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# Environmental Impact Assessment of Greenhouse Gases as part of a Future Circular Industry

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*"We do not inherit the earth from our ancestors, we borrow it from our children"*

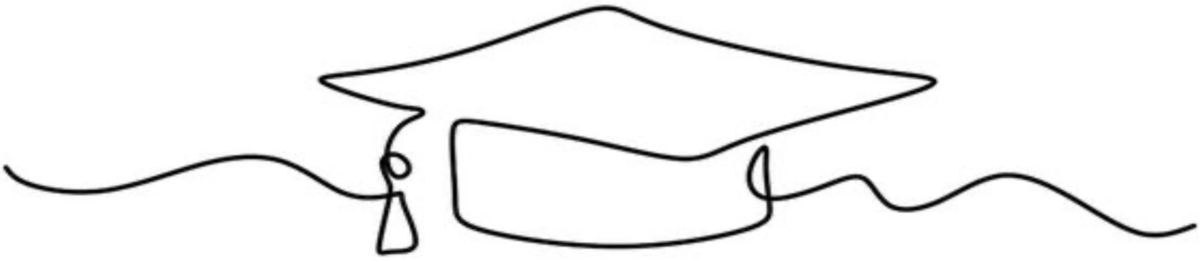
*Native American Proverb*

# Dedication

*To Our Families;*

*To Our Friends;*

*To All the people We love and cherish.*



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*To all our friends and colleagues, to everyone we met during this journey*

*And last but not least to my dearest friend, partner for sticking by me and helping me through this amazing journey.*

*Benmiloud Mohammed Zakaria*

*Blaila Mohamed El amine*

# ABSTRACT
# RÉSUMÉ

*Abstract*

The greenhouse effect is a process that occurs when gases in Earth's atmosphere such as (**$CO_2$**,**$CH_4$ , $NO_x$, $H_2O$**,**CFCs**) etc , trap the sun's heat. This process makes Earth much warmer than it would be without an atmosphere. The greenhouse effect is one of the reasons that makes earth a comfortable place to live in,

With the appearance of the industrial revolution, our activities and use of fossil fuels for energy have artificially increased greenhouse gases emissions in the atmosphere and by doing this we have altered a long running phenomenon. This had led to as what we know as climate change. This resulted in an increase in global warming due to temperatures rising that is by turn altering the planet's support systems in countless ways. So much so that life that we once knew is changing at a rapid pace, and for the first time in billions of years, we are witnessing un predicted catastrophic and rapid changes.

Our work aims first to understand the concept of planetary boundaries and all the concepts related to our subject of study, then to assess the gases dispersion in GP1Z complex using AERMOD modeling system and discuss their potential impact on the environment and people's lives. Finally, we conclude our work with reviewing the process of mitigation and offer some of the most innovative ways of greenhouse gases mitigation in what's called a future and circular industry.

**Keywords** : Greenhouse effect , Greenhouse gases , Industrial Revolution , Global warming , Climate change , Aermod dispersion model , future and circular industry , Mitigation , Planetary boundaries , Environmental impact .

# *Résumé*

L'effet de serre est un processus qui se produit lorsque des gaz présents dans l'atmosphère terrestre, tels que le **$CO_2$,** le **$CH_4$, le NOx, le $H_2O$ et les CFC**, piègent la chaleur du soleil. Ce processus rend la Terre beaucoup plus chaude qu'elle ne le serait sans atmosphère. L'effet de serre est l'une des raisons qui font de la Terre un endroit où il fait bon vivre,

Avec l'apparition de la révolution industrielle, nos activités et l'utilisation de combustibles fossiles comme source d'énergie ont augmenté artificiellement les émissions de gaz à effet de serre dans l'atmosphère et, ce faisant, nous avons modifié un phénomène de longue date. Cela a conduit à ce que nous appelons le changement climatique. Cela a entraîné une augmentation du réchauffement de la planète en raison de l'élévation des températures qui, à son tour, modifie les systèmes de soutien de la planète d'innombrables façons. A tel point que la vie que nous connaissions autrefois change à un rythme rapide, et pour la première fois depuis des milliards d'années, nous sommes témoins de changements catastrophiques et rapides non prévus.

Notre travail vise tout d'abord à comprendre le concept de frontières planétaires et tous les concepts liés à notre sujet d'étude, puis à évaluer la dispersion des gaz dans le complexe GP1Z en utilisant le système de modélisation AERMOD et à discuter de leur impact potentiel sur l'environnement et la vie des gens. Enfin, nous concluons notre travail en passant en revue le processus d'atténuation et proposons certaines des méthodes les plus innovantes d'atténuation des gaz à effet de serre dans ce que l'on appelle une industrie future et circulaire.



**Mots clés** : Effet de serre, Gaz à effet de serre, Révolution industrielle, Réchauffement climatique, Changement climatique, Modèle de dispersion Aermod, Industrie future et circulaire, Atténuation, Frontières planétaires, Impact environnemental..

| | |
|---|---|
| **CCS** | Carbon capture and storage |
| **CCUS** | Carbon Capture Utilization and Storage |
| **CFC** | Chlorofluorocarbon |
| **$CH_4$** | Methane |
| **CO** | Carbon oxide |
| **$CO_2$** | Carbon dioxide |
| **CPS** | Current Population Survey |
| **DNV** | Det Norske Veritas |
| **ENPEP** | Energy and Power Evaluation Program |
| **EOR** | Enhanced Oil Recovery |
| **FAO** | Food and Agriculture Organization |
| **GBP** | Global Business Projects |
| **GDP** | Gross Domestic Product |
| **GWP** | Global warming potential |
| **$H_2$** | Hydrogen |
| **$H_2O$** | Water |
| **HCFC** | Hydrochlorofluorocarbon |
| **HFC** | Hydrofluorocarbon |
| **INDC** | Intended Nationally Determined Contribution |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **ISO** | International Organization for standardization |
| **LEAP** | Long-range Energy Alternative Planning |
| **LNG** | Liquefied Natural Gas |
| **MARKAL** | Market Allocation Macro-economic model |
| **MIMEC** | Multisectoral, Intertemporal Model of Emissions Constraints |
| **NASA** | National Aeronautics and Space Administration |
| **NGO** | NonGovernmental Organization |
| **$NF_3$** | Nitrogene trifluoride |
| **$N_{OX}$** | Nitrogen oxides |
| **$N_2O$** | Nitrous oxide |

| | |
|---|---|
| **$O_2$** | Oxygen |
| **$O_3$** | Ozone |
| **OECD** | Organization for Economic Cooperation and Development |
| **PCB** | Polychlorinated Biphenyl |
| **PFC** | Perfluorocarbon |
| **PPM** | Part per million |
| **PSC** | Public Service Commission |
| **PPE** | Personal Protective Equipment |
| **$SF_6$** | Sulfur hexafluoride |
| **$SO_2$** | Sulfure dioxide |
| **$SO_x$** | Sulfure oxide |
| **STAIR** | Services, Transport, Agriculture, Industry, and Residential energy model |
| **TBL** | Triple Bottom Line |
| **UN** | United Nations |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **UV** | Ultraviolet |
| **WHO** | World Health Organization |
| **WN** | World nations |

# LIST OF FIGURES

# LIST OF TABLES

## *List of Figures*


Figure 1Decirptive diagram of a biosphere ............ 5
Figure 2Descriptive diagram of the different layers of the atmosphere ............ 6
Figure 3 Consequences of air pollution ............ 8
Figure 4 natural and artificial greenhouse effect ............ 9
Figure 5 Water cycle ............ 18
Figure 6 Carbon cycle ............ 19
Figure 7nitrogen cycle ............ 20
Figure 8 hazard , risk and risk level representation ............ 26
Figure 9 Control measures............ 27
Figure 10 Steps of Carrying risk assessments ............ 29
Figure 11 Global temperature variation ............ 48
Figure 12 Earth stability throughout the Holocene ............ 49
Figure 13 Variations of World population,CO2,Remaining Wilderness ............ 50
Figure 14 Carbon dioxide concentrations over the Holocene ............ 51
Figure 15 Planetary boundaries ............ 54
Figure 16 Location and vicinity of the GP1/Z complex ............ 57
Figure 17 Storage bins ............ 58
Figure 18 Storage spheres ............ 59
Figure 19 LPG Processing Trains ............ 59
Figure 21 Ships loading ............ 60
Figure 20 Truck loading ............ 60
Figure 22 Control room ............ 60
Figure 23 Seawater desalination ............ 60
Figure 24  schmatic diagram of the process ............ 64
Figure 25 Ground plan of the complex ............ 67
Figure 26 Organizational chart of GP1Z ............ 68
Figure 27 TESTO 350XL ............ 69
Figure 28 Testo 350XL ............ 70
Figure 29 AERMOD MODELING SYSTEM ............ 74
Figure 30 Method 1 Sytax, Type and Order ............ 75
Figure 31 Method 2 Syntax, Type and Order ............ 76

Figure 32 Figure 32 Wind rose of surface and profile from(a) blowing from (b) blowing to82

Figure 34 Dispersion pattern of CO2 ........ 84

Figure 35 NOx during the 1hour peak, averaging times (December) ........ 84

Figure 36 Structure of a Sectoral Mitigation Assessment ........ 90

Figure 37 Discrete Step CO2 - Reduction Cost Curve ........ 101

Figure 38Continuous Cost Curve ........ 102

Figure 39 Marginal, Incremental, and Average Cost Curves ........ 102

Figure 40 Princpal design keys for indusrty 4.0 ........ 109

Figure 41 carbon capture process ........ 111

Figure 42Carbon Capture Principle ........ 112

Figure 43 pre-combustion carbon capture ........ 113

Figure 44 post-combustion carbon capture ........ 114

Figure 45 oxy-fuel-combustion carbon capture ........ 114

Figure 46 Carbon transport ........ 117

Figure 47 Carbon storage ........ 119

Figure 48 Carbon CCU processes ........ 120

Figure 49 Large-scale CO2 capture projects in industry and transformation, actual vs. Net Zero Scenario, 2020-2030 ........ 121

Figure 50 Operating CO2 capture projects in industry and fuel transformation ........ 122

Figure 51 Capacity of CO2 capture projects in operation and under development in the industry and fuel transformation sectors by application ........ 123

Figure 52Global pipeline of commercial CCUS facilities operating and in development, 2010-2021 ........ 124

Figure 53 Carbon direct air capture process ........ 125

Figure 54 pellet process for direct air capture ........ 126

Figure 55 Direct air capture rate ........ 126

Figure 56 The deference between carbon capture and direct air capture ........ 127

# *List of Tables*


Table 1 Greenhouse gases ........................................................................................ 13

Table 2 Laws of Hydrocarbon activity safety concept and environment ........................... 31

Table 3Executives decrees of hydrocarbons activity safety concept and environment ...... 35

Table 4 presidential decrees of hydrocarbon activity safety legislation concept and environment ........................................................................................................................ 38

Table 5 Subchapter C Air Programs.................................................................................. 42

Table 6 Construction history of the GP1Z complex ......................................................... 56

Table 7 STATISTICS OF GREENHOUSE GASES EMISSIONS OF MARCH 2021 ..... 71

Table 8 Table 8 8STATISTICS OF GREENHOUSE GASES EMISSIONS JUNE 2021 71

Table 9 STATISTICS OF GREENHOUSE GASES EMISSIONS DECEMBRE 2021 ... 72

Table 10 AERMOD functions for particle and gas removal ............................................. 76

Table 11 The monitoring of CO, NOx emission in Mars 2021 .......................................... 78

Table 12 The monitoring of CO, NOx emission in juin 2021 ............................................ 78

Table 13 The monitoring of CO, NOx emission in December 2021.................................. 79

Table 14 Peak Values of CO2 ........................................................................................... 83

Table 15 Peak Values of NOx ........................................................................................... 83

Table 16 Examples of Analytical Tools Available for Mitigation Assessments................. 93

Table 17 Criteria for screen of mitigation options ............................................................ 96

Table 18 Numerical Estimates of Global Warming Potential .......................................... 103

Table 19 advantages and disadvantages of each process ................................................ 115

# Table of contents

**PROVERB**

**DEDICATION**

**ACKNOWLEDGEMENTS**

**ABSTRACT**

**RÉSUMÉ**

**ACRONYMS, INITIALISMS, AND ABBREVIATIONS**

**LIST OF FIGURES**

**LIST OF TABLES**

**GLOSSARY**

**GENERAL INTRODUCTION……………….…………………………………….…1**

## CHAPTER I: DEFINITIONS AND BASIC CONCEPTS

***INTRODUCTION* ........................................................................................... 3**

***I.1 ENVIRONMENT RELATED CONCEPTS AND DEFINITIONS*............................ 3**

**I.1.1 Environment ....................................................................................... 3**
**I.1.1.1 Defined by the ISO 14001.................................................................. 3**
**I.1.1.2 Environmental aspect ........................................................................ 3**
**I.1.1.3 Environmental impact ....................................................................... 3**

**I.1.2 Ecosystem........................................................................................... 3**

**I.1.3 Biomes.................................................................................................. 4**

**I.1.4 Biotic and abiotic factors ................................................................. 4**

**I.1.5 Fauna .................................................................................................... 4**

**I.1.7 Biosphere............................................................................................. 4**
**I.1.7.2 Hydrosphere ....................................................................................... 5**
**I.1.7.3 Atmosphere......................................................................................... 5**
**I.1.7.3.2 Stratosphere...................................................................................... 6**
**I.1.7.3.3 Mesosphere ....................................................................................... 7**
**I.1.7.3.4 Thermosphere ................................................................................... 7**
**I.1.7.3.5 Exosphere.......................................................................................... 7**
**I.1.7.3.6 Tropopause and stratopause ............................................................ 7**
**I.1.8 Gas ....................................................................................................... 7**
**I.1.9 Pollution .............................................................................................. 7**
**I.1.9.2 Soil pollution........................................................................................ 7**

**I.1.9.3 Light pollution** ........ 7
**I.1.9.4 Noise pollution** ........ 8
**I.1.9.5 Air pollution** ........ 8
**I.1.9.5.1 Consequences of air pollution** ........ 8
**I.1.10 Greenhouse effect** ........ 9
**I.1.11 Name Origin** ........ 10
**I.1.12 Greenhouse Gases** ........ 11
**I.1.13 The Greenhouse effect's implications** ........ 16
**I.1.13.1 Glacial masses thaw** ........ 16
**I.1.13.2 Coastal communities and islands floods** ........ 16
**I.1.13.3 Hurricanes increased danger of destruction** ........ 16
**I.1.13.4 Species migration** ........ 17
**I.1.13.5 Fertile places desertification** ........ 17
**I.1.13.6 The impact on agriculture and livestock** ........ 17
**I.1.14.1 Food scarcity** ........ 17
**I.1.14.2 Disease spread and pandemics** ........ 17
**I.1.15 A greenhouse** ........ 17
**I.1.16 Ozone depletion** ........ 18
**I.1.17 Biogeochemical cycle** ........ 18
**I.1.18 Climate** ........ 21
**I.1.19 Climate change** ........ 21
**I.1.20 Global warming** ........ 22
**I.1.21 Sustainable development** ........ 26
***I.2 DANGER , RISK AND HAZARDOUS PHENOMENA MANAGMENET CONCEPT26***
**I.2.1 Hazard** ........ 26
**I.2.1.1 Types of hazards** ........ 26
**I.2.2 Risk** ........ 27
**I.2.3 Control measures** ........ 27
**I.2.4 Risk assessment** ........ 29
**I.2.5 Carrying risk assessments** ........ 29
**I.2.5.1 Step 1: Identifying the hazards** ........ 30
**I.2.5.2 Step 2: Deciding who might be harmed and how** ........ 30
**I.2.5.4 Step 4: Recording findings** ........ 30
**I.2.5.5 Step 5: Reviewing assessment and updating as and when necessary** ........ 30
***CONCLUSION*** ........ ***30***

## CHAPTER II: REGULATIONS/METHODS AND TOOLS OF ENVIROMENTAL IMPACT ASSESSMENT

**INTRODUCTION ........................................................................................... 31**

**II.1 REGULATIONS ........................................................................................ 31**

**II.1.1 NATIONAL REGULATIONS ............................................................... 31**

**II.1.2 INTERNATIONAL REGULATIONS ..................................................... 40**

**II.2 TOOLS, METHODS AND SOFTWARES OF ENVIRONEMENTAL IMPACT ASSESSMENT................................................................................................. 43**

**II.2.1 METHODS.................................................................................................. 43**

**II.2.2 TOOLS ........................................................................................................ 44**

**II.2.3 SOFTWARES............................................................................................. 45**

**CONSLUSION.................................................................................................... 47**

## CHAPTER III: THE GREENHOUSE GASES ROLE IN CREATING GLOBAL TIPPING POINTS

***INTRODUCTION* ........................................................................................ 48**

***III.*1 Holocene and Anthropocene ............................................................... 48**

***III.*Climate Change and Ice Melt ............................................................... 49**

***III.3* Biosphere Integrity ................................................................................ 51**

***III.4* Ocean Acidification................................................................................ 53**

***III.5* Release of Novel Chemicals................................................................. 54**

***III.6* Atmospheric Aerosol Pollution ........................................................... 55**

***III.7 Stratospheric Ozone Depletion* ........................................................... 55**

## CHAPTER IV: ENVIROMENTAL IMPACT STUDY USING AERMOD

**INTRODUCTION………………………………………………………….……….56**

**IV.1 GP1Z Construction History……………………………………………..56**

**IV.2 Geographical Location and Vicinity of the Gp1z Complex………..…...57**

**IV.3 Technical Sheet of the GP1Z Complex……………………………..……..57**

**IV.4 Process Treatment…………………………………………………………..…61**

**IV.4.1 Production steps……………………………………………………..61**

**IV.5 Process diagram of the complex……………………………………………64**

**IV.6 The Characteristics of the Gp1z Complex…………………………………..65**

**IV.6.1 Trial Zone…………………………………………………………........65**

**IV.6.2 Utility Zone……………………………………………………………..65**

**IV.6.3 Storage And Loading Area…………………………………………….....65**

**IV.7 Ground plan of the complex………..……………………………………...67**

**IV.8 Organizational Chart…………………………..…………………………...68**

**IV.9 The company's greenhouse gas emissions………………………………….69**

**IV.9.1.1 Principle……………………………………………………………...69**

**IV.9.1.2 Purpose………………………………………………………………69**

**IV.9.2 Equipment……………………………………………………………..69**

**IV.9.3 Mode of Operation……………………………………………………70**

**IV.10 Statistics Of Greenhouse Gases Emissions…………………………...…..71**

**IV.11 Greenhouse gases impact evaluation using AERMOD……………………73**

**IV.11.1 Software Choice ……………………………………………………...73**

**IV.12 Application of AERMOD for CO and NOx dispersion modeling…………77**

**IV.12.1 Meteorological and topographical data collection……………………77**

**IV.12.2 Data of gases emission………………………………………………..78**

**IV.12.3 Results and Analysis of meteorological data…………………………..80**

**IV.12.3.1 CO, NOx dispersion model……………………………………..83**

**CONCLUSION……………………………………………………………….85**

## CHAPTER IV: MITIGATION ASSESSMENT

**INTRODUCTION ........................................................................................ 86**
**V.1 Preparing For A Mitigation Assessment ........................................................ 86**
**V.2 The Structure Of A Mitigation Assessment .................................................. 87**
**V.3 Time Horizon In Mitigation Assessment........................................................ 91**
**V.4 Approaches For Analysis Of Mitigation Options .......................................... 92**
**V.6 Screening Mitigation Options.......................................................................... 94**
**V.7 Defining Scenarios ........................................................................................... 97**
**V.8 Cost-Benefit Analysis Of Mitigation Options ................................................ 99**
**V.9 Integration Of Energy And Non-Energy Assessments................................. 104**
**V.10 Integration With Emission Inventories And Vulnerability And Adaptation Assessments................................................................................................. 104**
**V.11 National Metigation ..................................................................................... 105**

