agriculture/decay
Energy/process CO_2 emissions


Energy/process emissions $44GtCO_2$
31%
35%
27%
7%
Buildings
Industry
Transport
Other


Industrial carbon emissions $10GtCO_2$
45%
25%
19%
4%
4%
3%
Other
Steel
Cement
Paper
Plastic
Aluminium

03. Development of Business-as-Usual scenarios for the IPPU sector in the period 2014-2030



3.1. Methodology, Input Data and Assumptions

3.1.1. Methodology

The 2006 Guidelines on National GHG Inventory for the IPCC (GL 2006) were applied to conduct the GHG inventory in 2014 and develop the Business-as-Usual (BAU) scenario for the IPPU sector in the period 2020-2030.

GHG emissions in the industrial processes sector have been estimated from industrial activities which are not related to the energy sector. The main emissions sources in this sector have been created by industrial production processes, which are processes that convert chemically or physically raw materials. For example, blast furnaces in the iron and steel industry; ammonia and other chemical products manufactured from fossil fuels are used as raw materials; and the cement industry are industrial processes that release significant amounts of CO_2. In these processes, various GHGs, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) can be released.

According to the GL 2006, the formula to calculate each sub-sector under the IPPU sector is as following:

3.1.1.1. Mineral Industry (2A)

1) Cement production (GHG: CO_2) –2A1.

a. Overview

Cement is an important industry with a long history in Vietnam. The Vietnam Cement Corporation, which was established in 1994, was formerly known as the Cement Association, which was established in 1979.

Cement is produced by finely grinding a mixture of clinker, gypsum, and other additives. During calcination of clinker, when the limestone with the main component (~95%) calcium carbonate ($CaCO_3$) is heated in the furnace, decomposition reaction will be formed to form CaO and release CO_2 following the reaction below:

$CaCO_3 \rightarrow CaO + CO_2 \uparrow$

CaO then reacts with other oxides such as SiO_2, Al_2O_3, and Fe_2O_3 in the initial material to produce clinker; these reactions do not produce additional CO_2.

Although CH_4 and N_2O are emitted during the production of cement, according to current research results they only account for a very small amount compared to CO_2, so the calculation of these two substances can be ignored.

b. Method

According to the decision tree diagram in 2006 IPCC Guidelines, given sufficient data on clinker production and national emission factors, the most appropriate method is Tier 2. This method uses clinker production data, because CO_2 emissions only occur during clinker production. However, because there is no real data on clinker production in the country, the Tier 1 method has been used to calculate CO_2 emissions using the formula calculated according to 2006 IPCC Guidelines vol.3 chapter.2, page 2.8 as follows:

$$CO_2 Emissions = \left[\sum_i (M_{ci} \times C_{cl_i}) - Im + Ex\right] \times EF_{clc}$$

where:

CO_2 Emissions = CO_2 emissions from cement industry, tons

M_{ci} = Quantity of cement produced by type *i*, tons

C_{cli} = Ratio of clinker in type *i* cement, rate, ratio

Im = Quantity of imported clinker for domestic consumption, tons

Ex = Quantity of exported clinker, tons

$EF_{clinker}$ = Emissons factor of clinker, tons CO_2/ton clinker

c. Emissions Factor

Clinker emissions factor is calculated by the formula:

$EF_{clinker}$ = Ratio factor × CaO content in Clinker × CKD (1)

Since there is no national specific emissions factor in cement production, according to 2006 IPCC Guidelines the default value of 0.65 (65%) is used for CaO content in clinker. Other data are shown in Table 6.

Table 6: Data used to calculate the emissions factors in cement production

	Unit	Value	Sources
Ratio factor	tons CO_2/ton CaO	0.786	Molecular mass ratio between CO_2 and CaO
CaO content in Clinker	tons CaO/ ton clinker	0.65	Page 2.11, Volume 3, 2006 IPCC Guidelines
CKD correction factor		1.02	Page 2.11, Volume 3, 2006 IPCC Guidelines
$EF_{clinker}$	tons CO_2/ton clinker	0.52	Calculated by Formula (1)

2) Lime production (GHG: CO_2) – 2A2

a. Overview

Lime (CaO) is produced from limestone with the main component $CaCO_3$ by thermal decomposition method (calcination method). In addition, when burning dolomite rock ($CaCO_3.MgCO_3$), dolomite lime (CaO.MgO) will be obtained. The CO_2 generated during the decomposition of limestone and dolomite follows the reaction below; these two reactions are used to calculate CO_2 emissions from lime production.

$$CaCO_3 \rightarrow CaO + CO_2\uparrow$$

$$MgCO_3 \rightarrow MgO + CO_2\uparrow$$

b. Method

The 2006 IPCC Guidelines offer different Tiers for calculating GHG emissions from lime production. For Tier 2 and Tier 3, the calculated data require a clear distinction between the finished lime and lime kiln dust (LKD). Because there is no data on lime dust, the Tier 1 method is used in calculate GHG emissions for lime production. The calculation formula provided by the 2006 IPCC Guidelines is as follows:

$$CO_2 \text{ emissions} = EF_{lime} * \text{Lime quantity}$$

According to the 2006 IPCC Guidelines, if lime production data is not separated by lime type, the default ratio between high calcium lime/dolomite lime is 85/15 and the lime water ratio should be assumed to be 0 unless additional information is available. Therefore, the ratio 85/15 was applied to assess the CO_2 emissions in 2014 because the data were not disaggregated in detail by type of lime.

c. Emissions factor

Because there is no information on the content ratios of CaO and CaO.MgO, the default emissions factors are used according to Table 2.4 in Volume 3, 2006 IPCC Guidelines (page 2.22).

Emissions factors for lime are determined by the following formulas:

$$EF_{lime} = 0.85 \times EF_{high\ calcium\ lime} + 0.15 \times EF_{dolomite\ lime}$$

$$= 0.85 \times 0.75 + 0.15 \times 0.77$$

$$= 0.75 \text{ tons } CO_2/\text{ton lime}$$

where:

EF_{lime} = Average emissions factor of lime

$EF_{high\ calcium\ lime}$ = Emissions factor of high calcium lime

$EF_{dolomite\ lime}$ = Emissions factor of dolomite lime.

3) Glass production (GHG: CO_2) – 2A3

a. Overview

Glass products and their preparations are used commercially in a variety of categories, but the glass industry can be divided into four main categories: bottles, flat glass, fiberglass, and specialized glass.

Most commercial glass falls into the first two categories, and is almost entirely household glass with components of silica (SiO_2), soda (Na_2O) and lime (CaO), small amounts of aluminium (Al_2O_3), alkali compounds, and other minor ingredients. Fiberglass and specialized glass also have similar components. Private glass manufacturers will have copyrights on their products, but there are only minor changes in the components.

The materials used to produce glass that cause CO_2 emissions during the melting process are limestone ($CaCO_3$), dolomite Ca, $Mg(CO_3)_2$, and soda ash (Na_2CO_3). Where these materials are mined as mineral carbonates for use in the glass industry, they represent primary CO_2 emissions sources and should be included in emissions estimates. In the case of carbonate materials created through the process of carbonate hydroxide, they will not lead to CO_2 emissions and will not be included in the emissions estimate. There is a small amount of CO_2 emitted from the initial materials, barium carbonate ($BaCO_3$), ash ($3CaO_2P_2O_5$ + $xCaCO_3$), potassium carbonate (K_2CO_3)

and strontium carbonate ($SrCO_3$). In addition, anthracite coal powder or other organic materials added to create conditions for the reduction reaction in molten glass will combine with the oxygen available in the glass solution to form CO_2.

Carbonate activity in glass production is a complex chemical reaction at high temperatures and cannot be compared directly with the calcination process to produce dolomite lime or dolomite lime. However, this reaction (in 1500 °C) has the same impact on CO_2 emissions.

In fact, glass is not made from 100% raw materials but uses a certain amount of recycled scrap. Most manufacturing operations will aim to use scrap as much as possible, but due to limitations in glass quality when using too much scrap, the percentage of scrap is under 10% or less depending on the glass product group.

Cullet comes from two sources: broken household glass and foreign sources from recycling programmes. This second source is important in developed countries, but will be less in developing countries, where glass recovery is not common.

The retention of CO_2 in glass is determined to be relatively negligible and can be ignored for the purpose of estimating GHG emissions.

b. Method

The Tier 1 method may be applied in the absence of manufactured glass or carbonate data used in glass production. Tier 1 applies the default emissions factor and rate of scrap along with glass production statistics at the national level.

According to the 2006 IPCC Guidelines (Vol.3, Chap.2, page 2.28), CO_2 emissions from glass production is calculated by the following formula:

$$CO_2 \text{ emissions} = Mg \times EF_{glass} \times (1 - CR)$$

where:

CO_2 emission = CO_2 emissions from glass production, tons

Mg = Quantity of glass, tons

EF_{glass} = Emissions factor of glass production, tons CO_2/ton glass

CR = Ratio of scrap used in glass production, %

c. Emissions factor

Since Vietnam does not have national specific GHG emissions factors for glass production, the default emissions factor of the 2006 IPCC Guidelines is used for the calculation process as follows:

EF_{glass} = 0.2 tons CO_2/ton glass

3.1.1.2. Chemical industry (2B)

1) Ammonia (GHG: CO_2) – 2B1

a. Overview

Ammonia is one of the main chemical industries and is the main source of materials for the production of nitrogen compounds. Ammonia gas is used in many different applications such as fertilizer production, heating, pulping, nitric acid, and nitrate acid production. Anhydrous ammonia is produced by catalytic reaction that changes the structure of natural gas or other fossil fuels. Some examples of reactions using methane or carbon as input materials for the reaction to produce NH_3 and emit CO_2 are as follows.

$$C + H_2O = CO + H_2$$

$$CH_4 + H_2O = CO + 3H_2$$

$$CH_4 + 1/2\ O_2 = CO + 2H_2$$

$$CO + H_2O = CO_2 + H_2$$

$$N_2 + 3H_2 = 2\ NH_3$$

b. Method

GHG emissions from Ammonia production are calculated using the Tier 1 method, equation 3.1 in the 2006 IPCC Guidelines.

$E_{CO2} = AP \times FR \times CCF \times COF \times 44/12 - R_{CO2}$

where:

E_{CO2} = CO_2 emissions, kg

AP = Ammonia production, tonnes

FR = Fuel requirement per unit of output, GJ/tonne ammonia produced

CCF = Carbon content factor of the fuel, kg C/GJ

COF = Carbon oxidation factor of the fuel, fraction

R_{CO2} = CO_2 recovered for downstream use (urea production), kg

c. Emissions factor

Since there is no specific emissions factor for Vietnam in the production of ammonia, the coefficients are used according to the 2006 IPCC Guidelines.

Table 7: Fuel consumption factors by type of ammonia production technology

Technology	Fuel	FR (GJ/ton Ammonia)	Sources
Partial oxidation	Coal	42.75	Table 3.1 Chap 3 IPCC 2006
Steam reforming	Natural gas	34.20	Table 3.1 Chap 3 IPCC 2006

Table 8: Carbon content factors of fuels

Technology	Fuel	CCF (kg C/GJ)	Sources
Partial oxidation	Coal	26.00 (*)	Table 1.3 Chap 1 IPCC 2006
Steam reforming	Natural gas	15.30	Table 3.1 Chap 3 IPCC 2006

(Note: (*) The CCF value of the partial oxidation technology is taken from the average of bituminous coal types from 25.8 to 26.2)

2) Nitric acid production (GHG: N_2O) – 2B2

As of 2014, Vietnam had only one factory producing nitric acid with a capacity of 20,000 tons/year. To assess the BAU scenario for the following years, GHG emissions from nitric acid production will be calculated based on IPCC 2006 Guidelines as follows:

$E_{N2O} = EF_{N2O} \times Q$

where:

E_{N2O} = N_2O emission, kg

Q = Nitric acid production, tons

The emissions factor EF_{N2O} for nitric acid production for medium pressure combustion plants is 7 kg N_2O/ton nitric acid according to IPPU 2006 guidelines.