## CHAPTER VI: GREENHOUSE GASES MITIGATION TECHNOLOGIES

*INTRODUCTION* ........ *109*

*VI.1 6 Key Design Principles of an Industrial 4.0 (the smart factory)* ........ *109*

**VI.1.1 The industry 4.0 technologies and Triple Bottom Line Sustainability** ........ **110**

*VI.2 Carbone Capture Storage And Utilization (Ccus) Definition And Purpose* ........ *110*

*VI.1 Carbon Capture Main Steps* ........ *111*

*VI.2 Carbon Capture Princple* ........ *111*

**VI.2.1 Pre-combustion** ........ **112**

**VI.2.2 Post-combustion** ........ **113**

**VI.2.3 Oxy-fuel combustion** ........ **114**

*VI.3 Carbon capture and storage (CCS)* ........ *115*

**VI.3.1 CO2 transport** ........ **116**

**VI.3.2 CO2 storage** ........ **117**

*VI.4 Carbon capture and utilization (CCU)* ........ *119*

*VI.5 Carbon Capture And Climate Change* ........ *120*

*VI.6 Climate and energy scientists on CCS* ........ *120*

*VI.7 Ccus Facilities Worldwide* ........ *120*

*VI.8 CCUS facilities currently capture close to 40 Mt CO2 annually in industry and fuel transformation* ........ *121*

*VI.9 Momentum for CCUS is growing in all industrial sectors and region* ........ *122*

*VI.10 Net zero targets drive new momentum for CCUS* ........ *124*

*VI.11 Direct Air CapturE* ........ *124*

**VI.11.1 Direct Air Capture Pricniple** ........ **124**

**VI.11.2 How Dac Works** ........ **125**

*VI.12 The difference between CCS and DAC* ........ *127*

*VI.13 Trees and carbon capture* ........ *127*

*VI.14 Other Solutions* ........ *127*

*CONCLUSION* ........ *128*

**GENERAL CONCLUSION**……………….…………………………………..…*130*

**REFERENCE LIST**

**APPENDICES**

# GLOSSARY

**Anthropocene :** The period of time during which human activities have had an environmental impact on the Earth regarded as constituting a distinct geological age

**carbon footprint** : The total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions.

**Circular economy** : The production that has as little impact as possible on the environment by leaving less of a footprint. To make it sustainable, it must follow these three principles: reduce, reuse and recycle.

**Desertification :** The land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities

**Eutrophication:** The process in which a water body becomes overly enriched with nutrients, leading to plentiful growth of simple plant life. The excessive growth (or bloom) of algae and plankton in a water body are indicators of this process

**Global dimming :** The decrease in the amount of sunlight reaching the surface of the earth, believed to be caused by pollution in the atmosphere.

**Holocene:** the name given to the last 11,700 years* of the Earth's history — the time since the end of the last major glacial epoch, or "ice age."

**Linear economy** : The traditional model where raw materials are collected and transformed into products that consumers use until discarding them as waste, with no concern for their ecological footprint and consequences. It prioritizes profit over sustainability, with products made to be thrown away once they've been used

**Monoculture** the cultivation or growth of a single crop or organism especially on agricultural or forest land

**Negative Emissions** : One of the terms used by climate scientists in the Intergovernmental Panel on Climate Change (IPCC) for activities that remove carbon dioxide from the atmosphere. Other terms include Carbon Dioxide Removal (CDR) and Greenhouse Gas Removal (GGR).

**Savannization:** Conversion to savanna (typically of forest as a result of fire).

**Smog :** A fog made heavier and darker by smoke and chemical fumes also : a photochemical haze caused by the action of solar ultraviolet radiation on atmosphere polluted with hydrocarbons and oxides of nitrogen especially from automobile exhaust

**Tipping point** : The point at which a series of small changes or incidents becomes significant enough to cause a larger, more important change.

# GENERAL INTRODUCTION

Global warming is being caused by human activities. As a result, the greenhouse effect, rather from being a great ally as it once was, is now a threat to human survival.

This temperature rise has long-term negative impacts on the climate and affects a wide range of ecological systems. Extreme weather events, such as flooding of coastal cities, severe droughts, wildfires, devastating hurricanes, melting of glacial masses, and desertification of fertile areas, have increased in frequency and intensity, affecting millions of people and causing trillions of dollars in economic losses.

Throughout the years, the world population has increased to incredible numbers, with this high population came a high carbon emission rate into the atmosphere and a decline in wilderness. In 1937 the population was only at 2.3 billion with a carbon emission rate of 280 ppm and a percentage of 66% of wilderness left. it slowly moved to 3.0 billion in 1960 and 315 ppm of CO2 and 62% left. Then in 1997 it jumped to 5,9 Billions and 360 ppm and 46%, finally in 2020 the world population reached 7.8 with an emission rate of 415 and only 35% of wilderness left. which is really alarming. **[1]** "Human-caused greenhouse gas emissions damage human and environmental health," says Mark Radka, Chief of UNEP's Energy and Climate Branch. "And, in the absence of substantial climate action, the consequences will become more widespread and severe."

Greenhouse gases (GHG) emissions are critical to understanding and addressing the climate crisis: despite an initial dip due to Covid 19, the latest UNEP Emissions Gap rate shows a rebound and forecasts a disastrous global temperature rise of at least 2.7 degrees Celsius this century unless countries make much greater efforts to reduce emissions. And so, if we are to limit global warming to 1.5°C over pre-industrial levels by the end of the century, GHG emissions must be cut in half by 2030. **[2]**

Moreover, today, a regular measurement of atmospheric emissions of greenhouse gases is necessary in order to assess the environmental impact of these and compare them to regulatory thresholds. In addition, new practices, methods and solutions are to be established. to limit greenhouse gas emissions or completely cutting them.

Our work consists of evaluating the environmental impact of greenhouse gases as part of a future and circular industry. It starts with a general introduction and is subdivided into 6 chapters:

The first chapter gathers all the definitions and basic definitions related to the greenhouse gases, climate change, global warming and the environment in general, as well as the definitions and basic concepts related to the industrial safety and the danger, risk and hazardous phenomena management;

The second chapter is related in a first part to the regulations both national and international related to our subject of study, and in the second part to the methods, tools and softwares used for assessing the environmental impact;

The third chapter deals with the idea of earth's boundaries, their tipping points and their grand impact on our future lives;

The fourth chapter consists of presenting the industrial complex in which we had our internship, and in the second part of this chapter we explain and discuss the software we used to assess the atmospheric gases of that particular zone;

The fifth chapter clarifies the process of mitigation;

The last chapter explicates the new technologies and solutions developed to reduce greenhouse gas emissions in order to reduce the global temperature and stop climate changes.

And we finish our work with a conclusion and a presentation of appendices .

# CHAPTER I

# DEFINITIONS

# AND BASIC CONCEPTS

# INTRODUCTION

Whether it's gas, food, clothing, cars, furniture, water, toys, electronics, knickknacks or other goods, we are all consumers.

The key is not to stop consuming, but to start being mindful of our consumption habits and how each purchase or action affects the ecosystem.

The good news is that it's often not too difficult, expensive, or inconvenient to become more environmentally friendly. It can even be a fun challenge to implement among your family or coworkers. And though small changes at the individual level may seem trivial, just think how much cleaner the planet would be if everyone adopted even a few of behavior modifications.

For a better understanding of this concept; in this chapter we are going, first to define some terms that are related to the environment primarily and to the greenhouse effect precisely, In addition to some crucial health and safety terms and keywords.

## I.1 ENVIRONMENT RELATED CONCEPTS AND DEFINITIONS

### I.1.1 Environment

The collection of physical, chemical, and biotic elements (such as climate, soil, and living creatures) that interact with an organism or ecological community to determine its shape and survival. **[3]**

#### I.1.1.1 Defined by the ISO 14001

The term "environment" refers to the natural and human surrounds of a company. Air, water, land, flora and fauna (including humans), and natural resources of all types make up an organization's environment, which spans from within the organization to the global system. **[4]**

#### I.1.1.2 Environmental aspect

An element or attribute of an activity, product, or service that interacts or can interact with the environment is referred to as an environmental aspect. Environmental aspects can have an influence on the environment. The influence being either positive or negative, and they can have a direct and decisive influence or contribute either partially or indirectly to a bigger environmental change. **[4]**

#### I.1.1.3 Environmental impact

A change in the environment produced in part or fully by one or more environmental aspects is referred to as an environmental impact. An environmental impact might have a direct and decisive influence on the environment, or it can contribute only partially or indirectly to a bigger change in the environment. Furthermore, it has the potential to have either a positive or negative environmental impact. **[4]**

### I.1.2 Ecosystem

An ecosystem is a geographical region in which plants, animals, and other species, as well as weather and topography, coexist to build a bubble of life. Ecosystems comprise both biotic (living) and abiotic (nonliving) components. Plants, animals, and other species are examples of biotic factors. Rocks, temperature, and humidity are examples of abiotic variables.

Every aspect in an ecosystem is either directly or indirectly dependent on every other factor. A change in the temperature of an environment, for example, will frequently influence what plants thrive there. Animals that rely on plants for food and shelter will have to adjust to the changes, relocate to a different ecology, or die.

The whole surface of Earth is a series of connected ecosystems. Ecosystems are often connected in a larger biome. **[5]**

### I.1.3 Biomes

Area of the planet which can be classified according to the plant and animal life in it. **[6]**

Large portions of land, sea, or atmosphere are referred to as biomes. Forests, ponds, reefs, and tundra are all examples of biomes. They are classified broadly depending on the plants and animals that inhabit there. Within each forest, pond, reef, or portion of the tundra, many different ecosystems are to be found. **[5]**

### I.1.4 Biotic and abiotic factors

A biotic factor is a living creature that has an effect on another living thing population or the environment. Abiotic elements perform the same function as living components; however, they are non-living. An ecosystem is made up of both biotic and abiotic forces. Abiotic factors are required for biotic factors to survive. In turn, biotic factors can constrain the amount and types of biotic factors in an ecosystem. **[7]**

### I.1.5 Fauna

Fauna refers to all of the animal life found in a certain area or period of time. **[8]**

### I.1.6 Flora

Flora refers to all of the plants that are found in a specific location or period of time. **[9]**

### I.1.7 Biosphere

The region of the planet Earth where life naturally occurs, spanning from the deep crust to the lower atmosphere The lithosphere, hydrosphere, and atmosphere are the three components that make up the biosphere. **[10]**

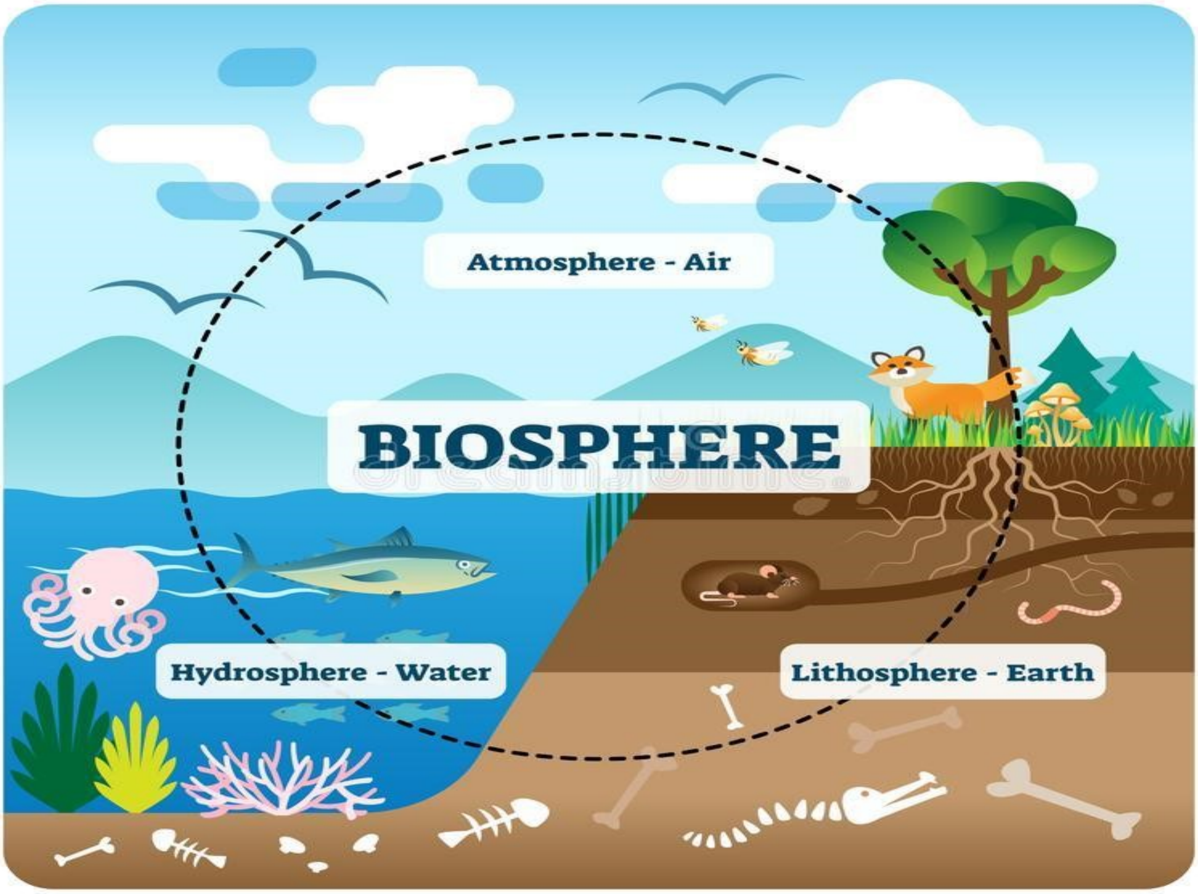


*Figure 1Decirptive diagram of a biosphere* ***[10]***

### I.1.7.1 Lithosphere

The solid section of the earth, including the crust and upper mantle **[11]**

### I.1.7.2 Hydrosphere

The water that covers or surrounds the globe's surface, including the oceans' water and the water in the atmosphere**. [12]**

### I.1.7.3 Atmosphere

The gaseous layers that encircle a planet or other celestial body. These gases are found in layers (troposphere, stratosphere, mesosphere, thermosphere, and exosphere) that are characterized by temperature and pressure differences. **[13]**

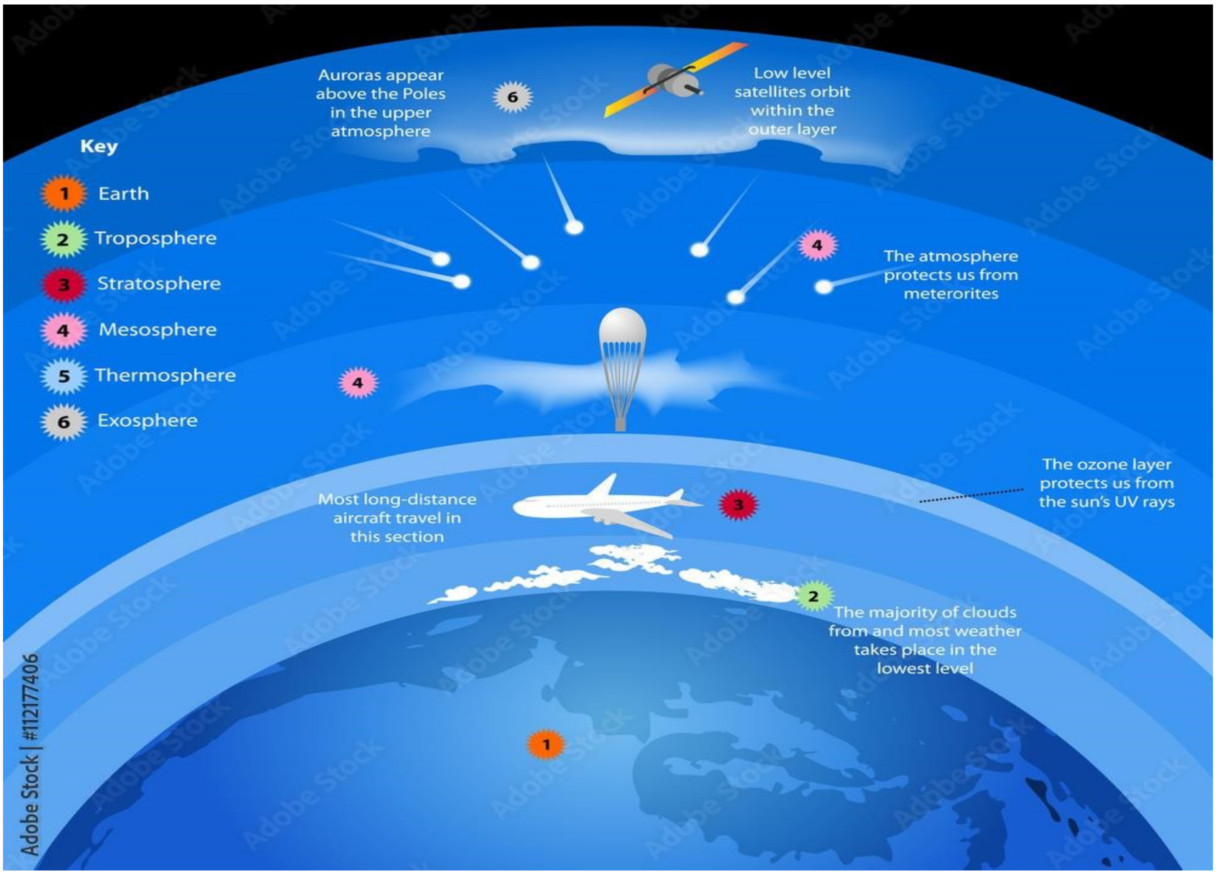


*Figure 2Descriptive diagram of the different layers of the atmosphere [13]*

### I.1.7.3.1 Troposphere

The lowest layer of the atmosphere, stretching from the earth's surface to around 6– 10 km in altitude (the lower boundary of the stratosphere). **[14]**

The troposphere is the site of the vast majority of atmospheric reactions. The atmospheric pollution concerns mainly this zone. In a simplistic way, we can consider that it is the zone where there is an excess of ozone. This one is mainly observed outside the cities. It is mainly due to vehicle emissions and, to a lesser extent, to industrial emissions. **[15]**

### I.1.7.3.2 Stratosphere

Above the troposphere, the layer of the earth's atmosphere that extends to roughly 50 kilometers above the surface (the lower boundary of the mesosphere). **[16]**

The stratosphere presents, at certain times of the year, a deficit of the ozone concentration, called (ozone hole). In this zone, ozone filters the ultraviolet rays harmful to life on earth. The causes of this ozone hole are mainly related to the emissions in the troposphere of pollutants such as chlorofluorocarbons (CFCs). As the troposphere and the stratosphere communicate very little with each other. These two layers are separated by a buffer zone that is difficult to cross - the tropopause - except for some chemical species that are not very reactive, such as CFCs. **[15]**

#### I.1.7.3.3 Mesosphere

Between 50 to 80 kilometers in altitude, the area of the earth's atmosphere above the stratosphere and below the thermosphere. **[17]**

#### I.1.7.3.4 Thermosphere

The part of the atmosphere above the mesosphere but below the height at which the atmosphere loses its continuous medium characteristics. It is characterized by a gradual increase in temperature as it rises in altitude. **[18]**

#### I.1.7.3.5 Exosphere

The earth's atmosphere's outermost layer. It stretches for nearly 400 kilometers above the surface of the planet. **[19]**

#### I.1.7.3.6 Tropopause and stratopause

the troposphere is separated from the stratosphere by the tropopause, whereas the stratosphere is separated from the mesosphere by the stratopause **[15]**

### I.1.8 Gas

Atmospheric gases are gases found in the atmosphere of the Earth. These gases are predominantly oxygen and nitrogen (which account for 99 percent of the air), with greenhouse gases (carbon dioxide, methane, nitrous oxide, water vapor, and ozone) accounting for 1% of the air. **[20]**

### I.1.9 Pollution

Any material that has an undesirable influence on the environment or the creatures that dwell in it is referred to as "pollution." Air pollution, water pollution, soil contamination, light pollution, and noise pollution are the five primary forms of pollution. **[21]**

#### I.1.9.1 Water pollution

Water pollution takes place when dangerous substances—often chemicals or microorganisms—contaminate a stream, river, lake, ocean, aquifer, or other body of water, the water quality deteriorates and the water becomes toxic to humans or the environment.

**[22]**

#### I.1.9.2 Soil pollution

Soil pollution is defined as the presence of toxic chemicals (pollutants or contaminants) in soil at concentrations high enough to endanger human health and/or the ecosystem. **[23]**

#### I.1.9.3 Light pollution

Light pollution is a type of waste energy that can cause adverse effects and degrade environmental quality. This squandered light is dispersed and reflected by solid or liquid particles in the atmosphere, then returned to people's eyes on the ground, obliterating their vision of the night sky**. [24]**

### I.1.9.4 Noise pollution

Any disturbing or undesired noise that disrupts with or affects humans or wildlife is classified as noise pollution. Noise pollution impacts wildlife by decreasing habitat quality, raising stress, and obscuring other noises. **[25]**

### I.1.9.5 Air pollution

It is the damaging of air caused by the presence of pollutants in the atmosphere that are affecting to human and other living species' health, or cause climatic or material damage.

**[26]**

#### I.1.9.5.1 Consequences of air pollution

The consequences of air pollution are divided in two principal kinds beside minor consequences such as the degradation of buildings:

- **sanitary and environmental impact:** disorders of the human health mainly, but also degradation of the grounds, water or vegetation.
- **climatic impact:** global warming.

Knowing the effects on the environment or on human health, strategies are developed to control pollution (alerts, monitoring) and legislation to control it. By applying and respecting the pollution standards, we can limit the pollution. But if efforts are made locally, there is not yet a planetary effort, on the greenhouse gases in particular **[15]**

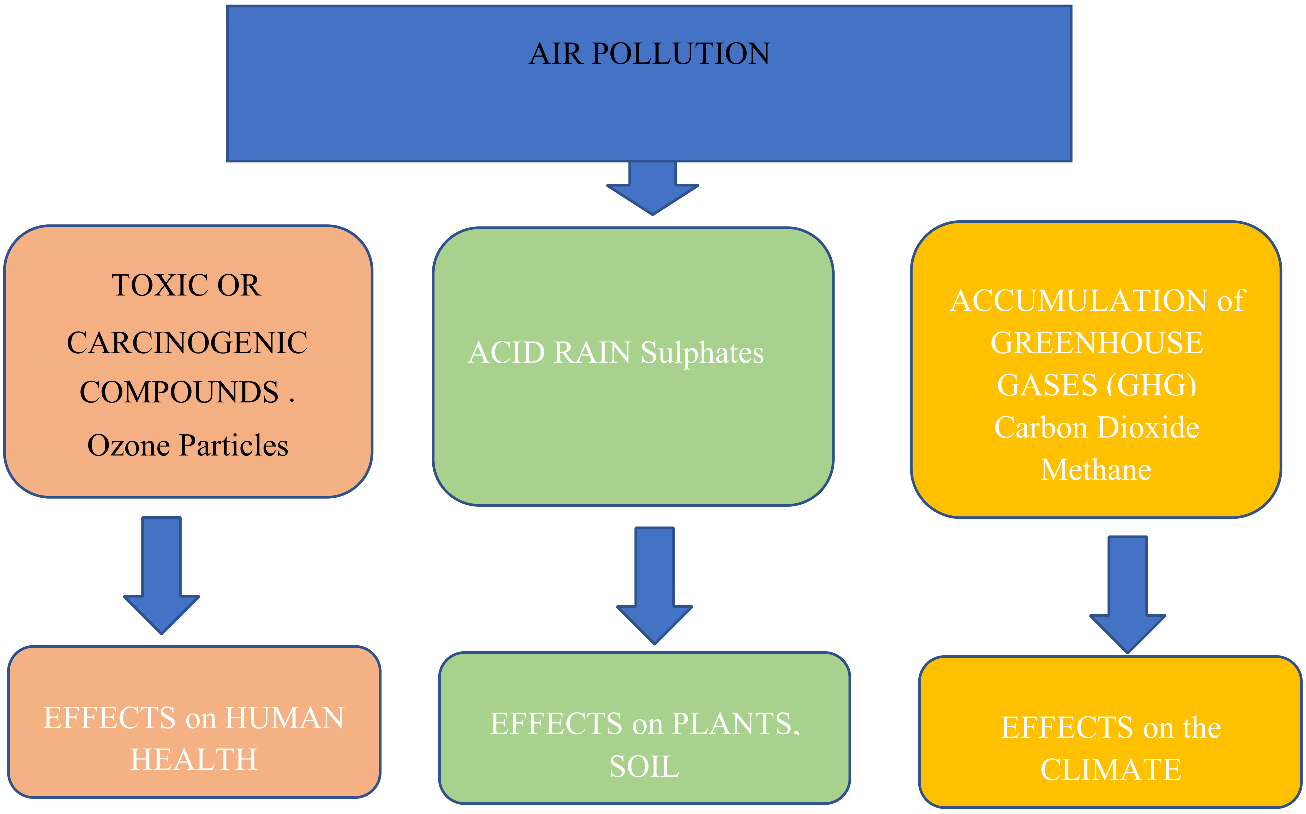


*Figure 3 Consequences of air pollution [15]*

### I.1.10 Greenhouse effect

The greenhouse effect occurs when gases in the atmosphere trap heat from the sun that would otherwise escape into space, this is what happens.

The greenhouse effect, which has been known since 1896, is the natural warming of the world caused by the property of certain gases in the atmosphere to retain heat radiated from the Earth's surface, insulating and warming the planet. Without the natural greenhouse effect's thermal blanketing, the Earth's climate would be around 33°C (about 59°F) colder, making survival for most living species impossible.

For nearly 4 billion years, the greenhouse effect has warmed the Earth. Now scientists are increasingly worried that human actions may be altering this natural process, perhaps resulting in harmful repercussions. Humans have developed several inventions that use fossil fuels such as coal, oil, and natural gas since the dawn of the Industrial Revolution in the 1700s. The combustion of these fossil fuels, as well as other activities such as clearing land for agriculture or urban populations, emits some of the same gases that trap heat in the atmosphere; these atmospheric gases have grown to levels greater than at any point in at least the past 650,000 years. As these gases accumulate in the atmosphere, they trap more heat at the Earth's surface, causing the climate to warm faster than it should. **[27] [28] [29] [30] [31] [32] [33] [34] [35]**

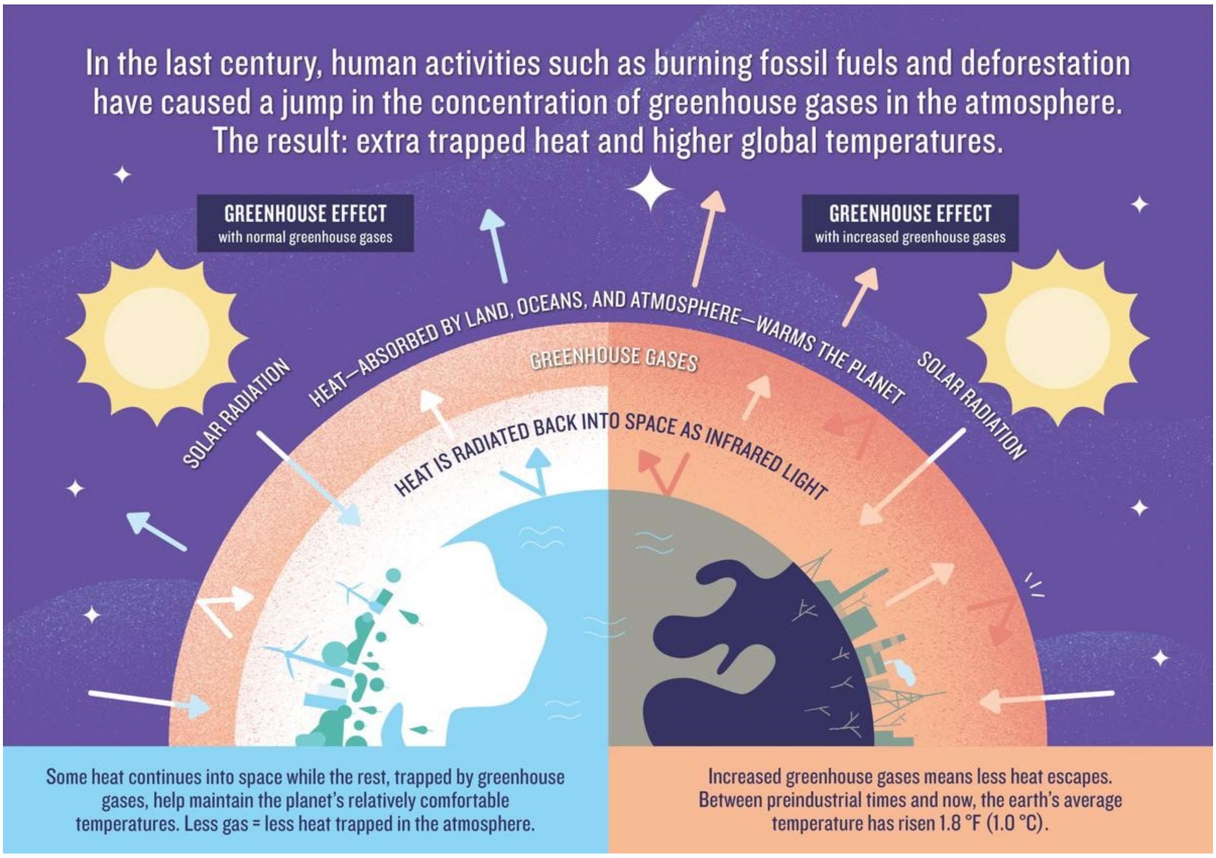


*Figure 4 natural and artificial greenhouse effect* ***[30]***

### I.1.11 Name Origin

While not named as such, Joseph Fourier [1] suggested the existence of the greenhouse effect in 1824. Claude Pouillet[2] reinforced the argument and the evidence in 1827 and 1838. John Tyndall [3] was the first to measure the absorption and emission of different gases and vapors in the infrared spectrum. From 1859 onwards, he demonstrated that the impact was caused by a very small part of the atmosphere, with the principal gases having little influence, and was mostly caused by water vapor, with small percentages from hydrocarbons and carbon dioxide**.** Svante Arrhenius [3], who made the first quantitative prediction of global warming due to a hypothetical doubling of atmospheric carbon dioxide, quantified the effect more fully in 1896. However, none of these scientists used the term "greenhouse" to refer to this effect; the term was first used in this context by Nils Gustaf Ekholm[5] in 1901. **[32]**

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**[1]Jean Baptiste Joseph Fourier** : was a French mathematician and physicist born **March 21, 1768** in Auxerre and died **May 16, 1830** in Paris. Joseph Fourier is known for having determined, by calculation, the diffusion of heat using the decomposition of any function into a convergent trigonometric series

**[2]Claude Servais Mathias Pouillet** (**16 February 1790 – 14 June 1868**) : was a French physicist and a professor of physics at the Sorbonne and member of the French Academy of Sciences (elected **1837**).

**[3]John Tyndall**, (**born August 2, 1820, Leighlinbridge, County Carlow, Ireland—died December 4, 1893, Hindhead, Surrey, England**) : Irish experimental physicist who, during his long residence in England, was an avid promoter of science in the Victorian era.

**[4]Svante August Arrhenius** (**19 February 1859 – 2 October 1927**) : was a Swedish scientist. Originally a physicist, but often referred to as a chemist, Arrhenius was one of the founders of the science of physical chemistry. He received the Nobel Prize for Chemistry in **1903**, becoming the first Swedish Nobel laureate. In **1905**, he became director of the Nobel Institute, where he remained until his death .

**[5]Nils Gustaf Ekholm** (**9 October 1848 – 5 April 1923**) was a Swedish meteorologist who led a Swedish geophysical expedition to Spitsbergen in **1882–1883**.[1]

### I.1.12 Greenhouse Gases

The Earth's atmosphere is mostly made up of nitrogen (78 percent) and oxygen (28 percent) (21 percent). These two most prevalent atmospheric gases have molecular properties that limit infrared energy absorption. Only a few greenhouse gases, which make up less than 1% of the atmosphere, provide any insulation to the Earth. Greenhouse gases are produced naturally or artificially.

Water vapor is the most frequent naturally occurring greenhouse gas, followed by carbon dioxide, methane, and nitrous oxide. Chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons are examples of man-made substances that behave as greenhouse gases (PFCs).

Human activities have significantly raised the concentrations of greenhouse gases in the atmosphere since the 1700s. Scientists are confirming that predicted increases in greenhouse gas concentrations are significantly increasing the atmosphere's capacity to hold infrared light, resulting in artificial warming of the Earth's surface. **[27] [28] [29] [30] [31] [32] [33] [34] [35]**

#### I.1.12.1 Water Vapor

Water vapor is the most prevalent greenhouse gas in the atmosphere, accounting for around 60 to 70% of the natural greenhouse effect. Humans have no direct influence on water vapor levels in the atmosphere. However, when human activities increase the concentration of other greenhouse gases in the atmosphere (resulting in greater temperatures on Earth), evaporation from oceans, lakes, and rivers, as well as water evaporation from plants, increases and raises the quantity of water vapor in the atmosphere. **[27] [28] [29] [30] [31] [32] [33] [34] [35]**

#### I.1.12.2 Carbon Dioxide

The carbon cycle is a set of natural mechanisms that continually circulates carbon dioxide in the environment. Carbon dioxide is released into the atmosphere through volcanic eruptions as well as the breakdown of plant and animal things. Animals respire by breaking down food to release the energy needed to generate and maintain cellular activity. Carbon dioxide is produced as a byproduct of respiration and is exhaled by animals into the environment. Carbon dioxide from the atmosphere is absorbed by the oceans, lakes, and rivers. Plants capture carbon dioxide and utilize it to generate their own food, integrating carbon into new plant tissue and release oxygen into the atmosphere as a byproduct.

Humans burn carbon-containing items such as fossil fuels such as oil, coal, and natural gas, wood or wood products, and some solid wastes to supply energy to heat houses, run vehicles, and fuel electricity-producing power plants. When these products are burnt, they emit carbon dioxide into the atmosphere. Furthermore, humans chop down vast swaths of forests for lumber or to clear space for cultivation or construction. This process, known as deforestation, may both liberate the carbon stored in trees and drastically reduce the number of trees available to absorb carbon dioxide.

As a result of these human activities, carbon dioxide levels in the atmosphere are rising faster than the planet's natural processes can absorb it. Scientists determined that carbon dioxide levels in the atmosphere had grown significantly since the Industrial Revolution began in the mid-1700s by examining air bubbles trapped in centuries-old glacier ice. At the time, carbon dioxide levels were around 280 molecules of CO2 per million molecules of air (known as parts per million or ppm). Carbon dioxide levels have risen to 385 ppm by 2007. Because carbon dioxide increases may linger in the atmosphere for decades, experts predict that these amounts will double or treble in the next century if current trends continue. **[27] [28] [29] [30] [31] [32] [33] [34] [35]**

### I.1.12.3 Methane

Methane, often known as natural gas, is produced by a variety of natural processes. Methane is released during the decomposition of carbon-containing substances found in oxygen-free conditions, such as garbage in landfills. As a consequence of digestion, ruminating animals such as cattle and sheep expel methane into the atmosphere. Methane is produced by microorganisms that reside in moist soils, such as rice fields, as they break down organic materials. It is also released during coal mining, as well as the production and transportation of other fossil fuels.