3) Petrochemical (Methanol/EDC/VCM) (GHG: CO_2, CH_4) – 2B8

Because there are no factories producing Methanol, EDC or VCM as of 2014, there is no GHG inventory for this area. To assess the BAU scenario for subsequent years, the calculation of the GHG emissions from the production of these chemicals is based on the 2006 IPCC Guidelines as follows:

$E_{CO2} = EF_{CO2} \times Q$

$E_{CH4} = EF_{CH4} \times Q$

where:

E_{CO2} = Emissions of CO_2, tons

E_{CH4} = Emissions of CH_4, kg

Q = Quantity of Methanol/EDC/VCM, tons

EF_{CO2} = Emissions factor for CO_2 (tons CO_2/ton product)

EF_{CH4} = Emissions factor for CH_4 (kg CH_4/ton product)

The GHG emissions factors for these types of production are as follows:

Table 9: GHG emissions factors for methanol/EDC/VCM industry

Emissions factor	Methanol	EDC	VCM
EF_{CO2} (tons CO_2/ton product)	0.67	0.191	0.294
EF_{CH4} (kg CH_4/ton product)	2.3	0.0226	0.0226

Source: IPCC, 2006

3.1.1.3. Metal industry (2C)

1) Iron and steel (GHG: CO_2) – 2C1

a. Overview

Untreated iron is produced by reducing iron oxide ore mostly in blast furnaces, often using carbon in coke or charcoal and as fuel and reducing agent. In most blast furnaces, this process is assisted by the use of carbonate-based fluxes.

Iron and steel production processes emit mainly CO_2 and CH_4. N_2O is also emitted during the production of iron and steel, but the emissions are very small and can be ignored in the calculation process (IPCC 2006 does not guide estimating N_2O emissions from steel production).

b. Method

Emissions during iron and steel production include two main types of emissions: 1) emissions from coking processing; and 2) emissions during the production of iron and steel. Emissions in coking coal processing are calculated and reported in the energy sector. For emissions in the production of iron and steel, there are emissions from the burning of fuel to generate energy (this is reported in the energy sector) and emissions due to the reactions in the smelter to create iron and steel (non-energy emissions reported in the field of industrial processes).

The 2006 IPCC Guidelines provides 3 Tiers for calculating CO_2 emissions from steel production (Tier 1 to Tier 3) and 2 Tiers for calculating CH_4 emissions from steel production (Tier 1 and Tier 3). With the initial data of total steel production in 2014, Tier 1 is applied to the calculation of CO_2 and CH_4 emissions. The formula for calculating emissions:

$$E_{CO2} = BOF \times EF_{BOF} + EAF \times EF_{EAF} + OHF \times EF_{OHF}$$

where:

BOF = Quantity of steel produced by Basic Oxygen Furnace technology, tons

EAF = Quantity of steel produced by Electric Arc Furnace technology, tons

OHF = Quantity of steel produced by Open Hearth Furnace technology, tons

EF = Emissions factor, tons CO_2/ton steel

c. Emissions factor

BOF and EAF technologies are currently in use in Vietnam. Each steel manufacturing technology has its own emissions factor, which is referenced in the 2006 IPCC Guidelines (Table 10).

Table 10: GHG emissions factor for the steel industry

Technology	BOF	EAF
Emissions factor, tons CO_2/ton steel	1.46	0.08

Table 11: GHG emissions factor for the aluminium industry

	CO_2	CF_4	C_2F_6
Emissions factor	1.6 tons/ton Al	0.4 kg/ton Al	0.04 kg/ton Al

2) Aluminium (GHG: CO_2, CF_4, C_2F_6) – 2C3

As of 2014, there are no aluminium factories in Vietnam, so there is no GHG inventory for this area. To assess the BAU scenario for subsequent years, the calculation of GHG emissions from aluminium production is based on the 2006 IPCC Guidelines as follows:

$E = EF \times Q$

where:

E = GHG emissions (E_{CO2}, E_{CF4}, E_{C2F6})

EF = Emissions factor of GHG

Q = Quantity of produced aluminium

The GHG emissions factor for the aluminium industry is as follows:

3.1.1.4. ODS substitution

There was already a GIZ project "Refrigeration and Air Conditioning Greenhouse Gas Inventory for Vietnam" in 2018 to conduct an inventory and propose GHG emissions reduction scenarios for this sector. However, the working group only has the project's final report, which does not show specific data on GHG emissions of each sector for 2025 and 2030. Therefore, the data for GHG inventory in this industry will not be updated in this report.

3.1.2. Assumptions and input data

1) Assumption

For cement, lime and glass production

The forecast data source for construction materials manufacturing group (cement, lime and glass) is updated to the latest data source (October, 2019).

For the cement industry, clinker content in cement will decrease from 83% in 2020 to 80% in 2030.

There are no specific statistics on the percentage of recycled scrap, so the assumption is that the percentage of recycled scrap in glass production is 10% (according to the IPPC Guidelines).

For chemical production (Ammoniac, Methanol, EDC and VCM)

Ammoniac, Nitric acid, Methanol, EDC and VCM: Because there is no forecast data, the report is based on industry planning data for the period 2020-2030 and the consultation data from the Vietnam Chemical Agency (Ministry of Industry and Trade).

Nitric acid: the report assumed that the two companies producing nitric acid will operate at 100% of their designed capacity.

For steel production

The report assumed that the operational efficiency of the steel industry in the period 2020-2025 is 70% of designed capacity for the whole industry and in 2030 will reach 100% of designed capacity in 2025.

For aluminium production

At present, there is no planning data for aluminium production to 2030 so aluminium production capacity to 2030 is assumed to remain unchanged compared to 2020 at 450,000 tons/year.

2) Activity Data

Data sources are collected using the following two main methods:

- Top-down method: Priority is given to data from management agencies; the order of priority is gradually reduced to the factory, applied for the steel industry, cement industry, etc.

- Bottom-up method: Priority is given to data from factories, applied only to the ammonia manufacturing industry.

- Operational data

The operational data for the past years from 2010 to 2014 has been compiled from sources such as:

- General Statistics Office of Vietnam;

- Vietnam Cement Industry Report - Vietnam Cement Association;

- Statistics of the Vietnam Steel Association;

- Research report of the Vietnam Institute for Building Materials - Ministry of Construction;

- Reports of fertilizer companies.

The collection of operational data is conducted according to the top-down approach, which prioritises the use of national data, then data from the ministries, then data from Research Institutes, and finally data from factories. The forecasting data is collected with highest priority given to the latest ministry data, and then approved planning.

The operational data for the cement industry is mainly taken from the cement industry report because the statistical yearbook does not have sufficient data on clinker production or exports and imports; emissions in the cement industry mainly from clinker production. The report of the cement industry in Vietnam is full of data on clinker production, imports and exports. Therefore, data from this report is used as the data to calculate GHG emissions of the cement industry.

Operational data for the lime and glass industries are taken from the Ministry of Construction's Technical Report on Input Data for GHG emissions reduction by improving the construction material manufacturing process.

For the chemical industry, as of 2014, there are no factories producing Methanol/EDC/VCM. Due to the lack of statistical data on ammonia production, the report uses data provided by fertilizer companies.

For the steel industry, since the yearbook has no data on steel classified by type of technology, operational data for the steel industry is taken from the report of the Vietnam Steel Association; these data concur with the data of the World Steel Association.

As of 2014, there are no aluminium factories in Vietnam so there are no sources of operational data.

By 2014, there was only one factory producing nitric acid in Vietnam, the Z95 factory of the Ministry of Defence, with a designed capacity of 20,000 tons/year.

A summary of operational data sources is given in Table 12.

Table 12: Operational data sources by industry

Industry	Data sources
Cement	Statistical Yearbook - General Statistics Office 2010 - 2013; Vietnam Cement Industry Report 2014
Lime Glass	Technical Report on Input Data for GHG emissions reduction by improving the construction material manufacturing process, Ministry of Construction
Ammonia	Reports of fertilizer companies
Nitric acid	Ministry of Industry and Trade
Iron and steel	Vietnam Steel Association, World Steel Association

Forecast data

The forecast data for production in all sectors are taken from industry development planning approved by the ministry or the Prime Minister, specifically for each industry as follows:

- ***Cement, lime and glass production***: Since the plans of the cement and lime industries have expired, the forecast data on cement production is based on the Ministry of Construction's data (Official Dispatch No. 53/BXD-VLXD dated October 2nd 2019). The clinker content in cement will be equal to 83% for 2020 and 80% for 2030 according to the final readiness plan for the cement industry in Vietnam (Final Readiness Plan for the Cement Sector in Vietnam – Nordic partnership initiative pilot programme).
- ***Ammonia production***: Estimated ammonia production for 2020 and 2030 include the actual capacity of the 4 plants that are in operation and the capacity of incoming projects (data provided by the Vietnam Chemical Agency).
- ***Production of nitric acid:*** According to consultation with the Ministry of Industry and Trade, by 2030, Vietnam will have 2 nitric acid factories, including the Ministry of Defence's Z95 plant, which has been put into operation and the factories of Vinacomin-Mining Chemical Industry Holding Corporation Ltd. (MICCO), which is about to start operation.
- ***Methanol/EDC/VCM production***: By 2020, there are no factories producing Methanol, EDC and VCM in Vietnam so the figures for methanol and VCM production in 2030 are based on consultation data from the Department of Chemicals.
- ***Iron and steel***: the expected capacity of iron and steel production is based on Decision No. 694/QĐ-BCT of the Ministry of Industry and Trade dated 31/01/2013 on draft "Approving adjustment of planning of steel production system to 2025, orientation to 2035".
- ***Aluminium***: Currently, Vietnam only has one aluminium factory, Daknong Aluminium Electrolysis Plant in Nhan Co Industrial Park, Dak R'Lap District, which is owned by Tran Hong Quan Metallurgical Co., Ltd. The project is expected to come into operation by the end of 2018 with a capacity of 450,000 tons of products/year. Thus, by 2020, aluminium production is expected to be 450,000 tons/year. There are no data for aluminium production to 2030 but it is forecast that without the support of electricity prices, the development of the aluminium industry will face many difficulties and the aluminium production forecast in 2030 will not change compared to 2020.

A summary of planning data for industries and their expected capacity to 2030 is given in Table 13.

Table 13: Expected industry capacity by 2030

Industry	Unit	2020	2025	2030	Data sources
Cement	Thousand tons	112,020	131,420	140,120	Official Letter No. 53/BXD-VLXD dated October 2nd, 2019
Glass	Thousand tons	275,000	330,000	395,000	Official Letter No. 53/BXD-VLXD dated October 2nd, 2019
Lime	Thousand tons	5,700	6,440	7,750	Official Letter No. 53/BXD-VLXD dated October 2nd, 2019
Ammonia	Thousand tons	1,842	1,860	2,592	Decision 676/2017/QD-BCT. Also the consultation data of 4 fertilizer companies (Ha Bac, Ninh Binh, Phu My, Ca Mau)

Industry	Unit	2020	2025	2030	Data sources
Nitric acid	Thousand tons	185	185	185	Ministry of Industry and Trade
Methanol	Thousand tons	0	300	300	Decision No. 676/2017/QĐ-BCT.
EDC	Thousand tons	0	0	96	Decision 676/2017/QD-BCT and 1621/2013/QD-TTg.
VCM	Thousand tons	0	0	200	Decision 676/2017/QD-BCT.
Iron and steel	Thousand tons	22,540	40,040	53,840	Decision 694/QĐ-BCT dated 31/01/2013 on draft „Approving adjustment of planning of steel production system to 2025, orientation to 2035".
Aluminium	Thousand tons	450	450	450	Tran Hong Quan company.