Methane in the atmosphere has more than doubled since 1750, and it might double again in the next century. Methane concentrations in the atmosphere are far lower than carbon dioxide concentrations, and methane only remains in the atmosphere for about a decade. However, it is an extraordinarily efficient heat-trapping gas—one molecule of methane is almost 30 times more efficient than a molecule of carbon dioxide at trapping infrared radiation radiated from the Earth's surface. **[27] [28] [29] [30] [31] [32] [33] [34] [35]**

### I.1.12.4 Nitrous Oxide

Nitrous oxide is emitted by the combustion of fossil fuels, and vehicle exhaust is a major producer of this gas. Furthermore, many farmers employ nitrogen-containing fertilizers to deliver nutrients to their crops. When these fertilizers degrade in the soil, they release nitrous oxide into the atmosphere. Nitrous oxide is also produced when fields are plowed.

Nitrous oxide levels in the atmosphere have climbed by 18% since 1750. Although this rise is less than that of the other greenhouse gases, nitrous oxide traps heat around 300 times more efficiently than carbon dioxide and can remain in the atmosphere for a century. **[27] [28] [29] [30] [31] [32] [33] [34] [35]**

### I.1.12.5 Ozone

Ozone is both a naturally occurring and man-made greenhouse gas. Ozone found in the upper atmosphere (stratosphere) is known as the ozone layer that protects life on Earth from the Sun's damaging UV radiation, which may cause cancer and other damage to plants and animals. However, ozone found in the lower atmosphere (troposphere) is a component of smog (a serious kind of air pollution) and is a greenhouse gas. In contrast to other greenhouse gases, which are well-mixed throughout the atmosphere, ozone in the lower atmosphere is often isolated to industrialized areas. **[27] [28] [29] [30] [31] [32] [33] [34] [35] [36]**

### I.1.12.6 Fluorinated compounds

Some of the most powerful greenhouse gases generated are purely the result of human activity. Fluorinated chemicals, such as CFCs and HCFCs, are employed in a wide range of production processes. One molecule of each of these synthetic substances traps heat several thousand times more effectively than a single molecule of carbon dioxide.

CFCs, which were originally produced in 1928, were widely employed in the production of aerosol sprays, foam blowing agents, packaging materials, solvents, and refrigerants. CFCs are nontoxic and safe to use in most applications, and they are inert in the lower atmosphere. In the high atmosphere, however, UV light degrades CFCs, releasing chlorine into the environment. Scientists first noticed that increased concentrations of chlorine were degrading the ozone layer in the upper atmosphere in the mid-1970s.

Beginning with the Montréal Protocol on Substances that Deplete the Ozone Layer in 1987, delegates from 47 nations created regulatory mechanisms to restrict CFC usage. By 1992, the Montréal Protocol had been updated to prohibit the manufacturing and use of CFCs globally, with the exception of select developing nations and for use in particular medical processes such as asthma inhalers.

Scientists developed CFC replacements such as HCFCs, HFCs, and PFCs. Because HCFCs continue to emit ozone-depleting chlorine into the environment, manufacture of this chemical will be totally phased out by the year 2030. Although HFCs and PFCs do not include chlorine and are not damaging to the ozone layer, they are potent greenhouse gases.
Another manmade compound, sulfur hexafluoride, is one of the most powerful greenhouse gases ever created. This synthetic gas molecule has roughly 24,000 times the warming impact of an equal quantity of carbon dioxide. However, it is only in trace amounts emitted into the atmosphere. **[27] [28] [29] [30] [31] [32] [33] [34] [35]**

*Table 1 Greenhouse gases*

| **Greenhouse gas** | **How it's produced** | **Lifetime in the atmosphere** | **Global warming potential** | **Chemical formula** |
|---|---|---|---|---|
| **Water Vapor** | More water evaporates from ground storage when the temperature of the atmosphere rises (rivers, oceans, reservoirs, soil,irrigation,cooling towers). Because the air is warmer, the absolute humidity is likely to be greater, resulting in more water vapor in the atmosphere. As a result, | From 8-9 days | Negligible because the anthropogenic emissions of water vapor irrigation) are removed via precipitation within weeks. | $H_2O$ |

| | | | | |
|---|---|---|---|---|
| | the larger concentration of water vapor may absorb more thermal infrared radiation emitted by the Earth, further warming the atmosphere. | | | |
| **Carbone Dioxide** | Emissions are principally caused by the combustion of fossil fuels (oil, natural gas, and coal), solid waste, and the use of trees and wood products. Land use changes also play an influence. Deforestation and soil degradation contribute carbon dioxide to the atmosphere, whereas forest regeneration removes it. | From 300 to 1000 years | 1 | $CO_2$ |
| **Methane** | Emitted during the production and transportation of oil, natural gas, and coal. Methane emissions are also caused by livestock and agricultural operations, as well as the anaerobic degradation of organic waste in municipal solid waste dumps. | 12.4 years | 25–36 | $CH_4$ |
| **Nitrous Oxide** | Emitted through agricultural and industrial processes, as well as the burning of fossil fuels and the disposal of solid waste. | 114-121 years | 265–298 | $N_2O$ |
| **Ozone** | Photochemical processes involving the | Tropospheric ozone has an | 62-69 | $O_3$ |

| | | | | |
|---|---|---|---|---|
| | air pollutant carbon monoxide (CO) are the principal anthropogenic source of surface O3. | atmospheric lifetime ranging from a few hours to a few weeks in polluted urban regions | | |
| **Fluorinated compounds** | A class of fluorine-containing gases that includes hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, among other compounds. These gases are produced by a number of industrial processes, as well as commercial and domestic usage, and do not occur naturally. Sometimes used as a replacement for ozone-depleting chemicals like chlorofluorocarbons. | A few weeks to thousands of years ;<br>HFCs: up to 270 years<br>PFCs: 2,600–50,000 years<br>NF3: 740 years<br>SF6: 3,200 years | Varies (23,500)<br>HFCs: up to 14,800<br>PFCs: up to 12,200<br>NF3: 17,200<br>SF6: 22,800 | HFCs, PFCs, $NF_3$, $SF_6$ |

### I.1.12.7 Global warming potential

The global warming potential (GWP) is a conversion factor that compares the influence of different greenhouse gases on the climate system. It is used to predict the relative impacts of different gases on global warming based on their radiative properties and residence time.

This tool usually gives correct estimates (good order of magnitude, acceptable accuracy for guiding policy decisions) provided that it is used in accordance with the accompanying assumptions, in particular the time period considered and the scenarios of changes in various atmospheric concentrations. Otherwise, the GWP is often inaccurate or even totally false when used outside its scope. **[37]**

### I.1.13 The Greenhouse effect's implications

The planet's average temperature is rising, which is affecting the planet's life circumstances. some of the most significant effects of this phenomenon are: **[15] [38] [39]**

### I.1.13.1 Glacial masses thaw

Glacier retreat has its own set of repercussions, including lower albedo (the proportion of solar energy reflected or returned to the atmosphere by the earth's surface), a worldwide rise in sea level, and the release of massive methane columns, to name a few.

### I.1.13.2 Coastal communities and islands floods

According to the Intergovernmental Panel on Climate Change (IPCC), the worldwide average sea level climbed 19 cm between 1901 and 2010. It is predicted that by 2100, sea levels would be 15 to 90 cm higher than they are currently, threatening 92 million people.

### I.1.13.3 Hurricanes increased danger of destruction

The greenhouse effect's intensification does not cause these catastrophic climatic occurrences, but it does enhance their severity. Hurricane development is linked to sea temperature — they only form over waters that are at least 26.51 degrees Celsius —

### I.1.13.4 Species migration

Many animal species will be compelled to relocate in order to survive the changes in the main climatic patterns brought about by the gradual rise in temperatures. Humans will also have to relocate: the World Bank estimates that by 2050, the number of people forced to evacuate their homes owing to catastrophic droughts or destructive floods might reach 140 million.

### I.1.13.5 Fertile places desertification

Global warming is having a significant influence on soil degradation processes and is contributing to desertification of places throughout the world, a phenomenon that kills all biological potential in afflicted areas, converting them into barren and unproductive land. According to the United Nations on the occasion of the World Day to Combat Desertification in 2018, 30% of land has been damaged and lost its true worth.

### I.1.13.6 The impact on agriculture and livestock

Global warming has already shortened the growing season in many regions of the world. Similarly, temperature and season variations influence the spread of insects, invasive plants, and illnesses that can harm crops. The same thing is happening with livestock: climate change is having a direct impact on significant species in a variety of ways, including reproduction, metabolism, illness, and so on.

## I.1.14 The consequences of greenhouse effect on human health

The greenhouse effect also has a direct impact on human health in the following ways: **[15] [38] [39]**

### I.1.14.1 Food scarcity

Climate change, according to the Food and Agriculture Organization (FAO), is raising serious concerns about food availability: in its most recent biennial report on the state of world food and agriculture, the FAO warns that a decline in agricultural production would result in food shortages, most notably in Sub-Saharan Africa and South Asia.

### I.1.14.2 Disease spread and pandemics

In addition to the difficulties caused directly by pollution, the World Health Organization (WHO) predicts that global warming would allow infectious illnesses such as malaria, cholera, and dengue fever to spread to far larger parts of the globe. Extreme heat, on the other hand, will exacerbate and exacerbate cardiovascular and pulmonary disorders.

### I.1.15 A greenhouse

(Also known as a glasshouse or, if sufficiently heated, a hothouse) is a building with walls and roof mostly composed of transparent material, such as glass, in which plants needing controlled climatic conditions are cultivated. These structures range in size from modest sheds to large industrial complexes. A cold frame is a minor greenhouse. When exposed to sunshine, the interior of a greenhouse gets much warmer than the outside temperature, safeguarding its contents in cold weather. **[40] [41]**

### I.1.16 Ozone depletion

The progressive lowering of the Earth's ozone layer in the upper atmosphere caused by the discharge of chemical compounds containing gaseous chlorine or bromine from industry and other human activities is known as ozone depletion. The thinning is most noticeable in the polar areas, particularly over Antarctica. Ozone depletion is a serious environmental issue because it increases the quantity of ultraviolet (UV) radiation that reaches the Earth's surface, increasing the risk of skin cancer, eye cataracts, and genetic and immune system damage. The Montreal Protocol, which was ratified in 1987, was the first of several extensive international treaties created to prohibit the manufacturing and use of ozone-depleting chemicals. The ozone layer is projected to recover over time as a consequence of continuing worldwide collaboration on this subject. **[15] [36] [42]**

### I.1.16.1 Relationship between Ozone depletion and greenhouse effect

Recently, scientists have discovered a coupling between the greenhouse effect and the destruction of the stratospheric ozone layer. The greenhouse effect increases the temperature of the troposphere. By compensation effect the temperature of the stratosphere decreases. It seems that this decrease approaches 0.8°C in the lower stratosphere and 3.0°C at 40 km altitude. In the PSC (Polar starsopheric clouds), the concertation of atoms is weaker when the temperature decreases. hence a greater availability of Cl° atoms to destroy the ozone layer. Statistically the recombination of Cl° is less frequent so the destruction of ozone is more important. The speed of ozone disappearance increases with the warming of the lower atmosphere due to the presence of greenhouse gases. The two phenomena "greenhouse effect" and "ozone hole" are therefore partly coupled. **[15]**

### I.1.17 Biogeochemical cycle

A biogeochemical cycle is the process through which a chemical substance cycles (is turned over or travels through) the Earth's biotic and abiotic compartments. The biosphere is the biotic compartment, whereas the abiotic compartments are the atmosphere, hydrosphere, and lithosphere. Chemical elements such as calcium, carbon, hydrogen, mercury, nitrogen, oxygen, phosphorus, selenium, iron, and sulfur have biogeochemical cycles, as do water and silica. There are also macroscopic cycles like the rock cycle, as well as human-induced cycles for synthetic substances like polychlorinated biphenyls (PCBs). There are reservoirs in some cycles where a material can linger or be sequestered for an extended length of time. **[43]**

### I.1.17.1 Water cycle

The water cycle, also known as the hydrologic cycle or the hydrological cycle, is a biogeochemical cycle that depicts the ongoing movement of water on, above, and beneath the Earth's surface. The mass of water on Earth remains relatively constant over time, but the distribution of water into the principal reservoirs of ice, fresh water, saline water (Salt Water), and atmospheric water varies based on a variety of climate conditions. The physical processes of evaporation, condensation, precipitation, infiltration, surface runoff, and subsurface movement transport water from one reservoir to another, such as from a river to the ocean or from the ocean to the atmosphere. As a result, the water undergoes several transformations, including liquid, solid (ice), and vapor.

The water cycle involves energy exchange, which causes temperature fluctuations. Water evaporates, absorbing energy from its surroundings and cooling the environment. It releases energy and heats the surroundings as it condenses. These heat transfers have an impact on the climate.

The cycle's evaporative phase cleanses water, which subsequently replaces the soil with freshwater. The movement of liquid water and ice carries minerals all over the world. It also plays a role in changing the Earth's geological characteristics through processes like as erosion and sedimentation. The water cycle is also necessary for the survival of most species and ecosystems on Earth. **[44]**

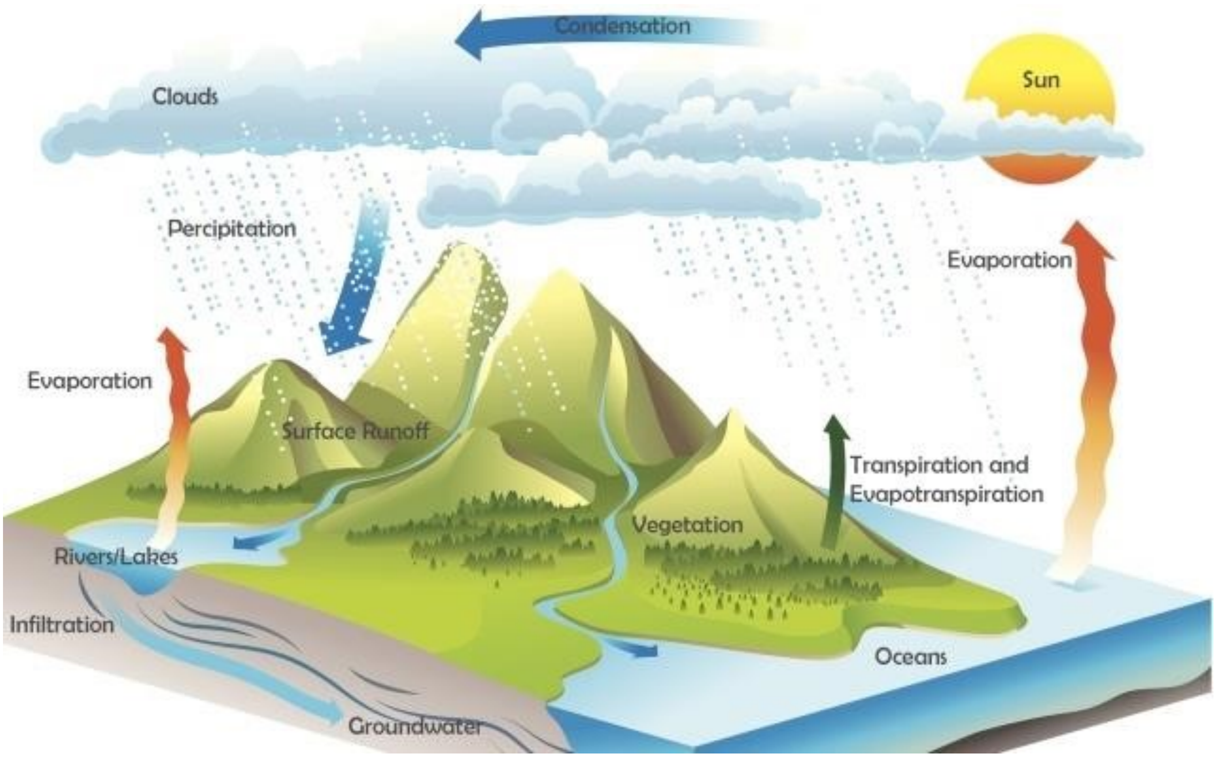


*Figure 5 Water cycle [44]*

### I.1.17.2 Carbon cycle

General term used in reference to the sum of all reservoirs and flows of carbon on earth. The flows tend to be cyclic in nature; for example, carbon removed from the atmosphere (one reservoir) and converted into plant tissue (another reservoir) is returned back into the atmosphere when the plant is burned.

The carbon cycle is the biogeochemical cycle in which carbon is transferred between the Earth's biosphere, pedosphere, geosphere, hydrosphere, and atmosphere. Carbon is a key component of biological substances as well as numerous minerals such as limestone. The carbon cycle, like the nitrogen cycle and the water cycle, consists of a series of processes that are critical to Earth's ability to maintain life. It depicts the flow of carbon as it is recycled and reused throughout the biosphere, as well as long-term processes of carbon sequestration to and release from carbon sinks. Carbon sinks on land and in the water presently absorb roughly one-quarter of anthropogenic carbon emissions each year.