2) Emissions Factors

The values of Global Warming Potential (GWP) of GHGs for 100 years in the IPPC AR4 Report were used in the development of the BAU and mitigation scenario for the IPPU sector (Table 14).

Table 14: The values of Global Warming Potential of GHGs

Gas	GWP
CO_2	1
CH_4	25
N_2O	298
HFC_s	124-14,800

Source: AR4 Report, IPCC, 2007

The emissions factors are used in the calculation of GHGs for industrial processes, according to the 2006 IPCC Guidelines, as described in Table 15:

Table 15: GHG emissions factors of industrial process

Industry	Emissions factor	Sources
Cement	EFclc = 0.52	IPCC 2006 Volume 3
Glass	EF = 0.2	IPCC 2006 Volume 3
Lime	EF= 0.75	IPCC 2006 Volume 3
Ammonia	FR= 42.75 (coal) FR= 34.2 (natural gas) CCF= 26 (coal) CCF= 15.3 (natural gas)	IPCC 2006 Volume 3 Table 3.1 IPCC 2006 Volume 3 Table 3.1 IPCC 2006 Volume 2 Table 1.3 IPCC 2006 Volume 2 Table 1.3

Industry	Emissions factor	Sources
Methanol	EF= 0.67 (CO2) EF= 2.3 (CH_4)	IPCC 2006 Volume 3 Table 3.12
Nitric acid	EF = 7 (N2O)	IPCC 2006 Volume 3 Table 3.3
EDC	EF= 0.196 (CO2) EF= 0.0226 (CH_4)	IPCC 2006 Volume 3 Table 3.17 IPCC 2006 Volume 3 Table 3.19
VCM	EF= 0.294 (CO_2) EF= 0.0226 (CH_4)	IPCC 2006 Volume 3 Table 3.17 IPCC 2006 Volume 3 Table 3.19
Iron and steel	EF = 1.46 (BOF) EF= 0.08 (EAF)	IPCC 2006 Volume 3 Table 4.1
Aluminium	EF = 1.6 (CO_2) EF = 0.4 (CF_4) EF = 0.04 (C_2F_6)	IPCC 2006 Volume 3 Table 4.10 IPCC 2006 Volume 3 Table 4.15 IPCC 2006 Volume 3 Table 4.15

3.2. Results

3.2.1. GHG inventory results in 2014

In order to unify the inventory reports of other fields submitted to the national committee on climate change, the data serving the inventory in this report are calculated to 2014. Data from 2014 and planning data of the sectors will be used for forecasting and scenario development.

3.2.1.1. Mineral industry (2A)

a. Cement production

CO_2 emissions in 2014 from the cement industry:

CO_2 emissions = (56,871 x 0.83 – 0 + 15,182) x 0.52 = 32,440.16 (thousand tons) = 32,440.16 (Gg)

b. Lime production

CO_2 emissions in 2014 from lime production:

CO_2 emissions = 0.75 × 3,256,000 = 2,442,000 (tons) = 2,442.00 (Gg)

c. Glass production

CO_2 emissions in 2014 from glass production:

CO_2 emissions = 1,789 × 0.2 × (1 – 0.1) = 322. 02 (thousand tons) = 322.02 (Gg)

3.2.1.2. Chemical industry

a. Ammonia

Based on practical data and emissions factors, the amount of CO_2 emitted during ammonia production is estimated in Table 16.

Table 16: The amount of CO_2 emitted from ammonia production in 2010-2014

Year	Quantity of ammonia	Fuel used to produce ammonia	Carbon content in fuel	Carbon oxidation factor of the fuel	CO_2 emitted
	(tons)	(GJ/ tons ammonia)	(kg C/GJ)	(%)	(kg CO_2)
		Ammonia produced from coal (partial oxidation)			
2010	116,867	42.75	26	1	476,291,459
2011	212,637	42.75	26	1	866,602,094
2012	191,039	42.75	26	1	778,580,545
2013	306,885	42.75	26	1	1,250,708,187
2014	365,635	42.75	26	1	1,490,144,627
		Ammonia produced from gas (steam reforming)			
2010	488,340	34.2	15.3	1	936,938,891
2011	453,477	34.2	15.3	1	870,050,042
2012	769,806	34.2	15.3	1	1,476,965,188
2013	921,017	34.2	15.3	1	1,767,081,637
2014	964,572	34.2	15.3	1	1,850,647,131

Part of the generated CO_2 is used to produce urea, so the amount of CO_2 emitted into the atmosphere will be the amount of CO_2 remaining after use.

Table 17: CO_2 emissions into the atmosphere from ammonia production activities during 2010-2014

Year	Quantity of Urea	CO_2 used to produce Urea	CO_2 emissions	CO_2 emissions
	(kg)	(kg CO_2)	(kg CO_2)	(Gg CO_2)
2010	997,148,000	731,241,867	681,988,483	681.99
2011	999,199,000	732,745,933	1,003,906,202	1,003.91
2012	1,655,116,820	1,213,752,335	1,041,793,398	1,041.79
2013	2,103,888,700	1,542,851,713	1,474,938,111	1,474.94
2014	2,186,455,200	1,603,400,480	1,737,391,278	1,737.39

b. Nitric acid production

In 2014, the nitric acid industry only had the Ministry of Defence's Z95 plant with a capacity of 20,000 tons/year. Therefore, the amount of GHG emissions in 2014 from nitric acid production is:

N_2O emissions = 7 x 20,000 = 140,000 kg N_2O = 140 tons N_2O

CO_2 emissions = N_2O emissions x $GWP_{N20(AR4)}$ = 140 tons * 298 = 41,720 tons = 41.7 Gg CO_2

c. Methanol/EDC/VCM production

Due to the fact that there are no factories producing Methanol, EDC or VCM as of 2014, there is no GHG inventory for this field.

3.2.1.3. Metal industry

a. Iron and steel

The CO_2 emissions in 2014 for iron and steel production is calculated as follows:

CO_2 emissions = 4,970 × 0.08 + 877 × 1.46 = 1,678.02 (Gg)

b. Aluminium

As of 2014, there are no aluminium factories in Vietnam, so there is no GHG inventory for this field.

3.2.1.4. GHG inventory of the IPPU sector in 2014

The GHG emissions from the IPPU sector in 2014 is shown in Table 18.

Table 18: GHG inventory results of the IPPU sector in 2014

STT	Industry	CO_2 emissions in 2014 (Gg)	Proportion, %
1	Mineral (2A)		
1.1	Cement production (CO_2) – 2A1	32,440.16	84.54
1.2	Lime production (CO_2) – 2A2	2,442.00	6.36
1.3	Glass production (CO_2) – 2A3	322.02	0.84
2	Chemical (2B)		
2.1	Ammonia (CO_2) – 2B1	1450.83	3.78
2.2	Nitric acid (N_2O) – 2B2	41.7	0.11
2.3	Methanol/EDC/VCM (CO_2) – 2B8	0.00	0
3	Metal (2C)		
3.1	Iron and steel (CO_2) – 2C1	1678.02	4.37
3.2	Aluminium (CO_2) – 2C3	0.00	0
	Total:	**38374.73**	**100**

It can be seen from Table 18 that cement production accounts for a very large proportion of GHG emissions. The remaining sub-sectors have much lower emissions than cement.

3.2.2. BAU scenario of the IPPU sector in the period 2014-2030

Based on the capacity and emissions factors for each sector as presented above, the GHG emissions scenario in the industrial process by 2030 is aggregated from three industries: mineral, chemical, and metal as shown in Table 19.

Table 19: BAU scenario of the IPPU sector in the period 2014-2030

Unit: $MtCO_2e$

GHG emissions sources	2010	2014	2020	2025	2030
2A. Mineral industry	25.48	35.20	53.13	60.77	64.81
2A1. CO_2 emissions from the cement industry	23.88	32.44	48.35	55.35	58.29
2A2. CO_2 emissions from the lime industry	1.45	2.44	4.28	4.83	5.81

GHG emissions sources	2010	2014	2020	2025	2030
2A3. CO_2 emissions from the glass industry	0.15	0.32	0.50	0.59	0.71
2B. Chemical industry	0.68	1.77	3.63	5.71	5.99
2B1. CO_2 emissions from the Ammonia industry	0.68	1.74	3.25	5.33	5.33
2B2. N_2O emissions from nitric acid production	0	0.04	0.39	0.39	0.39
2B8. CO_2 emissions from the petrochemical industry	0.00	0.00	0.00	0.00	0.28
2B8. CH_4 emissions from the petrochemical industry	0.00	0.00	0.00	0.00	0.00
2C. Metal industry	0.35	1.68	24.36	49.91	70.06
2C1. CO_2 emissions from the iron and steel industry	0.35	1.68	22.09	47.64	67.79
2C3. CO_2 emissions from the aluminium industry	0.00	0.00	0.72	0.72	0.72
2C3. CF_4 & C_2F_6 emissions from the aluminium industry	0.00	0.00	1.55	1.55	1.55
Total	**26.51**	**38.66**	**81.13**	**116.40**	**140.87**

The BAU curve for GHG emissions of industrial process is shown in Figure 1 and Figure 2.

Figure 1: BAU scenario of the IPPU sector in the period 2014-2030

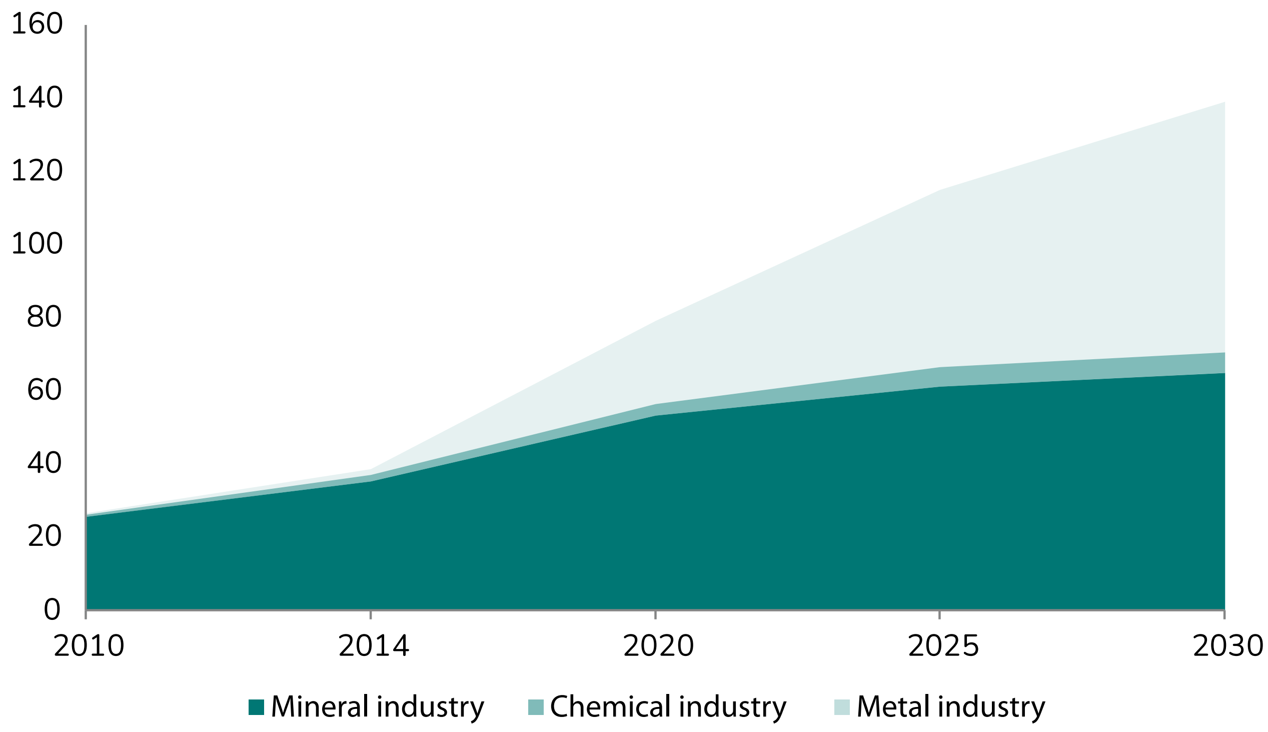


Figure 2: GHG emissions of sub-sectors to 2030

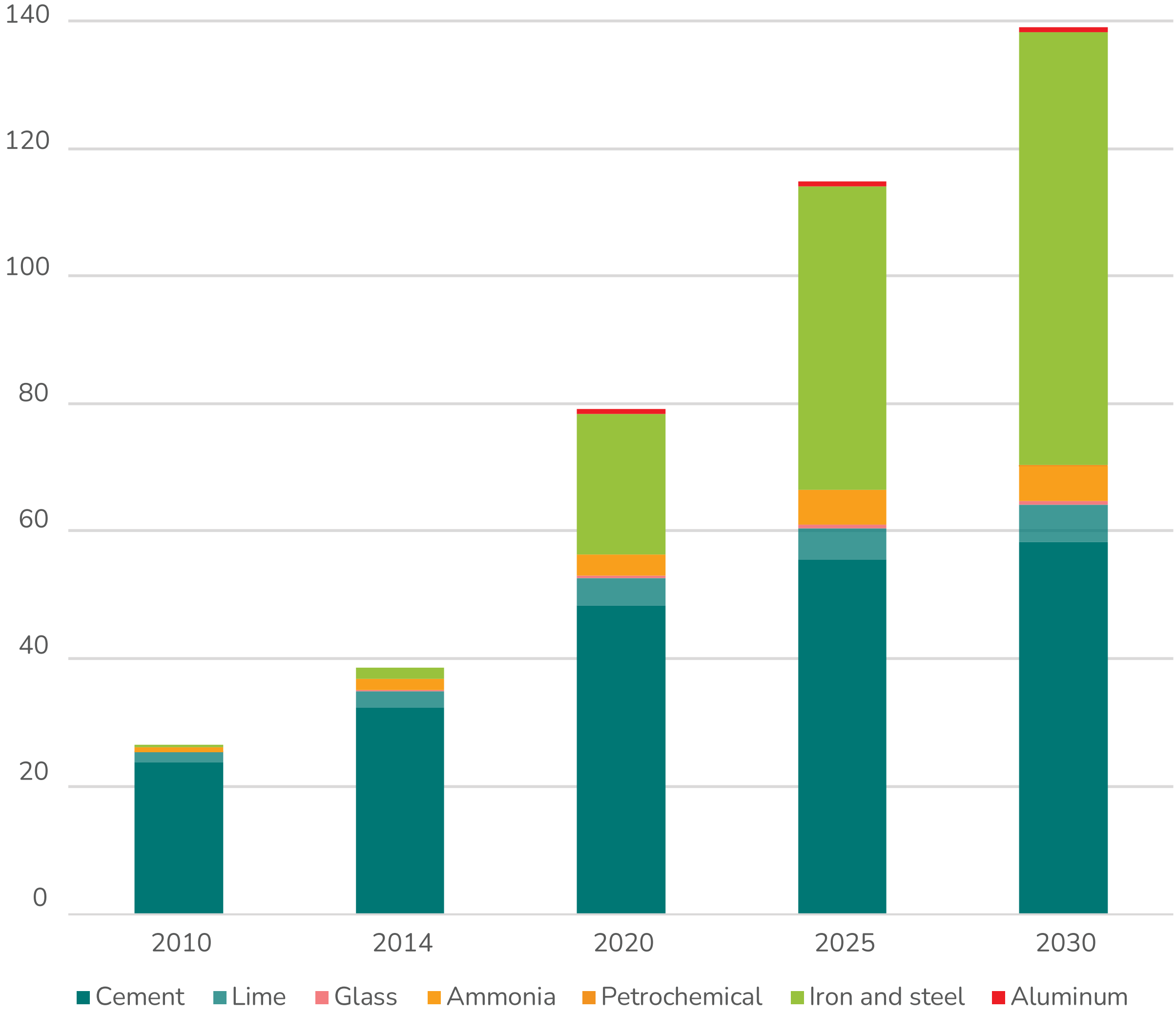
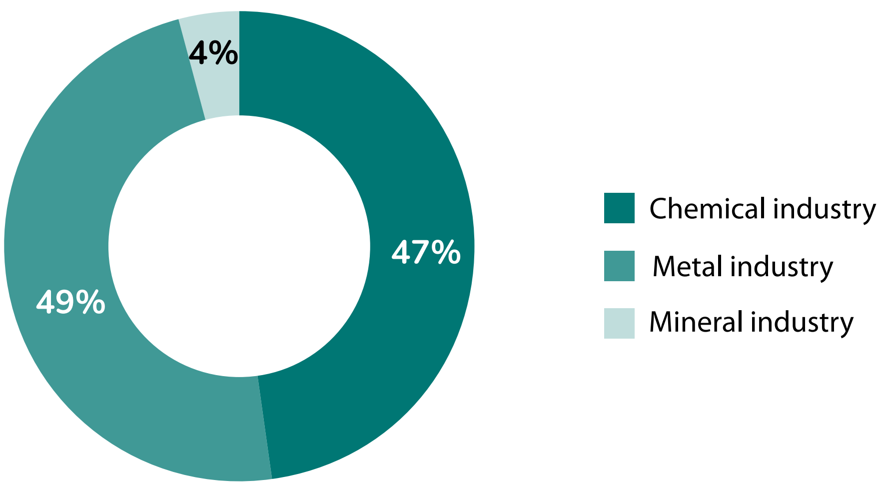


Figure 1 and Figure 2 clearly show that:

(1)The CO_2 emissions of the chemical industry are much lower than that of minerals and metal. In terms of percentages; the chemical industry accounts for only 4%, while the minerals and metal sectors account for 50% and 46%, respectively (Figure 3).

Figure 3: Ratio of GHG emissions of 3 industries



(2) In the mineral industry, the CO_2 emissions of the cement sub-sector are much greater than the limestone and glass sub-sectors (Figure 4).

(3) In the metal industry, the CO_2 emissions of the iron and steel sub-sector accounts for 99%, while the aluminium sub-sector accounts for only 1% (Figure 5).

Figure 4: Ratio of GHG emissions of sub-sectors in the mineral industry

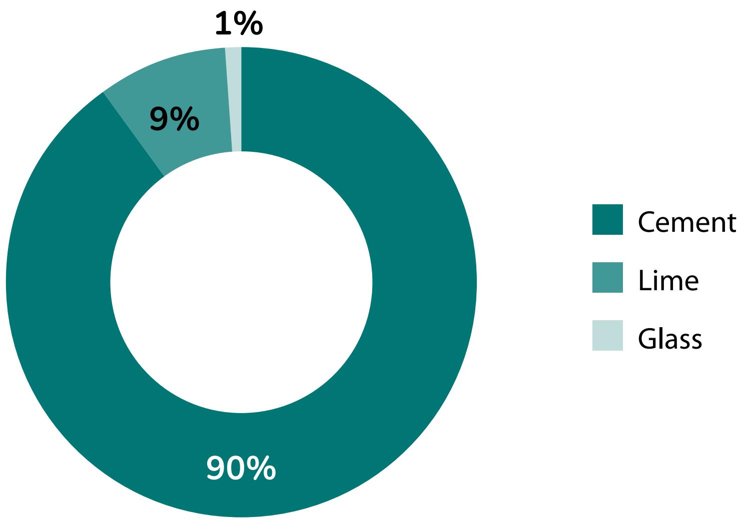
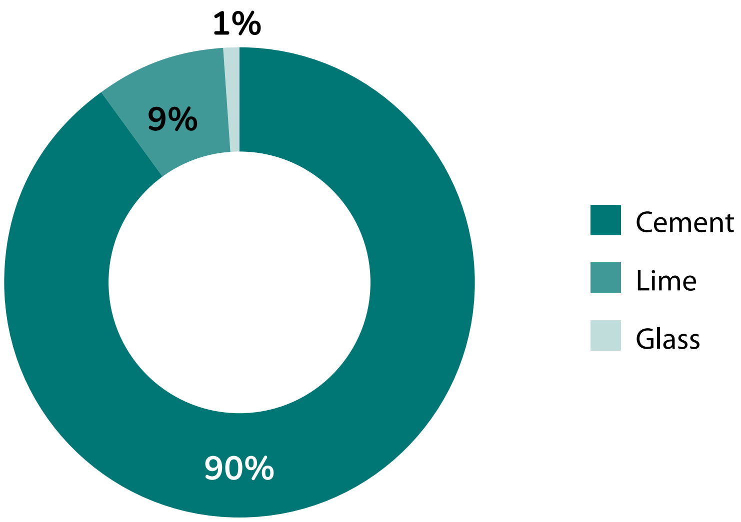


Figure 5: Ratio of GHG emissions of sub-sectors in the metal industry



From the above analysis, GHG emissions reduction options should focus on 2 sub-sectors accounting for the largest proportion of emissions: the cement sub-sector and the iron and steel sub-sector. In addition, the nitric acid industry has the potential to reduce emissions due to the availability of international project programmes to reduce GHG emissions from this sector.

04. Development of the mitigation scenario for the IPPU sector in the period 2020-2030

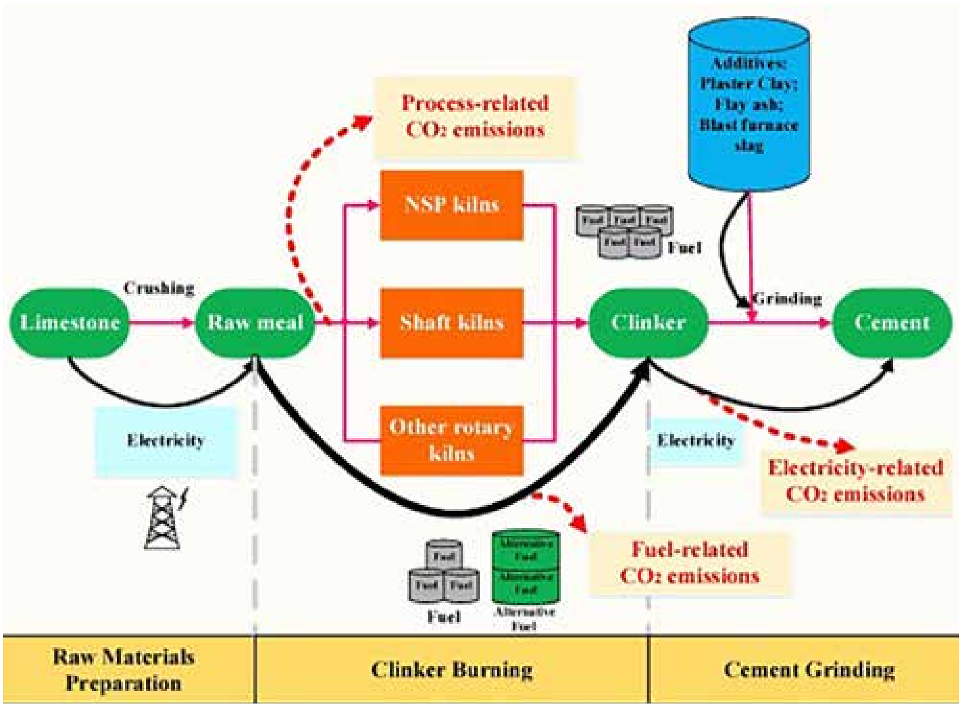


Photo Caption @ GIZ 2020

4.1. Methodology, Input Data and Assumptions

4.1.1. Methodology

The 2006 Guidelines on National GHG Inventory of the IPCC (GL 2006) were also applied to develop the mitigation scenario for the IPPU sector in the period 2020-2030. The specific equations for calculation of GHG emissions from each sub-category under the IPPU sector were presented in Section 3.1.1.