For many centuries, humans have disrupted the biological carbon cycle by changing land use, and more recently, by industrial-scale mining of fossil carbon (coal, petroleum and gas extraction, and cement manufacture) from the geosphere. By 2020, carbon dioxide levels in the atmosphere had risen nearly 52 percent above pre-industrial levels, forcing the Sun to heat the atmosphere and Earth's surface even more. Due to dissolved carbon dioxide, carbonic acid, and other chemicals, rising carbon dioxide has raised the acidity of the ocean surface by around 30%, fundamentally changing marine chemistry. The bulk of fossil carbon has been removed in the last half-century, and rates of extraction are fast increasing, leading to human-caused climate change. Because of the huge but finite inertia of the Earth system, the most serious effects for the carbon cycle and the biosphere, which is crucial to human civilization, are still to come. Restoring equilibrium to this natural system is a global priority, as outlined in the Paris Climate Agreement and Sustainable Development Goal 13. **[45]**

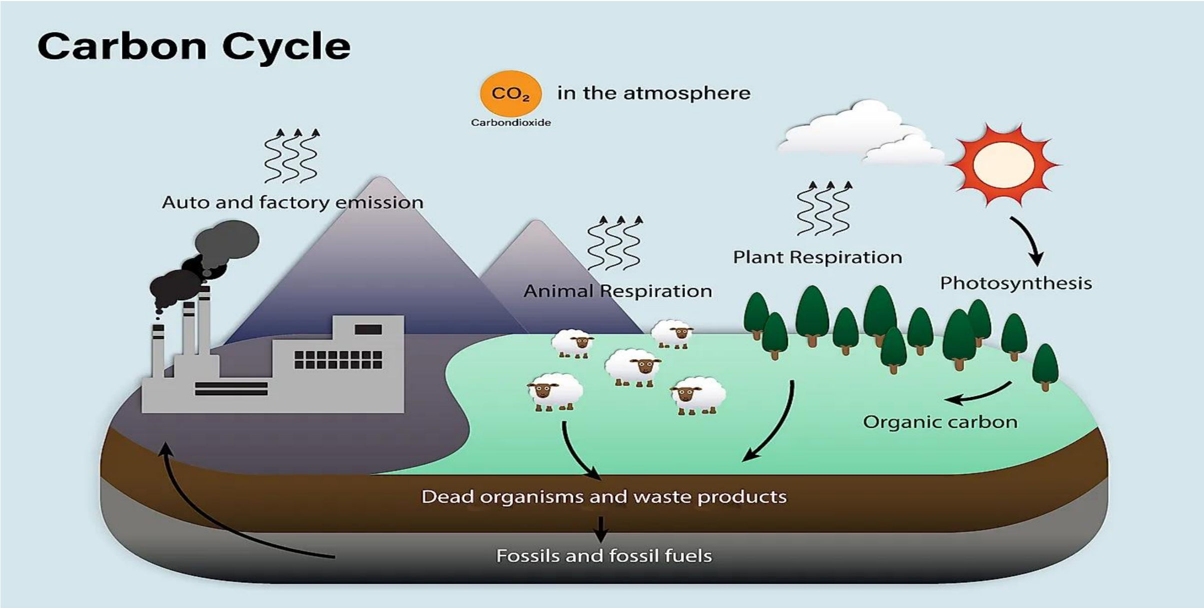


*Figure 6 Carbon cycle [45]*

### I.1.17.3 Nitrogen cycle

The nitrogen cycle is the biogeochemical cycle that converts nitrogen into various chemical forms as it travels through the atmosphere, terrestrial, and marine environments. Nitrogen conversion can occur through both biological and physical mechanisms. Fixation, ammonification, nitrification, and denitrification are all important processes in the nitrogen cycle. The bulk of the Earth's atmosphere (78 percent) is composed of atmospheric nitrogen, making it the primary source of nitrogen. However, the availability of atmospheric nitrogen for biological use is restricted, resulting in a scarcity of useable nitrogen in many types of ecosystems.

Ecologists are particularly interested in the nitrogen cycle because nitrogen availability may alter the pace of essential ecosystem processes such as primary production and breakdown. Human actions such as the use of fossil fuels, the use of artificial nitrogen fertilizers, and the release of nitrogen in wastewater have all had a significant impact on the global nitrogen cycle. Human manipulation of the global nitrogen cycle can have a harmful impact on both the natural environment and human health. **[46]**

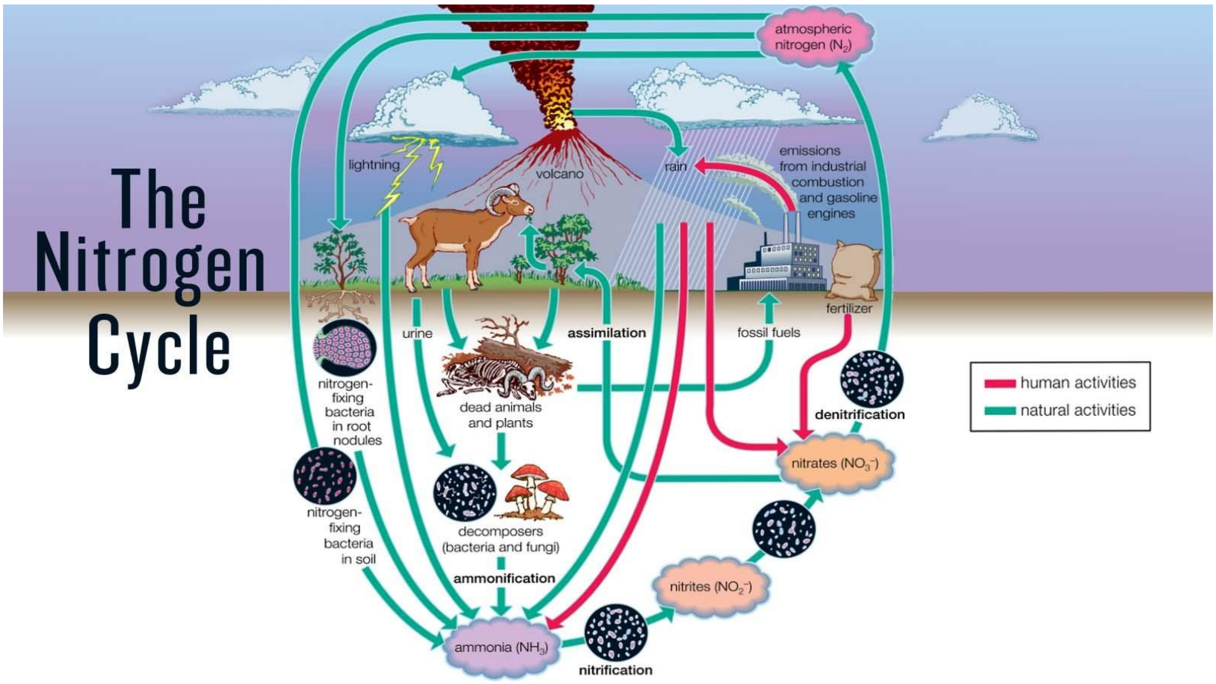


*Figure 7nitrogen cycle [46]*

### I.1.18 Climate

Climate can be defined as 'average weather' and is described in terms of the mean and variability of relevant characteristics such as temperature, precipitation and wind over a period of time ranging from months to thousands or millions of years. **[47]**

### I.1.19 Climate change

A change of climate is what is attributed directly or indirectly to human activity , that alters the composition of the global atmosphere , and which is in addition to natural variability observed over comparable time periods. **[47] [38]**

National Aeronautics and Space Administration "NASA"'s definition of climate change says it is "a broad range of global phenomena created predominantly by burning fossil fuels, which add heat-trapping gases to Earth's atmosphere. These phenomena include the increased temperature trends described by global warming, but also encompass changes such as sea-level rise; ice mass loss in Greenland, Antarctica, the Arctic and mountain glaciers worldwide; shifts in flower/plant blooming; and extreme weather events."

Climate change definition according to "Actu environment": Is a change in climate characteristics at a given location over time: warming or cooling.

#### I.1.19.1 Drivers of climate change

Since the creation of the Earth, there have been several ice ages and interglacial periods. Climate change is thus a natural and cyclical phenomenon.

Today, scientists are alerted by the speed at which the climate is changing. Species, both animal and plant, do not have time to adapt to such rapid climate change, which is why they are under threat, as are humans.

The current definition of climate change implies that certain forms of air pollution, mainly resulting from human activity, threaten to significantly alter the climate, contributing to global warming.

Greenhouse gas emissions, over-consumption of the world's resources and the reduction of natural CO2 sinks such as forests are all contributing to climate change.

Industry, transport, energy, fashion, intensive agriculture, etc. are all sectors that have a major impact on the climate balance. **[38] [15]**

**I.1.20 Global warming**

Global warming includes both warming induced by human greenhouse gas emissions and the resulting large-scale changes in weather patterns. Although there have been previous periods of climate change, since the mid-20th century human activities have had an unprecedented impact on the Earth's climate system and have caused changes on a global scale.

The main driver of warming is greenhouse gas emissions from human activities, over 90% of which are carbon dioxide (CO2) and methane (CH4). The burning of fossil fuels such as coal, oil and natural gas for energy consumption is the main source of these emissions, with additional contributions from agriculture, deforestation and industrial production. The human cause of climate change is not disputed by any scientific body of national or international standing. Temperature increases are accelerated or moderated by climate feedbacks, such as loss of sunlight-reflecting snow and ice cover, increases in water vapour (a greenhouse gas itself), and changes in terrestrial and ocean carbon sinks.

The temperature increase over land is about double the global average increase, leading to expanding deserts and more frequent heat waves and forest fires. Rising temperatures are also amplified in the Arctic, where they contribute to melting permafrost, glacial retreat and loss of sea ice. Warmer temperatures increase evaporation rates, leading to more intense storms and extreme weather. Impacts on ecosystems include the migration or extinction of many species as their environment changes, particularly in coral reefs, mountains and the Arctic. Climate change threatens people with food insecurity, water scarcity, flooding, infectious diseases, extreme heat, economic loss and displacement. These impacts have led the World Health Organization to call climate change "the greatest threat to global health" in the 21st century. Even if efforts to minimise future warming are successful, some effects will continue for centuries, including sea level rise, rising ocean temperatures and ocean acidification.

Many of these impacts are already being felt at the current level of warming, which averages over 1.2°C globally. The Intergovernmental Panel on Climate Change (IPCC) has published a series of reports that predict a significant increase in these impacts when global warming exceeds 1.5°C, and even more if it reaches 2°C. Further warming also increases the risk of triggering critical thresholds called tipping points.

Responding to climate change involves both mitigation and adaptation. Mitigation - limiting climate change - is about reducing greenhouse gas emissions and removing them from the atmosphere; methods include the development and deployment of low-carbon energy sources such as wind, solar and nuclear power, but also the phasing out of coal, oil and gas, improving energy efficiency, reforestation and forest preservation. Adaptation is about adjusting to the actual or expected climate, for example through better coastal protection, improved disaster management, assisted colonisation and the development of more resilient crops. Adaptation alone cannot avoid the risk of "severe, widespread and irreversible" impacts.

Under the 2015 Paris climate agreement, countries collectively agreed to keep warming "well below 2°C" through mitigation efforts. However, with these commitments made in 2015, global warming would still reach about 2.8°C by the end of the century. Limiting warming to 1.5°C would require halving emissions by 2030 and reaching near-zero emissions by 2050 **[15] [37] [48] [49]**

#### I.1.20.1 Consequences of global warming

##### I.1.20.1.1 Rising Sea Levels

Rising sea levels are being influenced by climate change. The global average sea level has risen roughly 8 inches (20 cm) in the last 100 years, and climate experts predict that it will rise much faster in the next 100 years as a result of climate change consequences.

Coastal cities such as New York are already seeing a rise in the number of flooding occurrences, and many of these cities may require seawalls to survive by 2050. Sea levels are anticipated to increase 1 to 4 feet (30 to 100 cm), enough to overwhelm numerous small Pacific island nations (Vanatu), famed beach resorts (Hilton Head), and coastal cities (Bangkok, Boston).

If the Greenland ice cap and/or the Antarctic ice shelf melt, sea levels might increase by up to 20 feet (6 meters), inundating areas such as Florida, the Gulf Coast, New Orleans, and Houston. **[15] [37] [48] [49]**

##### I.1.20.1.2 Ice fusion

According to projections, within the next 100 years, if not sooner, the world's glaciers will have vanished, as would the Polar ice cap and the massive Antarctic ice shelf, Greenland may be green again, and snow will be an uncommon occurrence at what are today the world's most popular ski resorts. **[15] [37] [48] [49]**

##### I.1.20.1.3 Torrential downpours and more powerful storms

While the particular circumstances that cause rainfall will not change, climate change will increase the amount of water in the atmosphere, resulting in intense downpours rather than continuous showers when it does rain.

The strength of hurricanes and typhoons will grow, and flooding will become more prevalent. **[15] [37] [48] [49]**

#### I.1.20.1.4 Heatwaves and droughts

Despite occasional rain, droughts and lengthy heatwaves will become more prevalent.

Rising temperatures are predictable, but it doesn't mean that certain regions of the world won't "enjoy" record freezing temperatures and devastating winter storms. (Heating disrupts the entire global weather system, shifting both cold upper air currents and hot dry ones.) Single snowballs and snowstorms do not refute climate change.)

However, hot, dry locales will get hotter and dryer, whereas temperate areas with frequent rainfall will become considerably hotter and drier.

The recent spate of record high temperature years and record number of worldwide droughts will become the norm, rather than the surprise that they have been. **[15] [37] [48] [49]**

#### I.1.20.1.5 Changing ecosystems

As the planet heats, entire ecosystems will shift.

Rising equatorial temperatures have already forced staple crops like rice north into formerly colder locations, and many fish species have traveled considerable distances to stay in waters that are the correct temperature for them.

In formerly colder areas, this may enhance fisherman's catches; in warmer regions, it may eliminate fishing; and in many locations, like as the US East Coast, fishermen may have to travel further to access fishing grounds.

Farmers in temperate zones are struggling with drier conditions for crops like corn and wheat, and once-prime growing zones are now threatened.

Some places may see total ecological transformation.

Climate change impacts and warming, for example, will soon drastically affect the forests in California and the East Coast; in Europe, hundreds of plant species will die and hundreds more will relocate thousands of kilometers. **[15] [37] [48] [49]**

#### I.1.20.1.6 Reduced food security

One of the most noticeable effects of rising temperatures is noticed in global agriculture, however the effects varied greatly between the relatively temperate developed world and the more tropical poor world.

Different crops grow best at certain temperatures, and as those temperatures vary, so does their productivity.

Rice productivity, the primary meal of more than one-third of the world's population, decreases by 10% for every 10 degrees Celsius increase in temperature.

Past climate-related concerns have been mitigated by significant breakthroughs in rice technology and ever-increasing fertilizer applications; nonetheless, projected temperature rises are expected to diminish rice output by 25% by 2050 in Thailand, the world's largest exporter of rice.

Simultaneously, global population estimates predict that the developing world will add 3 billion people by 2050, implying that developing-world food producers will need to quadruple staple crop output by then just to sustain present levels of food consumption. **[15] [37] [48] [49]**

#### I.1.20.1.7 Pests and Diseases

Rising temperatures are beneficial to agricultural pests, illnesses, and disease vectors.

Pest populations are increasing, and ailments that were formerly exclusively seen in tropical locations are increasingly becoming endemic in far larger areas.

In Southeast Asia, for example, where malaria had been limited to a rainy season sickness in most locations, it is now widespread practically all year.

Similarly, dengue disease, which was once exclusive to tropical locations, has become endemic throughout the region.

Temperature increases also hasten the reproduction of microorganisms and insects, hastening the rate at which they acquire resistance to control methods and medications (a problem already observed with malaria in Southeast Asia). **[15] [37] [48] [49]**

### I.1.20.2 The effect of global warming in climate change

Heat is energy, and when energy is added to any system, changes occur.

Because all systems in the global climate system are linked, adding heat energy creates a change in the global climate as a whole.

The ocean covers much of the planet, which causes it to heat up. More water evaporates into clouds as the ocean warms.

Where storms such as hurricanes and typhoons emerge, more energy-intensive storms form. As the atmosphere warms, glaciers and mountain snowpacks melt, as does the Polar ice cap and the vast ice shield protruding off Antarctica, boosting sea levels.

Temperature changes alter the major wind patterns that bring the monsoons to Asia and rain and snow all over the planet, making drought and uncertain weather more likely to happen.

This is why scientists have shifted their attention away from global warming and onto the broader issue of climate change. **[15] [37] [48] [49]**

### I.1.21 Sustainable development

Is the development that meets the needs of the present without compromising the ability of future generations to meet their needs

Sustainable development is an organizational concept for achieving human development goals while simultaneously preserving natural systems' ability to supply the natural resources and ecosystem services on which the economy and society rely. The targeted outcome is a state of society in which living circumstances and resources are utilised to suit human needs without jeopardizing the natural system's integrity and stability. Sustainable development is defined as development that satisfies the requirements of the present without jeopardizing future generations' ability to satisfy their own needs.

While the current notion of sustainable development is mostly drawn from the Brundtland Report of 1987, it is also based on previous concepts about sustainable forest management and twentieth-century environmental concerns. As the notion of sustainable development evolved, its emphasis switched to economic development, social development, and environmental conservation for future generations

The Sustainable Development Goals (2015-2030) of the United Nations address global concerns such as poverty, inequality, climate change, environmental degradation, peace, and justice. satisfy their own requirements. **[47] [50]**

## I.2 DANGER, RISK AND HAZARDOUS PHENOMENA MANAGMENET CONCEPT

### I.2.1 Hazard

A hazard is any source of potential damage, harm or adverse health effects on something or someone.

Basically, a hazard is the potential for harm or an adverse effect (for example, to people as health effects, to organizations as property or equipment losses, or to the environment).

When we refer to hazards in relation to occupational safety and health the most commonly used definition is ‘A Hazard is a potential source of harm or adverse health effect on a person or people. **[51] [52]**

#### I.2.1.1 Types of hazards

A common way to classify hazards is by category:

- **biological** - bacteria, viruses, insects, plants, birds, animals, and humans, etc.,
- **chemical** - depends on the physical, chemical and toxic properties of the chemical,
- **ergonomic** - repetitive movements, improper set up of workstation, etc.,
- **physical** - radiation, magnetic fields, pressure extremes (high pressure or vacuum), noise, etc.,
- **psychosocial** - stress, violence, etc.,
- **safety** - slipping/tripping hazards, inappropriate machine guarding, equipment malfunctions or breakdowns.

### I.2.2 Risk

Is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard. It may also apply to situations with property or equipment loss, or harmful effects on the environment.

When we refer to risk in relation to occupational safety and health the most commonly used definition is ‘risk is the likelihood that a person may be harmed or suffers adverse health effects if exposed to a hazard.’ **[51] [52]**

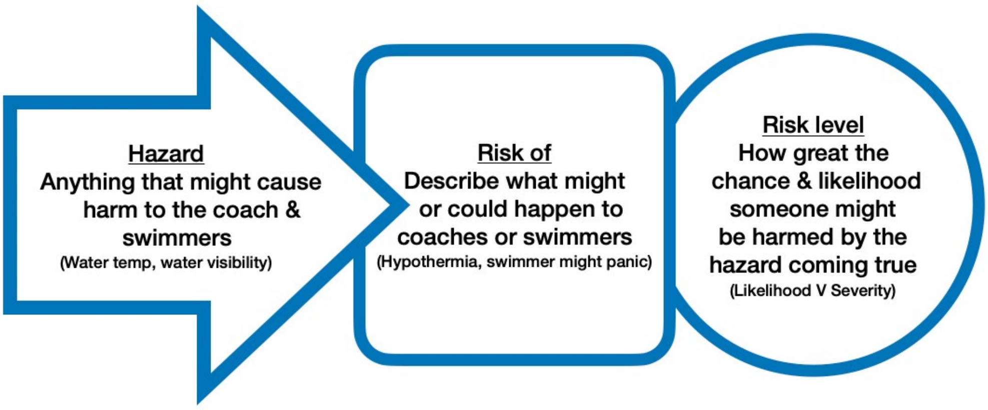


*Figure 8 hazard, risk and risk level representation* ***[52]***

### I.2.3 Control measures

Control measures include steps that may be performed to decrease the possibility of exposure to the danger, or the control measure might be to remove the hazard or lower the chance of that risk being realized. A basic control method would be to secure the moving pieces of equipment to eliminate the possibility of contact. When discussing control measures, we frequently refer to the control measure hierarchy. **[53]**

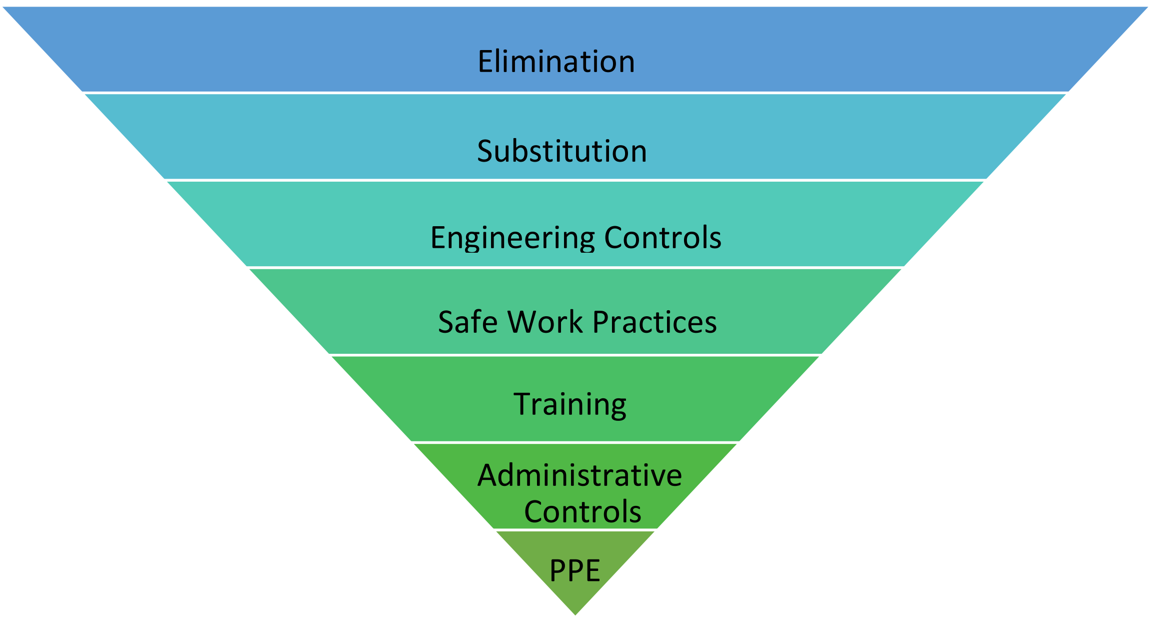


*Figure 9 Control measures*

#### **I.2.3.1** Elimination

Elimination is the most effective way to control a risk because the hazard is no longer present, and is the preferred way to control a hazard.

**I.2.3.2** Substitution

If it is not reasonably possible to remove the hazards and related risks, you must use the substitute approach to reduce the risks. Replace the task with a less dangerous technique to get the same result, or change a formula so that instead of dealing with a highly explosive fluid, employees work with a less explosive fluid.

**I.2.3.3** Engineering controls

An engineering control is a physical control measure that eliminates the hazard at its source (requires a physical change at the workplace). For example, when lifting large items, employ mechanical devices such as trolleys or pallet trucks; install guards around moving sections of equipment; install residual electrical safety switches; and install sound dampening methods to prevent exposure to unpleasant or harmful sounds.

**I.2.3.4** Safe Work Practice(s)

Work techniques or procedures designed to reduce exposure to a danger, as well as the information, training, and instruction required to guarantee workers can work safely, will be included in Safe Work Practices. To reduce risks, a company should design safe working procedures that explain the activity, identify the dangers, and document how the activities are to be completed.

**I.2.3.5** Training

Provide training to increase the skills and understanding of people exposed to hazards, as well as assistance to managers and employees in identifying and managing health and safety issues. Staff should be required to demonstrate competence in doing the task in accordance with the method during training; this might take the shape of a test.

**I.2.3.6** Administrative control(s)

This can involve adopting alternative work practices to protect employees from risks, such as limiting exposure time to a hazardous activity, such as working in a noisy environment, and/or using signs to notify individuals of a hazard.

**I.2.3.7** Personal Protective Equipment (PPE)

When all of the preceding steps are deemed to be insufficient in reducing risk to a manageable level, the next step is to give PPE to employees. Safety glasses, hardhats, fireretardant garments, ear defenders, and safety boots are all examples of personal protective equipment (PPE). Some sectors may also need user-worn warning devices, including as gas detectors and person-down detectors.

- Specification - is it suitable for the given task
- Fitting - items such as dust masks will often require specialist fitting to ensure an adequate seal
- Training in use - you cannot force staff to wear PPE so correct training is important for staff to understand the reason for use.

- Maintenance - it goes without saying that poorly maintained equipment is destined to fail at some stage.

### I.2.4 Risk assessment

Risk assessment is the process where a person should :

- Identify hazards and risk factors that have the potential to cause harm (hazard identification).
- Analyze and evaluate the risk associated with that hazard (risk analysis, and risk evaluation).
- Determine appropriate ways to eliminate the hazard, or control the risk when the hazard cannot be eliminated (risk control). **[54] [55]**

### I.2.5 Carrying risk assessments

The health and safety organization has recommended a five-step process for completing a risk assessment. This provides a useful checklist to follow to ensure that the assessment is suitably comprehensive. It involves:

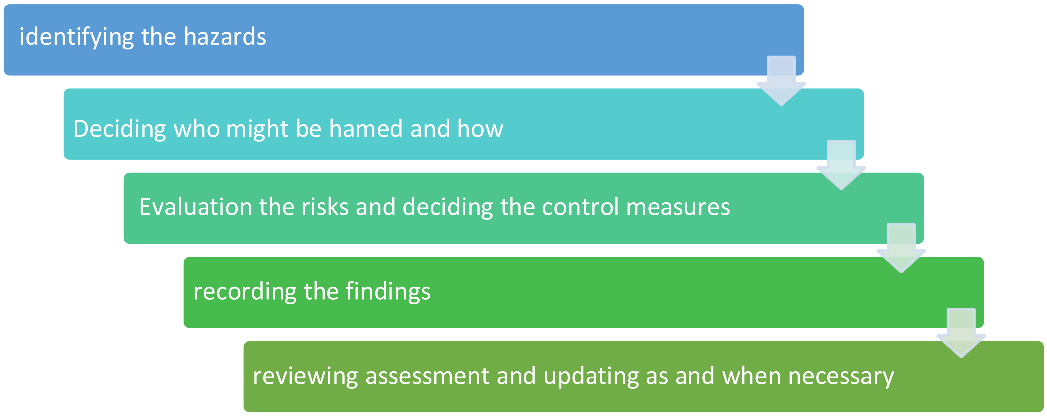


*Figure 10 Steps of Carrying risk assessments*

#### I.2.5.1 Step 1: Identifying the hazards

To detect risks, one must first comprehend the distinction between a hazard and a risk. A hazard is defined as "anything with the potential to cause harm," while a risk is defined as "the possibility of that potential harm being realized."

Hazards may be discovered using a variety of methods, such as strolling about the workplace or interviewing your staff.

#### I.2.5.2 Step 2: Deciding who might be harmed and how

Once the dangers are identified, one needs to figure out who may be hurt and how, such as "those working in the warehouse" or "members of the public." **I.2.5.3 Step 3: Evaluating the risks and deciding thecontrol measures**

After identifying the threats' and 'deciding who may be hurt and how,' one must then safeguard the people from harm. The dangers can be totally eliminated or regulated such that damage is unlikely.

### I.2.5.4 Step 4: Recording findings

The results should be documented; it is a legal obligation when there are 5 or more employees; and documenting the findings demonstrates that you have identified the dangers, determined who may be affected and how, and also illustrates how you plan to reduce the risks and hazards.

### I.2.5.5 Step 5: Reviewing assessment and updating as and when necessary

Remember that few workplaces remain static, and as a result, this risk assessment should be evaluated and revised as needed.

## CONCLUSION

The whole scientific world today agrees that since the very beginning of the industrial era, pollution has continued to worsen and pollutants emissions are significantly rising disturbing the planets balance.

In this chapter we have been able to describe the environment, its component plus the dangerous events associated to it. Moreover, we have found that Air pollution is one of the environmental damages most perceived by citizens. And much effort is still to be made in terms of reduction and prevention, particularly in developing countries.

# CHAPTER II
# REGULATIONS / METHODS AND TOOLS OF ENVIROMENTAL IMPACT ASSESMENT

## INTRODUCTION

In a world where standards and regulations are becoming more and more complex, organizations must be sufficiently vigilant and reactive. They must know the issues and apply these requirements upstream in order to be able to offer compliant products on the market. These issues are all the more strategic as the impacts in terms of costs and image of non-compliance and product returns are critical in a very competitive market.

The purpose of this chapter is to review the most important aspects of regulations (both national and international) and standards norms of environmental safety and hydrocarbon manipulation activities. Plus, we will try to remove certain ambiguities relating to activities relating to risk management, the various methods and risk analysis tools.

## II.1 REGULATIONS

### II.1.1 NATIONAL REGULATIONS

*Table 1 Laws of Hydrocarbon activity safety concept and environment*

| Executive decree N° | Date | Title | Text |
|---|---|---|---|
| **06-198** | 4 Joumada El Oula 1427 corresponding to 31 May 2006 | The regulation applicable to establishments classified for environmental protection | the purpose of this decree is to define the regulations applicable to establishments classified for the protection of the environment and, in particular, the authorisation and declaration regimes for the operation of classified establishments, the procedures for their issue, suspension and withdrawal, as well as the conditions and procedures for their control. |
| **. 06-02** | 7 January 2006 | Defining limit values, alert thresholds and air quality objectives in the event of atmospheric pollution. | The purpose of this decree is to define the limit values, alert thresholds and air quality objectives in case of air pollution.<br>Air quality monitoring concerns the following substances: nitrogen dioxide; -sulphur dioxide; -ozone; - fine suspended particles. |

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| | | | The possession and use of ionising radiation sources are subject to the authorisation regime with the exception of those which meet the conditions of exemption provided for by this decree and which only require a declaration to the Atomic Energy Commission. |
| **06-138** | 15 April 2006 | Regulating the emission into the atmosphere | of gases, fumes, vapours, liquid or solid particles, as well as the conditions under which their control is exercised.<br>The purpose of this decree is to regulate the emission into the atmosphere of gases, fumes, vapors, liquid or solid particles, as well as the conditions under which exercise their control. |
| **06-198** | 31 May 2006 | Defining the regulations applicable to establishments classified for the protection of the environment. | The purpose of this decree is to define the regulations applicable to establishments classified for the protection of the environment and, in particular, operating authorization and declaration systems for classified establishments, their terms of issue, suspension and withdrawal, as well as the conditions and terms of their control. |
| **07-144** | 19 May 2007 | Establishing the nomenclature of installations classified for | The purpose of this decree is to set the nomenclature of classified installations for |

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| | | the protection of the environment. | the Environmental Protection.<br>The nomenclature of facilities classified for the protection of the environment is a classification that includes:<br>Allocation of a four-digit section number.<br>The designation of classified installation activity.<br>The determination of the display radius of the classified installation.<br>The documents to be attached to the application for authorization to operate establishments classified, namely, as the case may be, the environmental impact study, the hazard study, the notice of impact on the environment and the report on dangerous products. |
| **07-145** | 19 May 2007 | Determining the scope, content and the content and approval procedures for environmental impact studies and notices on the environment | The study or notice of impact on the environment aims to determine the insertion of a project in its environment by identifying and evaluating the direct effects and/or indirect effects of the project, and verifies the assumption of the prescriptions relating to the protection of the environment by the project concerned.<br>The impact study or notice is drawn up at the expense of the promoter by offices studies approved by the |

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| | | | Minister for the Environment.<br><br>As soon as the study or impact notice is submitted for their approval, any modification of the size of the installations, the treatment capacity and/or the production and technological processes must be the subject of a new study or impact notice. |
| **07-207** | 30 June 2007 | Regulating the use of ozone-depleting substances, their mixtures and products containing them | The purpose of the provisions of this decree is to regulate the use of substances which deplete the ozone layer, hereinafter referred to as "controlled substances whether alone or mixed with other substances, as well as products containing them |
| **07-299 and 07-300** | 27 September 2007 | fixing respectively the application modalities of the complementary tax on atmospheric pollution of industrial origin and on industrial wastewater | These two decrees enshrine the polluter-pays principle;<br><br>The determination of the discharged pollution loads, in order to fix the coefficient<br><br>applicable multiplier, is operated on the basis of the analyzes carried out by<br><br>the national observatory for the environment and sustainable development “ONEDD” |
| **06-162** | 17 May 2006 | declaring the industrial zone of Arzew as a major risk zone. | The present decree aims at fixing the measures to be taken inside the industrial zone of Arzew and the hydrocarbon port area |

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| | | | adjoining it, within the framework of the prevention of a major risk and/or the management of a disaster. |
| **93-68** | 3 mars 1993 | application of the tax on activities polluting or dangerous for the environment. | The purpose of this decree is to define the activities subject to the tax on activities polluting or dangerous for the environment |
| **09-336** | 20 octobre 2006 | the tax on activities polluting or dangerous for the environment | The purpose of this decree is to define the activities subject to the tax on activities polluting or dangerous for the environment pursuant to the provisions of article 117 of law n° 91-25 of December 18, 1991 relating to the finance law for 1992. The list of activities polluting or dangerous for the environment affected by a multiplier coefficient between one (01) and four (04) is appended to the original of this decree |
| **06-02** | 7 Dhou El Hidja 1426 corresponding to January 7, 2006 | of defining the limit values | The purpose of this decree is to alert thresholds and air quality objectives in the event of atmospheric pollution. |
| **2000-73** | 26 Dhou El Hidja 1420 corresponding to April 1, 2000 | supplementing Executive Decree No. 93-165 of July 10, 1993 | The purpose of this decree is regulating atmospheric emissions from smokers gas dust odors and solid particles from fixed installations. |

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|---|---|---|---|
| **16-262** | 13 October 2016 | Ratifying the Paris Agreement on climate change | -adopted in Paris on 12 December<br>2015 OJ No. 60 of 13 October 2016<br>The Parties recognise the importance of international support and cooperation for adaptation efforts and the need to take into account the needs of developing country Parties, particularly those that are particularly vulnerable to the adverse effects of climate change. |

*Table 2Executives decrees of hydrocarbons activity safety concept and environment*

| Executive decree N° | Date | Title | Text |
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| **06-198** | 4 Joumada El Oula 1427 corresponding to 31 May 2006 | The regulation applicable to establishments classified for environmental protection | the purpose of this decree is to define the regulations applicable to establishments classified for the protection of the environment and, in particular, the authorisation and declaration regimes for the operation of classified establishments, the procedures for their issue, suspension and withdrawal, as well as the conditions and procedures for their control. |
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| | | | subject to the authorisation regime with the exception of those which meet the conditions of exemption provided for by this decree and which only require a declaration to the Atomic Energy Commission. |
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| **06-198** | 31 May 2006 | Defining the regulations applicable to establishments classified for the protection of the environment. | The purpose of this decree is to define the regulations applicable to establishments classified for the protection of the environment and, in particular, operating authorization and declaration systems for classified establishments, their terms of issue, suspension and withdrawal, as well as the conditions and terms of their control. |
| **07-144** | 19 May 2007 | Establishing the nomenclature of installations classified for the protection of the environment. | The purpose of this decree is to set the nomenclature of classified installations for the Environmental Protection.<br>The nomenclature of facilities classified for the protection of the environment is a classification that includes:<br>Allocation of a four-digit section number.<br>The designation of classified installation activity. |

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| | | | The determination of the display radius of the classified installation.<br>The documents to be attached to the application for authorization to operate establishments classified, namely, as the case may be, the environmental impact study, the hazard study, the notice of impact on the environment and the report on dangerous products. |
| **07-145** | 19 May 2007 | Determining the scope, content and the content and approval procedures for environmental impact studies and notices on the environment | The study or notice of impact on the environment aims to determine the insertion of a project in its environment by identifying and evaluating the direct effects and/or indirect effects of the project, and verifies the assumption of the prescriptions relating to the protection of the environment by the project concerned.<br>The impact study or notice is drawn up at the expense of the promoter by offices studies approved by the Minister for the Environment.<br>As soon as the study or impact notice is submitted for their approval, any modification of the size of the installations, the treatment capacity and/or the production and technological processes must be the subject of a new study or impact notice. |
| **07-207** | 30 June 2007 | Regulating the use of ozone-depleting substances, their mixtures and products containing them | The purpose of the provisions of this decree is to regulate the use of substances which deplete the ozone layer, hereinafter referred to as "controlled substances whether alone or mixed with other substances, as well as products containing them |

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| **07-299 and 07-300** | 27 September 2007 | fixing respectively the application modalities of the complementary tax on atmospheric pollution of industrial origin and on industrial wastewater | These two decrees enshrine the polluter-pays principle;<br>The determination of the discharged pollution loads, in order to fix the coefficient<br>applicable multiplier, is operated on the basis of the analyzes carried out by<br>the national observatory for the environment and sustainable development “ONEDD” |
| **06-162** | 17 May 2006 | declaring the industrial zone of Arzew as a major risk zone. | The present decree aims at fixing the measures to be taken inside the industrial zone of Arzew and the hydrocarbon port area adjoining it, within the framework of the prevention of a major risk and/or the management of a disaster. |
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| | | | |
|---|---|---|---|
| | | | objectives in the event of atmospheric pollution. |
| **2000-73** | 26 Dhou El Hidja 1420 corresponding to April 1, 2000 | supplementing Executive Decree No. 93-165 of July 10, 1993 | The purpose of this decree is regulating atmospheric emissions from smokers gas dust odors and solid particles from fixed installations. |