The mitigation scenario in the cement, iron and steel sub-sectors was developed based on development plans of those sectors which were approved by line ministries, such as NAMA cement in 2016.

In October 2019, Vietnam signed the NACAG Declaration in which Vietnam affirms its commitment to help ensure reduction of N_2O from nitric acid production with the aim of phasing out these emissions globally as soon as possible. There are two nitric acid production plants located in Vietnam. One plant belongs to Z95 Chemical Company under the Ministry of Defence (20.000 tons/year). The other is a commercial plant belonging to Vinacomin-Mining Chemical Industry Holding Corporation Ltd. (MICCO) (500 tons/day). This MICCO one is compatible with the grants mechanism offered by NACAG. The mitigation scenario is that mitigation technology to reduce N_2O emissions at MICCO's nitric acid plant is installed by the end of 2022.

4.1.2. Assumptions and input data

1) Assumptions for cement production

The assumption to develop mitigation options for the cement industry is based mainly on two main issues:

- Assumption of production scale: the cement industry reaches an average of 1,348 kg/person/year.
- Assumption of clinker composition: Clinker in cement will be gradually reduced from an average of 83% in 2014 to 80% in the BAU scenario and 69% with domestic efforts in 2030.
- Total cement production capacity from 2011-2015 was taken from data in the cement industry report
- Production of the cement industry is forecast for 2020-2030 based on the Ministry of Construction's data.
- According to data provided by the Ministry of Construction, cement production in 2030 will be 140,120 tons (1,348 kg/person/year). However, the cost estimation of the 1,348 kg/person/year scenario is based on the cost data in the Vietnam Nordic Partnership Initiative Pilot Program (scenario of 800 kg/person/year; 1,000 kg/person/year; 1,200kg/person/year).

The two scenarios are defined as:

1. BAU scenario: cement production is expected to be 1,348 kg/person/year with 80% clinker content in 2025 and 2030.
2. Mitigation scenario: cement production at 1,348 kg/person/year with the scenario of Best Available Technique Practice (BATP), clinker content is 76% in 2025 and 69% in 2030.

To ensure the target of emissions reduction under the given scenarios, the NAMA of the cement industry has identified a number of emissions reduction options, including four emissions reduction measures related to the industrial process. These options focus on using grinding additives to replace clinker. The reduction of clinker content in cement will lead to a reduction in clinker demand and thus reduce emissions from clinker production in particular, and in the cement industry in general.

In the selection of GHG mitigation options in the IPPU sector for the revised NDC1, criteria to be used for assessment include:

- *Availability of technology*: Technologies are available and have been applied domestically and abroad, especially those that have been applied in practice and have high potential for scaling-up, bringing high efficiency.
- *Mitigation potential*: Priority is given to high potential emissions reduction options, especially those in sectors with high emissions levels and are closely linked to specific items as set out in the Sectoral Strategy and Development Plans.
- *Economic efficiency*: Selecting technology options that are in line with the development strategy of enterprises and have high economic efficiency including low mitigation costs (USD/tCO_2e), moderate total investment, and fast capital recovery time.
- *Co-benefits:* the selected mitigation options also bring co-benefits to the economy, society, and environment.

Based on the above criteria and the supply of clinker alternative additives provided by the Ministry of Construction, the cement industry mitigation options are described in Table 20.

Table 20: Assumptions for mitigation options in cement production

Option	Implementation period	Assumption
I1. GBFS grinding to replace clinker in cement component	2021-2030	By 2030, GBFS will replace the 10% reduction in clinker quantity, contributing to bringing clinker content in cement from 83% in 2020 to 76% in 2025 and 69% in 2030 with the cement production scenario of 1,348 kg/person/year
I2. Fly ash grinding to replace clinker in cement component	2021-2030	By 2030, fly ash will replace the 25% reduction of clinker quantity, contributing to bringing clinker content in cement from 83% in 2020 to 76% in 2025 and 69% in 2030 with the cement production scenario of 1,348 kg/person/year
I3. Pozzolana grinding to replace clinker in cement component	2021-2030	By 2030, pozzolana will replace the 25% reduction of clinker quantity, contributing to bringing clinker content in cement from 83% in 2020 to 76% in 2025 and 69% in 2030 with the cement production scenario of 1,348 kg/person/year
I4. Limestone grinding to replace clinker in cement component	2021-2030	By 2030, limestone will replace the 40% reduction in clinker quantity, contributing to bringing clinker content in cement from 83% in 2020 to 76% in 2025 and 69% in 2030 with the cement production scenario of 1,348 kg/person/year

According to the report of the Northern Europe Vietnam Partnership Pilot Program, these additives can replace clinker at different ratios in each factory. However, in order to achieve the reduction of clinker volume by 69% under the mitigation scenario for the whole cement industry, the above additives (GBFS: fly ash: Pozzolana: limestone) are to replace clinker at a ratio of (10:25:25:40).

2) Assumptions for nitric acid production

The assumption to develop mitigation options for nitric acid production is based on Vietnam's participation in the NACAG project, which aims to reduce N_2O emissions for the nitric acid manufacturing industry. Accordingly, when installing minimizing technology, N_2O emissions may be reduced by up to 98%. The company able to receive funding from the above project is Vinacomin-Mining Chemical Industry Holding Corporation Ltd.

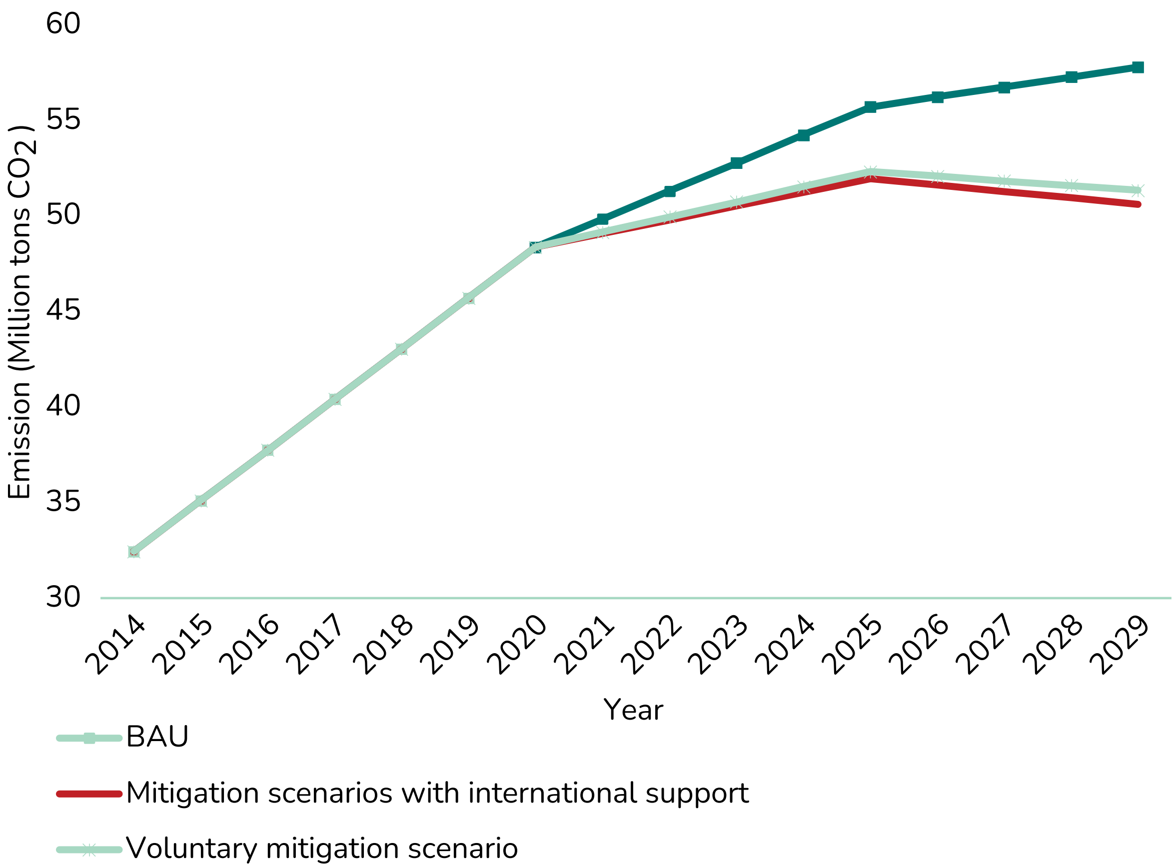
4.2. Results

4.2.1. Mitigation potential and cost of options in the IPPU sector

1) Mitigation options in the cement industry

CO_2 emissions in the cement industry under 2 scenarios: BAU scenario (cement output 1,348 kg/person/year with 80% clinker) and mitigation scenario (cement output 1,348kg/person/year with 69% clinker) are described in Figure 6.

Figure 6: CO_2 emissions of the scenarios in cement production



Data on CO_2 emissions from the cement industry according to the scenarios for each year (2014-2030 period) are presented in Table A.3 (Annex).

The mitigation potential of cement production is calculated based on updated data from the Ministry of Construction. The cost data are estimated based on the cement NAMA corresponding to voluntary and international support mitigation scenarios (Table 21).

Table 21: Cost and mitigation potential in cement production

Options	Mitigation potential ($MtCO_2e$)						Mitigation cost * (USD/tCO_2e)	
	2015-2030		2025		2030			
	Voluntary	International support	Voluntary	International support	Voluntary	International support	Voluntary	International support
I1. GBFS grinding to replace clinker in cement component	0	4.28	0	0.38	0	0.80		-50
I2. Fly ash grinding to replace clinker in cement component	10.71	0	0.94	0	2.00	0	-50	
I3. Pozzolana grinding to replace clinker in cement component	10.71	0	0.94	0	2.00	0	-61	
I4. Limestone grinding to replace clinker in cement component	17.14	0	1.5	0	3.21	0	-64	
Total	**38.56**	**4.28**	**3.38**	**0.38**	**7.21**	**0.80**		

**Converted to 2014 with a discount factor 10%*

2) Mitigation options for nitric acid production

For nitric acid production: applying BAT technology at MICCO's factory to reduce N_2O emissions (which can reduce up to 98% N_2O), leading to 80% reduction in N_2O emissions from nitric acid production compared to the BAU scenario. Thus, emissions from nitric acid production can be reduced as follows:

Table 22: CO_2 emissions in the IPPU sector for the scenarios

Unit: $MtCO_2e$

Year	2014	2020	2025	2030
BAU scenario	0.04	0.39	0.39	0.39
International support scenario	0.04	0.08	0.08	0.08
Mitigation potential	0	0.31	0.31	0.31

The CO_2 emissions from nitric acid production for all years in the period 2014-2030 are shown in Table A.4.

The nitric acid industry's capacity to reduce greenhouse gas emissions is calculated based on 85-98% reduction efficiency, depending on the type of technology applied. The mitigation cost to nitric acid industry is as follows:

Table 23: Cost and mitigation potential in cement production

Mitigation option	Mitigation potential ($MtCO_2e$)						Mitigation cost * (USD/tCO_2e)	
	2015-2030		2025		2030			
	Voluntary	International support	Voluntary	International support	Voluntary	International support	Voluntary	International support
I5. Installation of BAT technology to reduce N_2O emissions.	0.00	2.70 – 3.06	0.00	0.30 – 0.34	0.00	0.30 – 0.34	0.00	0.46 – 1.34

Emissions reduction costs are calculated to include initial investment costs, engineering, training, and supervision of the installation of emissions reduction equipment. Operating costs will be met by the plants.

3) Mitigation scenario

CO_2 emissions of BAU and mitigation scenarios for IPPU are shown in Table 24 and Figure 7:

Table 24: CO_2 emissions in the IPPU sector for the scenarios

Unit: $MtCO_2e$

Year	2014	2020	2025	2030
BAU scenario	38.66	81.13	116.40	140.87
Voluntary mitigation scenario	38.66	81.13	113.33	133.66
CO_2 reduction with voluntary mitigation scenario	0	0	3.07	7.21
Mitigation scenario with international support	38.62	81.13	112.68	132.55
CO_2 reduction with international support mitigation scenario	0	0	3.72	8.32

The CO_2 emissions from the IPPU sector for each year in the 2014-2030 period is presented in Table A.4.

Thus, with international and voluntary mitigation measures, emissions for the BAU scenario have been significantly reduced:

» For the voluntary mitigation scenario, in 2030, CO_2 emissions will be 133.07 million tons, 7.21 million tons lower than the BAU scenario, equivalent to a reduction of 5.14%.

» For the mitigation scenario with international support, in 2030, CO_2 emissions will be 132.54 million tons, 8.32 million tons lower than the BAU scenario, equivalent to a reduction of 5.92 %.

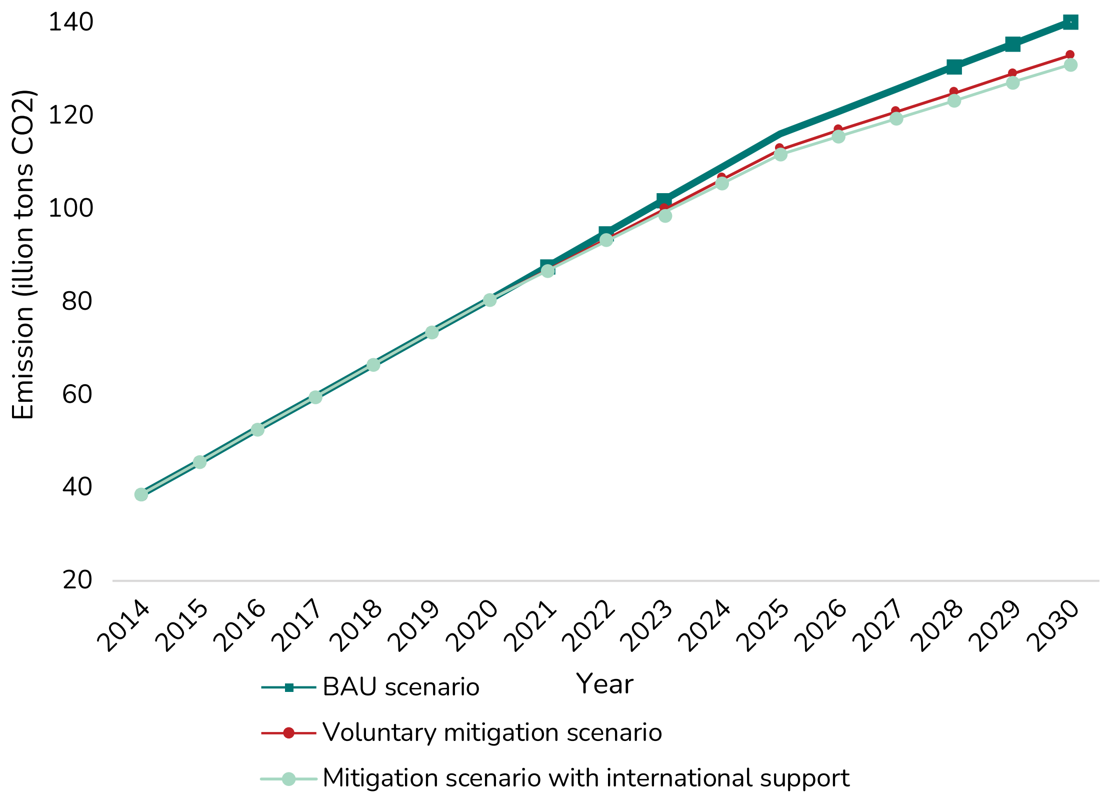


Figure 7: CO_2 emissions for the scenarios

4.2.2. Impact assessment of mitigation options on society, economy, and environment

The implementation of options in the cement industry has some positive effects as summarized in Table 25.

» Economy:

✓ Reducing energy consumption in clinker grinding leads to energy saving from clinker production.

✓ Attaining relatively high economic efficiency because the cost to produce high quality clinker is not much higher than the average grade of clinker production, while the cost of mineral additives is equal to 1/4 -1/5 of the clinker price. According to calculations, every 1% increase in additives in PCB30 cement will reduce production costs by about 3,000 VND/ton.

» Social: Positive impact on the health of people surrounding clinker production plants.

» Environment:

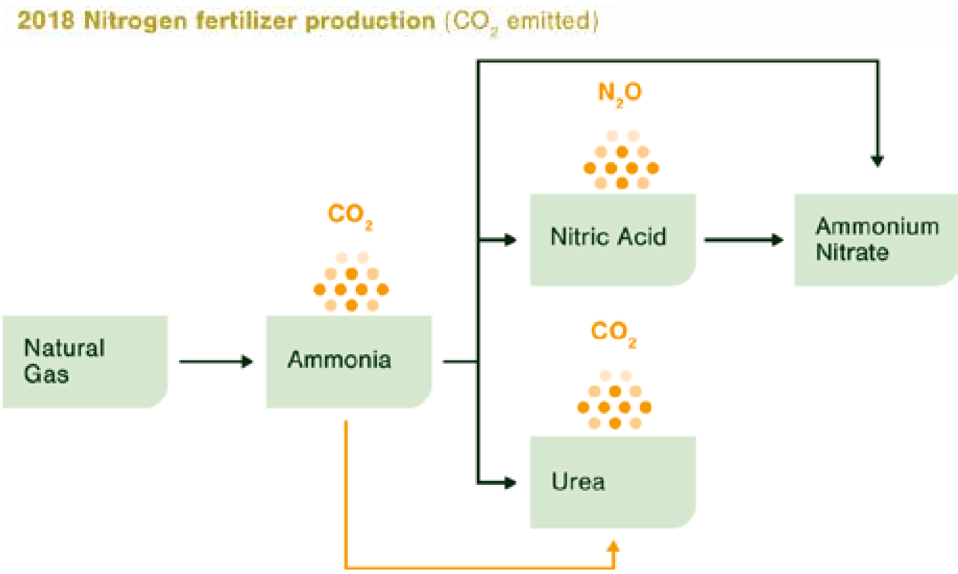
✓ Reduced environmental pollution in clinker grinding process by reducing clinker production.

✓ Using waste steel slag to contribute to reducing environmental pollution caused by landfills.

Table 25: Summary of the positive effects of mitigation options

Options	Energy and materials	Environment
I1. GBFS grinding to replace clinker in cement component	Energy consumption can be reduced from 0.42 - 1.88 GJ/ton of cement with cement containing 30 to 70% GBFS	For each ton of clinker saved by the mitigation option, the reduction will be: Dust: from 0.01 to 0.4 mg. NO_x: from 0.4 to 6 mg SO_2: from 0.02 to 7mg CO: from 1 to 4 mg TOC: 0.01 to 1 mg HF: from 0.8 to 10 g HCl: from 2 to 50 g PCDD/F: from 200 to 1000 ng Hg: from 20 to 600 mg
I2. Fly ash grinding to replace clinker in cement component	Can save 3.58 GJ energy for each ton of clinker replacement	
I3. Pozzolana grinding to replace clinker in cement component	Use of heat energy reduced from 0-600 MJ/ton of cement; use of electricity reduced from 0 to 25 KWh/ton of cement	
I4. Limestone grinding to replace clinker in cement component	For cement from 25 to 35% of limestone, the heat energy demand will be reduced from 0.22 to 0.60 GJ/ton of cement. Electricity demand will also decrease by 12–23 kWh/ton of cement	

05. Requirements for implementation of mitigation options in the IPPU Sector



5.1. Finance

The financial requirements for voluntary mitigation options for the cement industry range from USD 18.07 to USD 543.36 million. The financial needs for options with international support are similar, due to the fact that international support is given only to the application of GBFS to replace clinker. The financial need for voluntary options to 2030 is USD 713.85 million and the financial need for options with international support ranges from USD 198.84 to USD 201.1 million. The total financial need for voluntary options and international support ranges from USD 912.7 to USD 914.9 million (Table 26)

To replace clinker in cement, the above materials also need to go through processing to meet the mixing requirements[1], especially fly ash. To be used as a clinker alternative, fly ash must be treated through foam flotation, triboelectrostatic separation. This new technology is being developed. Special grinding methods are also being studied to increase the reaction speed of fly ash, thereby increasing the content of fly ash in cement.

Financial needs, including initial investment costs, engineering, training, supervision and operation range from USD 0.96 million to USD 3.22 million depending on the type

[1] Climate Technology Centre and Network (CTCN) - UNEP

of N_2O reduction technology. The NACAG focuses all initial investments on engineering, training and monitoring. It is assumed operating costs will be met by plants.

Table 26: Financial needs for mitigation options in the cement industry

Options	Mitigation potential cumulative to 2030 (MtCO2e/year)		Financial needs to 2030 (million USD)	
	Voluntary	International support	Voluntary	International support
I1. GBFS grinding to replace clinker in cement component	0	4.28	0	197.88
I2. Fly ash grinding to replace clinker in cement component	10.71	0	543.36	0
I3. Pozzolana grinding to replace clinker in cement component	10.71	0	152.42	0
I4. Limestone grinding to replace clinker in cement component	17.14	0	18.07	0
I5. Installation of BAT technology to reduce N_2O emissions	0	2.70 – 3.06	0	0.96 – 3.22
Total	**38.56**	**6.98-7.34**	**713.85**	**198.84-201.1**

5.2. Policies, Technology and Capacity Building

Regarding policies, the mitigation options in this report are carefully proposed based on existing policies; i.e. they can be implemented without additional policies. Therefore, according to the IP expert's opinion, it is necessary to assess how these mitigation options will be implemented after several years so supporting policies can be proposed if necessary. Besides, according to the IP expert, the mitigation options in the IPPU sector can be implemented without any further technical support. At present, due to a lack of information on the cost of mitigation options in the steel industry, it is difficult to implement mitigation options or apply for technology support.

In terms of capacity building, apart from the cement and steel industries, the size of IPPU industries is small, so capacity building in these sub-sectors will not be helpful. However, according to expert opinion, it is helpful to have capacity building in GHG inventories for the IPPU sector as currently this sector has yet to receive substantial international support. Although there was a recent GIZ project on GHG inventory of ozone-depleting substances, most of the calculations were conducted by foreign experts, so the data could not be checked or publicized. From that perspective, future international support on GHG inventory in the IPPU sector should be focused on data collection and calculation so that Vietnamese experts can implement the GHG inventory by themselves; or have the detailed databases published so that those reports can be used more effectively.