*Table 3 presidential decrees of hydrocarbon activity safety legislation concept and environment*

| Presidential Decree Nº | Date | Title | Text |
|---|---|---|---|
| **16-262** | 13 October 2016 | Ratifying the Paris Agreement on climate change | -adopted in Paris on 12 December 2015 OJ No. 60 of 13 October 2016<br>The Parties recognise the importance of international support and cooperation for adaptation efforts and the need to take into account the needs of developing country Parties, particularly those that are particularly vulnerable to the adverse effects of climate change. |
| **15-119** | 13 May 2015 | Accepting the Doha Amendment to the Kyoto Protocol to the United Nations Framework Convention on Climate Change, adopted Doha, Qatar, on 8 December 2012. | This decree consents to the Doha Amendment to the Kyoto Protocol to the United Nations Framework Convention on Climate Change, adopted in Doha, Qatar, on 8 December 2012. |
| **14-376** | 8 Rabie El Aouel 1436 corresponding to 30 December 2014 | Ratifying the memorandum of understanding between the Government of the People's Democratic Republic of Algeria and the Government of the State of Kuwait in the field of environment and sustainable development, | The memorandum of understanding between the government of the People's Democratic Republic of Algeria and the Government of the State of Kuwait in the field of environment and sustainable development, signed in Kuwait City on 2 October 2013 |

| | | | |
|---|---|---|---|
| | | signed in Kuwait-City on 2 October 2013 | |
| **11-246** | 10 July 2011 | On the accession of the People's Democratic Republic of Algeria to the International Convention on Intervention on the High Seas in the Event of an Accident Causing or Likely to Cause Pollution by Hydraucarbons, adopted in Brussels on 29 November 1969, and its Protocol, done in London on 2 November 1973 | Under the terms of this Presidential Decree, the People's Democratic Republic of Algeria accedes to the International Convention on Intervention on the High Seas in Cases of Accidents Involving or Likely to Involve Oil Pollution, adopted in Brussels on 29 November 1969, and the Protocol thereto, done in London on 2 November 1973 |
| **07-94** | 29 Safar 1428 corresponding to 19 March 2007 | The ratification of the amendment to the Montreal Protocol on substances that deplete the ozone layer, adopted in Beijing on 3 December 1999. | This Presidential Decree ratifies the amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in Beijing on 3 December 1999. |

## II.1.2 INTERNATIONAL REGULATIONS

### II.1.2.1 Important Laws

#### II.1.2.1.1 - United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC entered into force on 21 March 1994. Today, membership of the Convention is almost universal. The 197 countries that have ratified it are called Parties to the Convention.

The UNFCCC is a "Rio Convention", one of three adopted at the "Rio Earth Summit" in 1992. Its sister conventions are the Convention on Biological Diversity (CBD) and the Convention to Combat Desertification (UNCCD). The three are intrinsically linked. It is in this context that the Joint Liaison Group was set up to strengthen coordination between the three Rio Conventions, with the ultimate aim of developing synergies in their activities on issues of mutual interest. It now also includes the Ramsar Convention on Wetlands. Preventing human activities that are 'dangerous' to the climate system is the ultimate goal of the UNFCCC.

### II.1.2.2 - Kyoto Protocol to the United Nations Framework Convention on Climate Change.

The Kyoto Protocol was adopted on 11 December 1997. Owing to a complex ratification process, it entered into force on 16 February 2005. Currently, there are 192 Parties to the Kyoto Protocol.

In short, the Kyoto Protocol operationalizes the United Nations Framework Convention on Climate Change by committing industrialized countries and economies in transition to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets. The Convention itself only asks those countries to adopt policies and measures on mitigation and to report periodically.

The Kyoto Protocol is based on the principles and provisions of the Convention and follows its annex-based structure. It only binds developed countries, and places a heavier burden on them under the principle of "common but differentiated responsibility and respective capabilities", because it recognizes that they are largely responsible for the current high levels of GHG emissions in the atmosphere.

### II.1.3 ISO INTERNATIONAL STANDARDIZATION ORGANIZATION

#### II.1.3.1 Environmental Management

The ISO 14000 family of environmental management standards, written by technical committee ISO/TC 207, Environmental management, are defined as global benchmarks to promote good practices in management and design for the environment.

• **ISO 14001**, Environmental management systems – Requirements and Guidelines for its use.

This standard contributes to the objectives of organizations seeking to operate by promoting a sustainable environment.

#### II.1.3.2 Quantification of GHG emissions

ISO standards are designed to be policy-neutral, allowing for integration

ISO GHG standards in many GHG programs around the world. That whether their application is voluntary or mandatory, the increasing use of ISO standards on GHGs attests to their versatility and their contribution to bringing GHG markets closer to world. They provide an internationally agreed framework for measuring emissions greenhouse gas emissions, verify the declarations and accredit the organizations that carry out this type of activities to ensure accuracy and completeness. The main standards in the field are:

- **ISO 14064,** Greenhouse gases
- **ISO 14065,** Greenhouse gases – Requirements for organizations providing greenhouse gas validations and verifications for accreditation or other forms of recognition.

#### II.1.3.3 Mitigation and adaptation

ISO has established partnerships with key international stakeholders, such as the United Nations Framework Convention on Climate Change (UNFCCC) and the World Bank, to establish strategic roadmaps for a standards system on mitigating climate change and adapting to its effects.

- **ISO 14080**, Greenhouse gas management and associated activities – Framework and principles of methodologies for climate action.

This standard defines a framework and principles to improve the compatibility of programs mitigation and adaptation, and develop the different approaches in this area. Furthermore, several standards are being developed to help organizations and communities adapt to better withstand climate change, including standards on the assessment vulnerability assessment, adaptation planning, and adaptation monitoring and evaluation.

These include the following standards in particular:

- **ISO 14090**, Adaptation to climate change – Principles, requirements and guidelines
- **ISO 14091**, Adaptation to climate change – Vulnerability, impacts and risk assessment
- **ISO 14092**, GHG management and related activities: requirement and guidance of adaptation planning for organizations including local governments and communities **[56]**

**II.1.4 United states' code of federal regulations [57]**

Title 40: Protection of Environment

Chapter I Environmental Protection Agency

*Table 4 Subchapter C Air Programs*

| Part N° | Title |
|---|---|
| 61 | National Emission Standards for Hazardous Air Pollutants |
| 63 | National Emission Standards for Hazardous Air Pollutants for Source Categories |
| 75 | Continuous Emission Monitoring |
| 82 | Protection of Stratospheric Ozone |
| 85 | Control of Air Pollution from Mobile Sources |
| 86 | Control of Emissions from New and In-Use Highway Vehicles and Engines |
| 87 | Control of Air Pollution from Aircraft and Aircraft Engines |
| 88 | Clean-Fuel Vehicles |
| 89 | Control of Emissions from New and In-Use Nonroad Compression-Ignition Engines |
| 90 | Control of Emissions from Nonroad Spark-Ignition Engines at or Below 19 Kilowatts |

| | |
|---|---|
| **91** | Control of Emissions from Marine Spark-Ignition Engines |
| **92** | Control of Air Pollution from Locomotives and Locomotive Engines |
| **94** | Control of Emissions from Marine Compression-Ignition Engines |
| **98** | Mandatory Greenhouse Gas Reporting |

Subchapter U Air Pollution Controls: includes control of Greenhouse Gas Emissions from various types of Engines and regulation of Fuels, Fuel Additives, and Regulated Blend stocks

### II.1.5 The consolidated Acts and regulations of Canada: [58]

Consolidated Acts: Greenhouse Gas Pollution Pricing Act (S.C. 2018, c. 12, s. 186):

- **Part 1 Fuel charge**: includes regulatory charges and taxes enforced by the government on the use of fossil fuels
- **Part 2 Industrial Greenhouse gas emissions:** explains the pricing Mechanism for Greenhouse Gas Emissions, the regulations that needs to be followed the administrations and the enforcement of them and the offences and punishment to whom breaks the law
- **PART 3 Application of Provincial Schemes**: How to best apply the act
- **PART 4 Report to Parliament:** Every year the Minister of the Environment must prepare a report on the administration of this Act and have a copy of the report tabled in each House of Parliament.

## II.2 TOOLS, METHODS AND SOFTWARES OF ENVIRONEMENTAL IMPACT ASSESSMENT

### II.2.1 METHODS

#### II.2.1.1 Ad hoc methods

Ad hoc approaches show broad regions of potential consequences by providing composite environmental factors (for example, flora and fauna) that are likely to be impacted by the planned activity.

These strategies entail establishing a team of professionals who discover impacts in their respective fields of expertise. Each parameter is addressed independently, as is the nature of the consequences (long term or short term, reversible or irreversible)

These approaches provide an approximate estimate of overall effect while indicating the wide locations and general kind of potential affects. The assessor uses an intuitive technique to make a broad-based qualitative assessment in this procedure. **[59]**

#### II.2.1.2 Checklist method

Environmental elements are described in an organized fashion using important weightings for components and scaling algorithms for the effects of each choice in this method.

Checklists are excellent predictors of impact detection. They efficiently pique their audience's interest and raise their level of awareness. The identification of impacts is a critical function of an environmental impact assessment.

**II.2.1.3 Matrix Method**

This technique provides a framework for the interplay of various project activities and the potential environmental implications induced by them. When project activities are recorded on one axis (typically vertical) and environmental repercussions are reported on the other, a basic interaction matrix is generated. Leopold et al. pioneered this approach in 1971. It includes around 100 project acts as well as approximately 88 environmental characteristics and circumstances.

**II.2.1.4 Overlays**

This method is based on a collection of maps of a project area's environmental characteristics that cover physical, social, ecological, and aesthetic aspects. It allows for separate mapping of critical environmental features at the same scale as the project's site plan (Ex: wetlands, steep slopes, soils, floodplains, bedrock outcrops, wildlife habitats, vegetative communities, cultural resources, etc.

In the past, environmental elements were mapped on translucent plastic in various colors. A modern approach for performing the same function employs computer software, hardware, data, and professional personnel. It is known as GIS (Geographic Information Systems).

**II.2.2 TOOLS**

**II.2.2.1 Environmental Monitoring**

This concept refers to the monitoring of the expected impacts of a project in order to improve environmental management practices. It is also an instrument for implementing EIAs, especially for monitoring activities with an adverse impact on the environment.

**II.2.2.2 Environmental and Social Management Plan (EMSP)**

Also known as the environmental mitigation or control plan, is an action plan or system that defines how, when, who, what and where to integrate environmental mitigation and control measures throughout the implementation of a project. **[59]**

**II.2.2.3 Environnemental Audit (Post Audit)**

A management tool used mainly in the field of industrial companies, the term environmental audit refers to the internal, systematic, periodic and objective examination of environmental management practices within the company.

**II.2.2.4 Environmental Management System (EMS)**

It is a means of ensuring the effective and ongoing implementation of an environmental management plan and compliance with environmental objectives and targets. The EMS is usually applied to an organization or an operating site such as an industrial plant, a public transport system or a waste disposal site.

Environmental life cycle assessment or life cycle assessment evaluates the environmental burden of a product or activity from cradle to grave.

- What are the key points of a product from an environmental point of view?
- What are the priorities for action to improve a product, taking into account both its environmental effectiveness and its costs?

**II.2.2.5 Sustainable Development Indicators (SDI)**

The monitoring of the results of the implementation of sustainable development must be carried out with the help of a system of effective indicators that make it possible to evaluate the progress made in relation to the objectives set and to help formulate policies in line with them. These indicators must be consensual and give a representative picture of the three dimensions of sustainable development (society, economy, and environment).

**II.2.2.6 Clean Development Mechanism**

To combat the global phenomenon of climate change, two major agreements have been adopted by the international community:

- The United Nations Framework Convention on Climate Change (1992, Rio)
- The Kyoto Protocol, adopted in 1997

The latter sets quantified commitments for 40 industrialized countries and countries in transition to a market economy to limit or produce anthropogenic greenhouse gases (GHGs) for the period 2008-2012

**II.2.3 SOFTWARES**

**II.2.3.1 ALOHA Software**

ALOHA® is the hazard modeling program for the CAMEO® software suite, which is used widely to plan for and respond to chemical emergencies.

It allows you to enter details about a real or potential chemical release, and then it will generate threat zone estimates for various types of hazards. ALOHA can model toxic gas clouds, flammable gas clouds, BLEVEs (Boiling Liquid Expanding Vapor Explosions), jet fires, pool fires, and vapor cloud explosions. The threat zone estimates are shown on a grid in ALOHA and they can also be plotted on maps in MARPLOT®, Esri's ArcMap, Google Earth, and Google Maps. The red threat zone represents the worst hazard level, and the orange and yellow threat zones represent areas of decreasing hazard.

**II.2.3.2 CALPUFF Modeling System**

CALPUFF is an advanced non-steady-state meteorological and air quality modeling system developed by scientists at Exponent, Inc. It is maintained by the model developers and distributed by Exponent. The model has been listed by the U.S. Environmental Protection Agency (EPA) as an alternative model for assessing long range transport of pollutants and their impacts on Federal Class I areas and for certain near-field applications involving complex meteorological conditions when the selection and use occur in agreement with the appropriate reviewing authority and approval by the EPA Regional Office (see details on CALPUFF's Regulatory Status). **[59]**

The modeling system consists of three main components and a set of preprocessing and post-processing programs. The main components of the modeling system are CALMET (a diagnostic three-dimensional meteorological model), CALPUFF (an air quality dispersion model), and CALPOST (a post-processing package). In addition to these components, there are numerous other processors that may be used to prepare geophysical (land use and terrain) data in many standard formats; meteorological data (surface, upper air, precipitation, and buoy data); and interfaces to other models such as the Penn State/NCAR Mesoscale Model (MM5), the National Centers for Environmental Prediction (NCEP) Eta/NAM and RUC models, the Weather Research and Forecasting (WRF) model and the RAMS model.

### II.2.3.3 AERSCREEN View

AERSCREEN View is a user-friendly interface for the US EPA AERSCREEN screening-level air quality model and associated modeling programs. It estimates worst-case impacts of ground level concentrations for a single source by interfacing with the screening mode of the AERMOD model. Scenarios can include simple or complex terrain, building downwash, and NO2 chemistry.

With AERSCREEN View, users can perform simultaneous model runs for a variety of source types and scenarios. The Scenario Wizard makes it easy to create and manage inputs for different model inputs. The program also contains many attractive display options for model output including text, graphical, and tabular formats. Preliminary modeling with AERSCREEN View can remove the need for more complicated modeling, saving you time, and resources.

### II.2.3.4 AUSTAL View

AUSTAL View is a graphical user interface for the official German Federal Environmental Agency air dispersion model .

The AUSTAL model was developed according to Germany's air pollution control regulation TALuft (Technical Instructions on Air Quality). AUSTAL is a Lagrangian particle tracking air dispersion model that contains its own diagnostic wind field model (TALdia). The model takes into account the influence of topography on the wind field and therefore on the dispersion of pollutants.

### II.2.3.5 PHAST

Standardized data regarding the distribution, quality, reach, and variation in public health services provided at the community level and in wide use across states and communities do not exist. This leaves a major gap in our nation's understanding of the value of prevention activities and, in particular, the contributions of our government public health agencies charged with assuring community health promotion and protection. Public health and community leaders, therefore, are eager for accessible and comparable data regarding preventive services that can inform policy decisions about where to invest resources. **[59]**

### II.2.3.6 AERMOD View

AERMOD View is a complete and powerful air dispersion modeling package which seamlessly incorporates the U.S. EPA's preferred regulatory air dispersion model into a powerful, easy-to-use interface.

The AMS/EPA Regulatory Model (AERMOD) is the state-of-the-science, steady state Gaussian air dispersion model based on planetary boundary layer theory. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain and urban heat island effects, and advanced meteorological turbulence calculations. AERMOD is used extensively to assess pollution concentration and deposition from a wide variety of sources in locations all over the world.

## CONSLUSION

In this chapter, we have presented an overview of methods, tools and software for analyzing environmental risk such as: Checklist method, Matrix Method, environmental monitoring, ALOHA, PHAST and AERMOD VIEW. Knowing that there are other methods have already been presented in literatures such as the ordinary risk assessment methods (HAZOP, MADS/MOZAR, APR...etc).

As we have presented the most important concepts and legal texts on environmental safety and hydrocarbon manipulation activities.

# CHAPTER III

# THE GREENHOUSE GASES ROLE IN CREATING GLOBAL TIPPING POINTS

## INTRODUCTION

This chapter, which is the introduction of our work, treats some of today's crucial issues related to planetary systems functionings, climate changes and human development and most importantly that of the greenhouse gases role in creating global tipping points.

### *III.*1 Holocene and Anthropocene

Our understanding of how our planet works is always advancing, we can now see more clearly than ever our life's intricate complexity is essential for our own survival. But biodiversity is collapsing and our climate is changing.

We are the first generation thanks to science to be informed that we might be undermining the stability and the ability of planet earth to support human development as we know it. We were jumping between plus/minus ten degrees Celsius [-10°C/10°C] in a decade for global temperature variability for the past 100.000 years since the 1st appearance of modern humans. We had to put it simple a rough time. What's critical is that the temperature stabilized just 10000 years ago.

Geologists have given this period of stability its own special name it's called the "Holocene". It is a warm period where the planet mean temperature varies between plus minus 1 degree Celsius [-1°C/1°C] during the entire period. This is what established the modern world as we know it. The Holocene stable temperatures gave us a stable planet, sea levels stabilized. For the first time we had predictable seasons and reliable weather. This stability was fundamental. For the first time civilization was possible and humanity wasted no time in taking advantage. This is the interglacial stage that has enabled us to develop modern civilizations as we know it.