06. Measurement, Reporting and Verification for mitigation activities in the IPPU sector

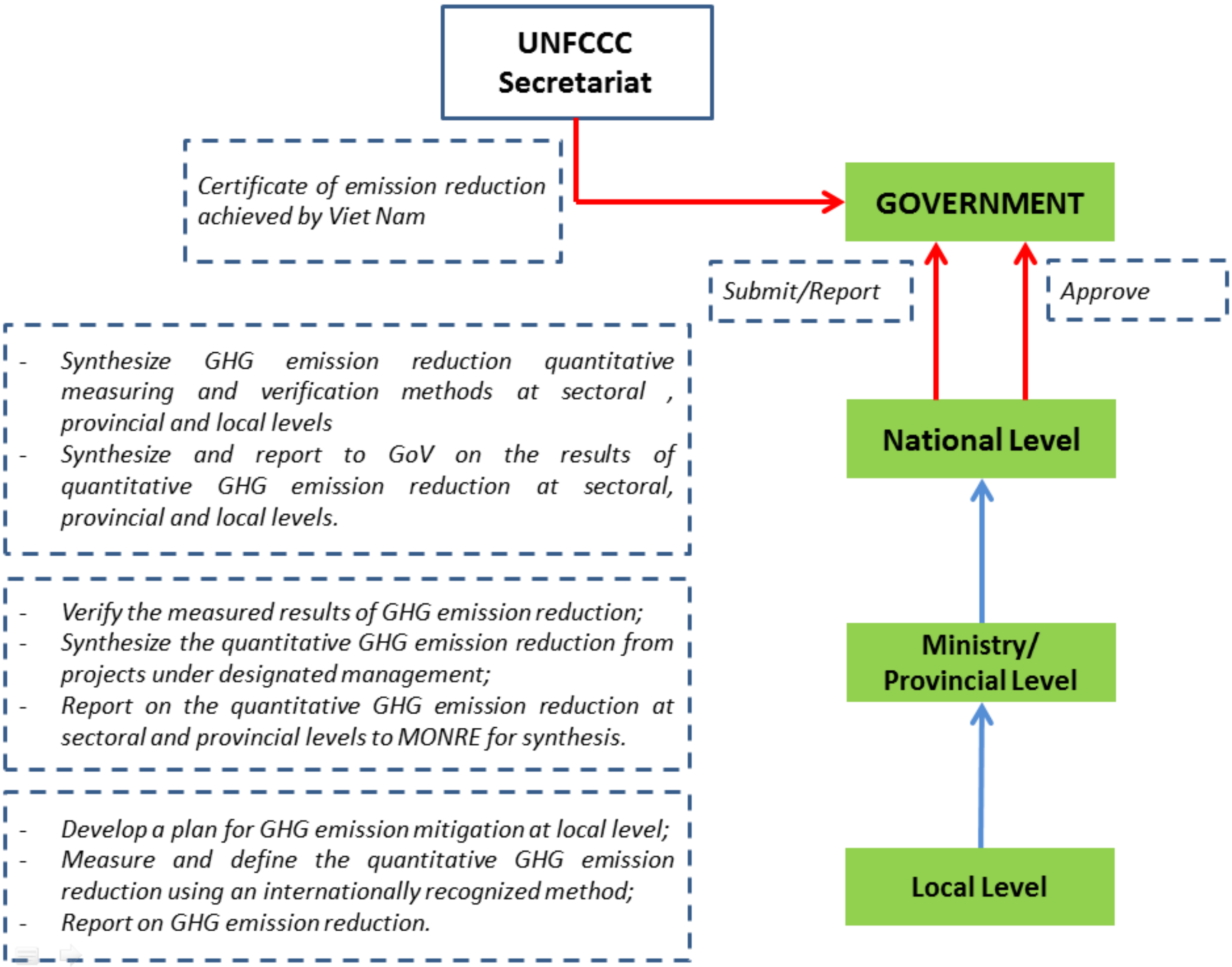
6.1. Measurement, Reporting and Verification at national level

The establishment of a Measurement, Reporting and Verification (MRV) system at national, sectoral and local levels is necessary in order to assess the implementation and impact of each action to reduce GHG emissions as well as to ensure GHG emission reduction targets in the NDC are achieved. Decision No. 2053/QD-TTg dated October 28th, 2016 of the Prime Minister approving the Plan for Implementation of the Paris Agreement stipulated the tasks to be executed in the period 2016-2020, in which the establishment of the MRV system is one of the key tasks in the period 2018-2010.

The national MRV system was proposed in the Third National Communication of Vietnam, and is illustrated in Figure 8.

Figure 8: The proposed MRV system at the national level

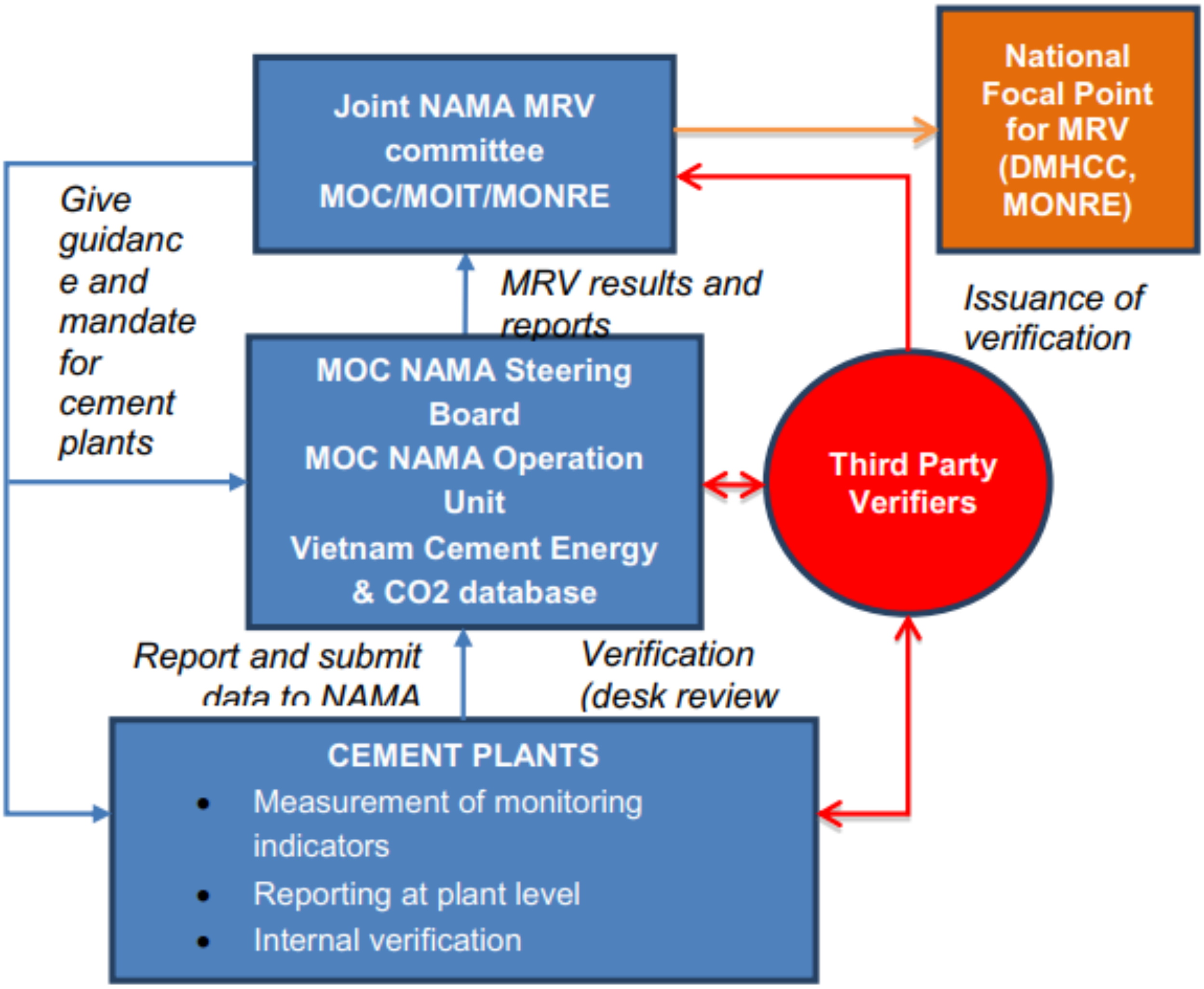
Source: MONRE (2019)



6.2. Measurement, Reporting and Verification for mitigation activities in the IPPU Sector

An example of the MRV system designed for a NAMA in the cement sector developed by the Ministry of Construction and other related ministries and agencies, was illustrated in the Third National Communication of Vietnam.

Figure 9: Institutions for MRV NAMA cement in Vietnam



To implement the designed MRV system at the plant level in Vietnam at international standards, the highest priority is to standardize the MRV system and formally regulate its implementation at the plant level. A new regulation on mandatory GHG reporting should be developed and adopted that regulates the major aspects, including: description of the reporting procedure and requirements; mandatory reporting format for the companies to present the data in line with the centralized MRV system requirements; and incentives for companies to provide reports

To address the major gap in data needs and practices in MRV of non-GHG emissions at the sector level, MOC should take the leading role to propose practices for designing and implementing MRV at the sector level in a close consultation and consensus with other relevant authorities as well as donors, once they are identified.

A NAMA design should create sufficient incentives and/or rewards to cement plants/companies that voluntarily reduce their GHG emissions beyond BAU. Such incentives will increase the willingness and commitment of cement companies to perform MRV.

Providing suitable training and capacity building for technicians and people in charge in the cement plants should be conducted in parallel in order to achieve effective and proper MRV practices as designed.

At the sectoral level, the basic technical infrastructure - the database that meets the international (CSI) standard has been set up under this project activity. The biggest challenge is to update the database on a regular basis. The roles of MOC and different options to manage the database were elaborated in the previous section.

The second challenge is to define a suitable structure and roles for entities to perform regular verification at both plant and sector levels. To a certain extent, MOC as a management agency of the MRV system could take over the task, especially at the plant level. However, it is highly recommended to allocate and regulate verification so that an independent third party(ies) can reform the service. This will reduce the burden on resource demands on the governmental budget on the one hand and increase the transparency and creditability of the system on the other.

Conclusion

According to the GHG inventory result for the IPPU sector, the cement sub-sector is the biggest emitter of GHGs at up to 84.55%, while total GHG emissions of the remaining 6 sub-sectors account for only 15.45%.

Forecast scenarios and calculation results show that the chemical industry produces only 4.56% of the sector's GHG emissions, a much smaller amount than the other two sub-sectors.

In the mineral industry, the cement sub-sector is responsible for up to 87.02% of GHG emissions. Similarly, in the metal industry, the iron and steel sub-sector is responsible for up to 96.47%.

This study has determined the GHG emissions reduction potential compared to the BAU and the contribution of the IPPU sector to Vietnam's revised NDC1 for the 2021-2030 period based on application of the 2006 IPCC Guidelines and the selection of prioritized mitigation technologies for the IPPU sector. Vietnam has sufficient potential to reduce GHG emissions for the cement industry at a rate of 5.14% in the voluntary mitigation scenario, and 6.14% in the international support scenario.

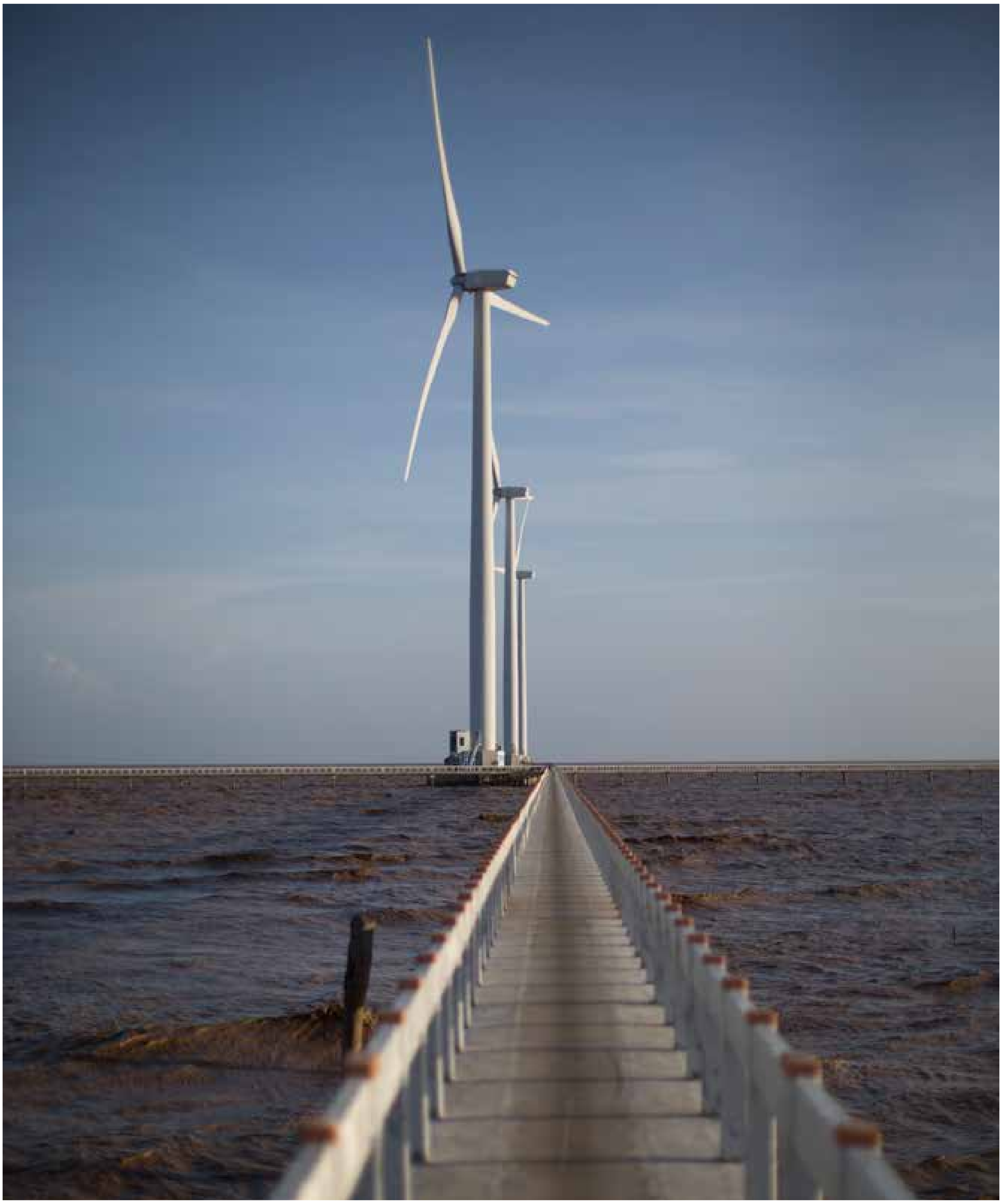
Mitigation in the IPPU sector was proposed in two sub-sectors: cement production and nitric acid production. Regarding cement production, four mitigation options were proposed, including: 1. GBFS grinding to replace clinker in cement component; 2. Fly ash grinding to replace clinker in cement component; 3. Pozzolana grinding to replace clinker in cement component; and 4. Limestone grinding to replace clinker in cement component. In nitric acid production, the application of BAT technology at the MICCO factory was proposed to reduce N_2O emissions.

As a result, with international and voluntary mitigation measures, the amount of CO_2 emissions can be significantly reduced compared to the BAU scenario. For the voluntary mitigation scenario, in 2030, CO_2 emissions in the mitigation scenario will be 133.07 million tons, which is 7.21 million tons CO_2e lower than the BAU scenario, equivalent to a reduction of 5.14%. Regarding the mitigation scenario with international support, in 2030, CO_2 emissions will be 131.07 million tons, which is 8.32 million tons CO_2e lower than the BAU scenario, equivalent to a reduction of 5.92%. For nitric acid production, with international support, the potential to reduce greenhouse gas emissions is enormous (80% reduction compared to the BAU scenario for nitric acid production).

The total amount of domestic funding needed to achieve a GHG reduction of 5.14% compared to the BAU scenario by 2030 is USD 713.85 million. An additional USD 198.84 million to USD 201.1 million would need to be mobilized from international sources in order to achieve the total GHG emissions reduction of 5.92% compared to the BAU scenario by 2030. The total financial need for voluntary options and international support ranges from USD 912.7 million to USD 914.9 million.

The implementation of mitigation options in cement production can also bring positive impacts on the economy (e.g. reducing energy consumption in clinker grinding), society (e.g. improving people's health), and the environment.

In order to achieve its mitigation targets, the study also recognizes the barriers and constraints in terms of policy, technology, finance and capacity building with a corresponding proposal to overcome those barriers. Regarding policies and technology, the mitigation options in this report were carefully proposed based on existing policies and available technology so at present no additional policies or technology support is needed. However, capacity building in GHG inventory for the IPPU sector should be improved.



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Annex

Table A.1: Gas emissions in coke manufacturing

Parameter	Emission level, kg/ton of coke
VOC	0.3
Benzene	0.1
Flying dust	0.15
Sulphur oxide	0.5
Nitrogen Oxide	0.6
Total Phenol	0.5
Total Cyanide	0.2

Table A.2: Wastewater in coke manufacturing

Parameter	Emission level. g/ton of coke
COD	100
Benzene	0.015
Total Nitrogen	12
Cyanide	0.03
Phenol	0.15

Table A.3: CO_2 emissions from the IPPU sector in the period 2014-2030

Unit: $MtCO_2e$

Year	2014	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU scenario	38.62	81.13	88.18	95.24	102.29	109.35	116.40	121.29	126.19	131.08	135.98	140.87
Voluntary mitigation scenario	38.62	81.13	87.57	94.01	100.45	106.89	113.33	117.40	121.46	125.53	129.60	133.66
CO_2 reduction with voluntary scenario	0	0	0.61	1.23	1.84	2.46	3.07	3.89	4.73	5.55	6.38	7.21

Year	2014	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Mitigation scenario with international support	38.62	81.13	87.44	93.75	100.06	106.37	112.68	116.65	120.63	124.60	128.58	132.55
CO_2 reduction with international support mitigation scenario	0	0	0.74	1.49	2.23	2.98	3.72	4.64	5.56	6.48	7.4	8.32

Table A.4: CO_2 emissions from the cement sector in the period 2014-2030

Unit: $MtCO_2e$

Year	2014	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU scenario	0.04	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Mitigation scenario with international support	0.04	0.39	0.39	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
CO_2 reduction with international support mitigation scenario	0	0	0	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

Table A.5: CO_2 emissions in cement production in period 2014-2030

Unit: $MtCO_2e$

Year	2014	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU scenario	32.44	48.35	49.75	51.15	52.55	53.95	55.35	55.94	56.53	57.11	57.70	58.29
Voluntary mitigation scenario	32.44	48.35	49.14	49.92	50.71	51.49	52.28	52.04	51.81	51.56	51.32	51.08
CO_2 reduction with voluntary mitigation scenario	0.00	0.00	0.61	1.23	1.84	2.46	3.07	3.90	4.72	5.55	6.38	7.21
Mitigation scenario with international support	32.44	48.35	49.07	49.79	50.50	51.22	51.94	51.61	51.28	50.94	50.61	50.28
CO_2 reduction with international support mitigation scenario	0.00	0.00	0.68	1.36	2.05	2.73	3.41	4.33	5.25	6.17	7.09	8.01

Table A.6: Investment cost for mitigation options of the IPPU sector in case of conditional contribution

Unit: million USD

Investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	All periods
I1. GBFS grinding to replace clinker	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	7.79
I5. Installation of BAT technology to reduce N_2O emissions	0	0.32 - 1.07	0.32 - 1.07	0.32 - 1.07	0	0	0	0	0	0	0	0.96 – 3.22
Sum by year	0.71	1.03 - 1.78	1.03 - 1.78	1.03 - 1.78	0.71	0.71	0.71	0.71	0.71	0.71	0.71	8.75 – 11.01

Table A.7: Operating costs for mitigation options for the IPPU sector in case of conditional contribution

Unit: million USD

Operating cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	All periods
I1. GBFS grinding to replace clinker	2.88	5.76	8.64	11.52	14.40	17.28	20.16	23.04	25.92	28.80	31.68	190.09
I5. Installation of BAT technology to reduce N_2O emissions	0	0	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.48 – 0.68
Sum by year	2.88	5.76	8.693 - 8.716	11.573 - 11.596	14.453 - 14.476	17.333 - 17.356	20.213 - 20.236	23.093 - 23.116	25.973 - 25.996	28.853 - 28.876	31.733 - 31.756	190.57 - 190.77

Note: Operating costs of option "I5. Installation of technology to reduce N_2O emissions" are paid by the plant when receiving NACAG investment.

Table A.8: Total cost for mitigation options of the IPPU sector in case of conditional contribution

Unit: million USD

Total cost (Investment + Operation)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	All periods
I1. GBFS grinding to replace clinker	3.59	6.47	9.35	12.23	15.11	17.99	20.87	23.75	26.63	29.51	32.39	197.89
I5. Installation of BAT technology to reduce N_2O emissions	0	0	0.373 – 1.146	0.373 – 1.146	0.373 – 1.146	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	0.053 – 0.076	1.437 – 3.894
Sum by year	3.59	6.47	9.723 - 10.496	12.603 - 13.376	15.483 - 16.256	18.043 - 18.066	20.923 - 20.946	23.803 - 23.826	26.683 - 26.706	29.563 - 29.586	32.443 - 32.466	199.327 - 201.784

Table A.9: Investment costs for mitigation options for the IPPU sector in case of unconditional contribution

Unit: million USD

Investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	All periods
I2. Fly ash grinding to replace clinker	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	3.96
I3. Pozzolana grinding to replace clinker	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	1.65
I4. Limestone grinding to replace clinker	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	3.74
Sum by year	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	9.35

Table A.10: Operating costs for mitigation options for the IPPU sector in case of unconditional contribution

Unit: million USD

Operating cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	All periods
I2. Fly ash grinding to replace clinker	1.88	3.76	5.63	7.51	9.39	11.27	13.15	15.03	16.90	18.78	20.66	123.96
I3. Pozzolana grinding to replace clinker	0.60	1.19	1.79	2.39	2.99	3.58	4.18	4.78	5.38	5.97	6.57	39.42
I4. Limestone grinding to replace clinker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum by year	2.48	4.95	7.42	9.9	12.38	14.85	17.33	19.81	22.28	24.75	27.23	163.38

Table A.11: Total cost for mitigation options for the IPPU in case of unconditional contribution

Unit: million USD

Total cost (Investment + Operation)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	All periods
I2. Fly ash grinding to replace clinker	2.24	4.12	5.99	7.87	9.75	11.63	13.51	15.39	17.26	19.14	21.02	127.92
I3. Pozzolana grinding to replace clinker	0.75	1.34	1.94	2.54	3.14	3.73	4.33	4.93	5.53	6.12	6.72	41.07
I4. Limestone grinding to replace clinker	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	3.74
Sum by year	3.33	5.8	8.27	10.75	13.23	15.7	18.18	20.66	23.13	25.6	28.08	172.73

Table A.12: Potential of emissions reduction in case of unconditional contribution

Unit: $MtCO_2e$

Voluntary	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	All periods
I2. Fly ash grinding to replace clinker	0.04	0.09	0.13	0.18	0.22	0.27	0.31	0.35	0.40	0.44	0.49	2.93
I3. Pozzolana grinding to replace clinker	0.04	0.09	0.13	0.18	0.22	0.27	0.31	0.35	0.40	0.44	0.49	2.93
I4. Limestone grinding to replace clinker	0.07	0.14	0.21	0.28	0.35	0.43	0.50	0.57	0.64	0.71	0.78	4.68
Sum by year	0.15	0.32	0.47	0.64	0.79	0.97	1.12	1.27	1.44	1.59	1.76	10.54

Table A.13: Potential of emissions reduction in case of conditional contribution

Unit: $MtCO_2e$

International support	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	All periods
I1. GBFS grinding to replace clinker	0.08	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.83	0.92	5.50
I5. Installation of BAT technology to reduce N_2O emissions	0	0	0.30 – 0.34	0.30 – 0.34	0.30 – 0.34	0.30 – 0.34	0.30 – 0.34	0.30 – 0.34	0.30 – 0.34	0.30 – 0.34	0.30 – 0.34	2.70 – 3.06
Sum by year	0.08	0.17	0.55 - 0.59	0.63 - 0.67	0.72 - 0.76	0.8 - 0.84	0.88 - 0.92	0.97 - 1.01	1.05 - 1.09	1.13 - 1.17	1.22 - 1.26	8.2 - 8.56

International Climate Initiative (IKI)

This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag

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Published by:
GIZ Office Vietnam
Project "Support to Vietnam for the Implementation of the Paris Agreement"

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