The Holocene is the only state of the planet we know for certain can support the modern world as we know it. Since the dawn of civilization, we have depended on this stable state of the planet, a planet of two permeant ice caps, flowing rivers ,a cloak of forest reliable weather and an abundance of life. **[1]**

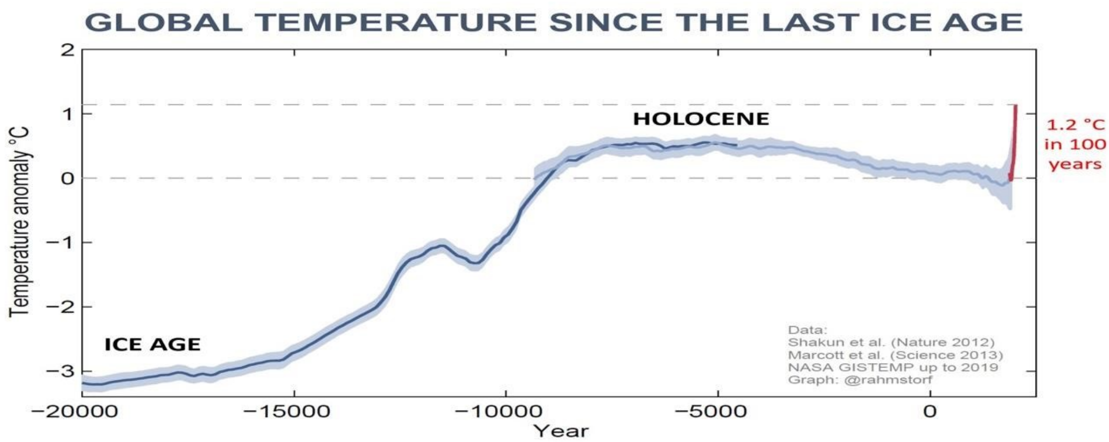



*Figure 1 Global temperature variation [1]*

Throughout the Holocene this stable planet has given us food to eat, water to drink and clean air to breath. But we have just left the Holocene behind. The exponential rise in humans' presence on planet earth has now reached a stage where we have now created our own geological epoch. we are now in the Anthropocene, the age of humans, because we now are the primary drivers of change on planet earth, we have converted half the world's habitable land to grow crops and rear livestock. We move sediment and rock than all the earth's natural processes. More than half the ocean is actively fished, nine on ten (9/10) breathe unhealthy air. And, in a single life time, we have warmed the earth by more than $1°c$. In just 50years, we managed to push ourselves outside a state that we've been in for the past 10000 years.

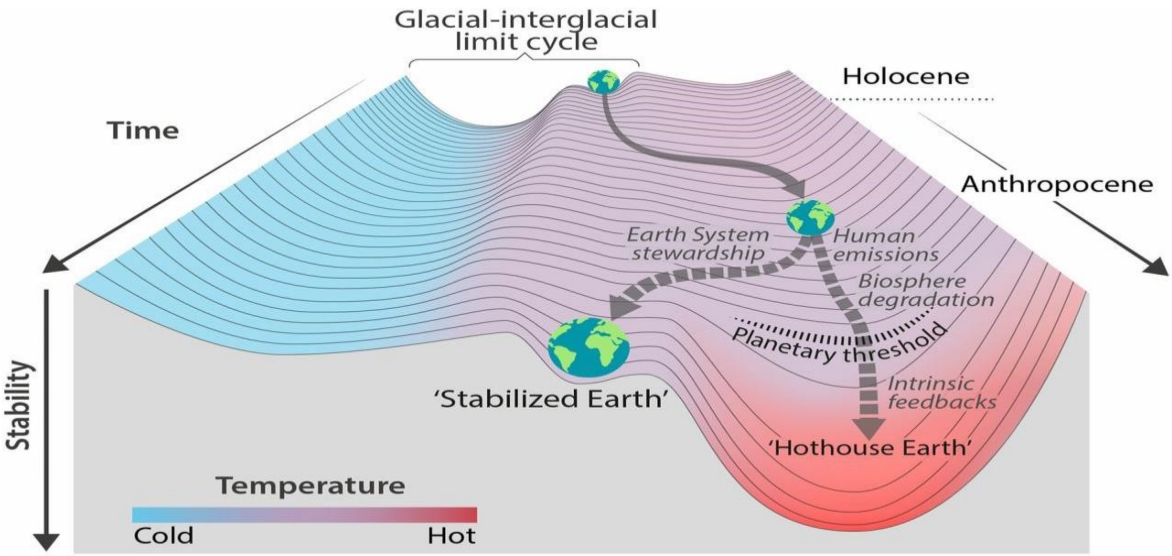



*Figure 2 Earth stability throughout the Holocene* ***[1]***

### *III.* Climate Change and Ice Melt

Glaciers melting irrespective of whether it's a small glacier at Kebnekaise or whether we're talking about Greenland, because they all add together to this fantastic capacity of cooling the planet. This cooling effect was fundamental in keeping earth's temperature throughout the Holocene.

The planet's ice was reflecting just the right amount of the sun's energy back into space; usually, 90 to 95% of sun's heath is absorbed by these white surfaces. But now instead of self-cooling they're self-warming and self-melting and that is the most dramatic tipping point in earth's system (it is a point beyond which a change becomes irreversible).

Today's climate is already too hot for Greenland .so in the current climate Greenland is already beyond its threshold, where it's now losing 10000 $m^3$ /s of ice. This loss rate will only continue as the climate heats up. So, is Greenland lost? Evidently it is. Unless we can significantly cool the earth's climate. The melting of the Greenland ice cap will inevitably continue.

When you cross a tipping point you can enter a point of no return, the melting of green lands ice cap would raise see levels around by 7 meters and now hundreds of coastal cities are threatened by rising seas. Even Antarctica is losing mass and ice.

Tipping points do interact and everything in the earth's system is connected. If one part of the climate system crosses its tipping point then that might make it more likely for other systems to also cross their critical threshold. So, with the ongoing global warming we're increasing the risk of crossing tipping points in the earth's system .When we cross tipping points, we unleash irreversible changes that would mean that the planet will go from our best friend to a position where it dampens, and reduces stress, sucking up $CO_2$ taking up heat, absorbing impact and tipping over to a point where it could self-reinforce warming and become a foe.

***The climate is being warmed by greenhouse gases. So, it's in our emission of these gases that we find a global tipping point***. Earth's temperature was closely tacking the concentration of carbon dioxide in the atmosphere. **[1]**

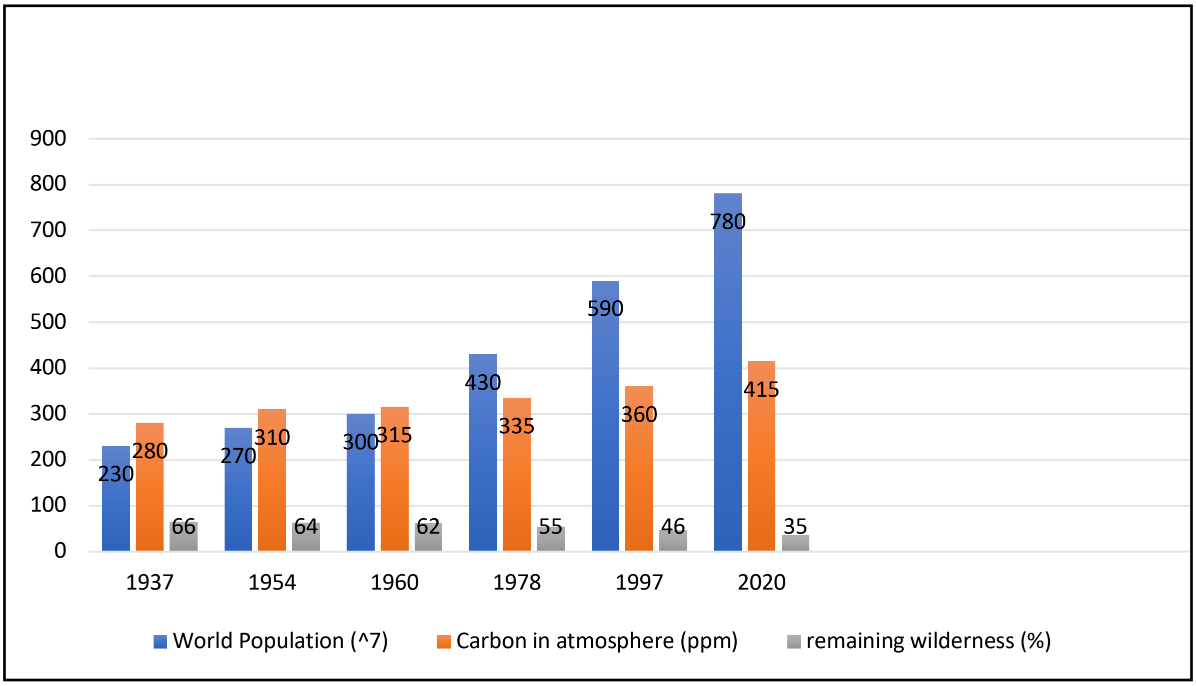



*Figure 3 Variations of World population,CO2,Remaining Wilderness **[1]***

During the Holocene this concentration remained relatively steady, but that all changed with industrial revolution, in 1988, we passed 350ppm of $CO_2$ in the atmosphere.

This was the moment we crossed the boundary. Ever since then, we've been at risk of triggering changes that lead to runaway warning. Once we crossed 415 ppm of CO2 in the atmosphere, we started to see the impacts of being in the middle of the danger zone in the climate boundary in terms of rising frequency of droughts and heat waves, floods, accelerated melting of ice and accelerated thawing of permafrost and higher frequency of forest fires.

Once again, we moved towards 450 m³ ppm of CO2 in the atmosphere, furthermore the climate planetary boundary is equal to 1.5°C warming, and it just provides all this evidence and we take a huge risk if we allow ourselves to go beyond 1.5°C . For now we are at 1.1°C and we're rapidly moving towards 1.5°C. And to stay within the planetary boundary on climate, we need to reach fossil-fuel free world economy within the next 30 years. While that target for global temperature may have grabbed all the headlines. It was known that this was only one part of a bigger picture. For our planet's stability relies on more than just its climate.

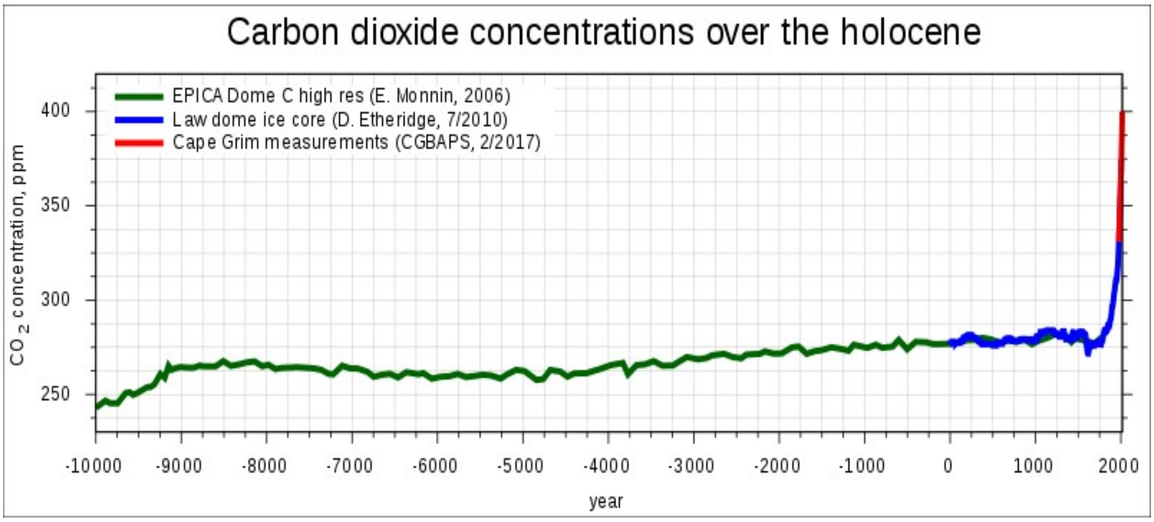



*Figure 4 Carbon dioxide concentrations over the Holocene* ***[1]***

### *III.3* Biosphere Integrity

We have 4 biosphere boundaries; boundaries that are in the living earth, these include the land configuration (Biomes), second is biodiversity, third the blood stream (the hydrological cycle) And finally the injection of nutrients that are fundamental for the functioning of the living biosphere, the nitrogen and phosphorus cycles.

#### *III.3.*1 Loss of Biomes / Land Use Change

We are fast approaching a major tipping point in one of the planet's largest remaining wildernesses (The amazon). Large swathes of Amazon have been cleared for livestock and soya farming; this is pushing us closer to triggering inversible change across much of what remains. **[1].**

Amazon being a rainforest, it creates its own climate and according to a study, the data shows large parts of the rain forest are drying out. In the Amazon, the dry season lasts a maximum of 3 months. But with global warning and fast degradation due to human activities, in particular livestock and soya farming, the dry season has become 6 days longer each decade since the1980’s.

As the forest is reduced and fragmented, its ability to recycle water and generate rain into the dry season is diminished. If the dry season becomes longer than 4 months, the jungle trees die and are replaced by Savana. ["A process called savannization). If deforestation goes above 20 to 25% of the forest, with global warming increasing, we are likely to experience an irreversible process of savannization that could affect 50 to 60 % of the entire Amazon . 20% of the amazon is already lost, and it is about to tip from planetary friend to a planetary foe.

As trees die and carbon is released into the atmosphere. the Amazon could release 200 billion of CO2 over the next 30 years. (Equivalent to all the carbon emitted worldwide for the past 5 years).

And it's not only the rain forests, trees of every description are invaluable in maintaining planetary stability. So much so that a loss of just 25% of the world's forest cover would trigger catastrophic tipping points. But we have already cleared 40 which means we are well in the danger zone for this boundary.

***III.3.2*** **Loss of Biodiversity and Extinctions**

A second major concern of deforestation is a loss of biodiversity of nature. (It is the 2nd of biosphere boundaries) because it underpins our own ability to thrive on earth, but we are not treating it well.

Everywhere around the world nature is in decline. 2million of plants and animals out of 8million are threatened with extinction. If we continue with this negative trend, we might be headed towards a sixth mass extinction. In just 50 years, humanity has wiped out 68 % of global wildlife populations. We are in the midst of a biodiversity crisis. Around 70% of the world's crop species rely to some extent on insect pollination. But the expansion of intensive monoculture is leading to a drastic decline in insects. Biodiversity is essential, it is the toolbox for the functioning of our societies. It is a fundamental piece of the puzzle to make food production, clean air, lean water, carbon sequestration and nutrient recycling to work. And of course, the decline is not just confined to insects. Wildlife has been squeezed out as our agriculture has expanded across a lot much of earth's habitable land. Today, of all birds on Earth, only 30% are wild and of all the mammals on the planet, wild species now make up by weight, only 4%. **[1]**

A single boundary for the loss of nature may be hard to pinpoint, because of nature's complexity, but one thing is clear, we've already crossed well beyond it. And this needs to stop now. The equivalent of 1.5°C maximum allowed warming would be a loss of nature from now onwards.

***III.3.3*** **Global Hydrological Cycle and Freshwater Use**

The third biosphere boundary relates to the planet's bloodstream. One needs roughly 3000 liters of fresh water every day for as to stay alive. We only need 50 liters for hygiene and drinking, another 100 is used for washing households needs, industry needs 150, and the rest 2500 is for food. Globally, we've still as far as assessment shows today in the safe zone on freshwater, but we're rapidly moving towards a danger zone.

### *III.3.4* Biogeochemical Flows and Use of Fertilizers

The last of biosphere boundaries involve the flow of nutrients (nitrogen and phosphorus). They are the essential components of all living things, the key ingredients in fertilizers. The impacts of their increasing use are well observed today: the Baltic that was once a healthy environment dominated by fish like cod , is now cleared and recognized as the most polluted sea on earth due to overfishing that removed many of the fish and fertilizers that washed off the surrounding fields (that drives tipped the Baltic into disaster). It is when you have many Baltic Sea equivalents across the planet that there is reason for deep concern, because it's a signal that the entire planet is gradually losing its resilience and gradually becoming weaker and weaker.

Nitrogen is taken out of the air and chemically converted into a form that is able to be used by plants. Or in the case of phosphorus, it is dug up out of the ground, and it is mined. These chemical pathways or ways to mine phosphorus were developed by scientists and these ways were efficient and that basically doubled, tripled and quadrupled food production around the world. This was invaluable in feeding a growing population, but we got into the habit of applying far more fertilizers than the crops could actually use. The unused nutrients wash into rivers, over fertilizing them too. A process called eutrophication, what is seen are algal blooms, Sort of looks like a blue-green scum on the top of the lake. They often smell terrible because we are smelling the rotting of that algae.

As it's decomposing it uses up Oxygen. Reduced oxygen changes the chemical composition of the lake sediment on the bottom of the lake, causing it to release more phosphorus. Once a lake is eutrophicated, it just enters a cycle of creating more and more phosphorus. **[1].**

### *III.4* Ocean Acidification

The same issue of eutrophication is found in oceans, where we get what are called dead zones from the same nutrients, and these few hundred dead places are seen everywhere all around the world. Eutrophication in the ocean may have been an important contributor to one of the world's 5 previous mass extinction events. Already today, some dead zones have expanded to cover ten thousands of square kilometers. Our overuse of phosphorus and nitrogen is one of the least known but most critical impacts we're having on the biosphere.

We're already deep into the danger zone; [Nutrients, water, our forests, biodiversity and the climate] five big elements of our planet that regulate stability and underpin our own survival, but this still isn't the full picture. For we haven't accounted for a little-known drama that's playing out in the oceans.

Its impact on our planet's stability could outplay all others. When we emit CO2 in the atmosphere, about a third of these emissions ends up in the ocean. That has changed the chemistry of the ocean. It has changed the pH and made it less alkaline or more acidic. Hence the name "acidification". When CO2 dissolves in water, it creates carbonic acid. Over the past few decades, the world's ocean has become 2.6 % more acidic, and as long as carbon dioxide concentrations in the atmosphere remain high, the ocean will continue acidifying.

The acid reacts with chemicals in the water called carbonate ions, reducing their concentrations.

It affects a broad suite of organisms, particularly those that need carbonate to grow their skeletons, things like mollusks, oysters and mussels. Ocean acidification has an ominous history. Global changes in the acidification, the pH of the ocean can actually cause mass extinctions. So, as we manipulate earth's climate, we're literally playing with the fire in terms of the unforeseen consequences of moving past these planetary boundaries into uncharted territory.

We are still within the safe zone for ocean acidification but we're pushing towards the danger zone and potentially a catastrophic mass extinction. For all the of complexities of earth, scientists discovered that there are only 9 systems that keep our planet stable. But they've not yet identified where the boundaries lie for two of them.

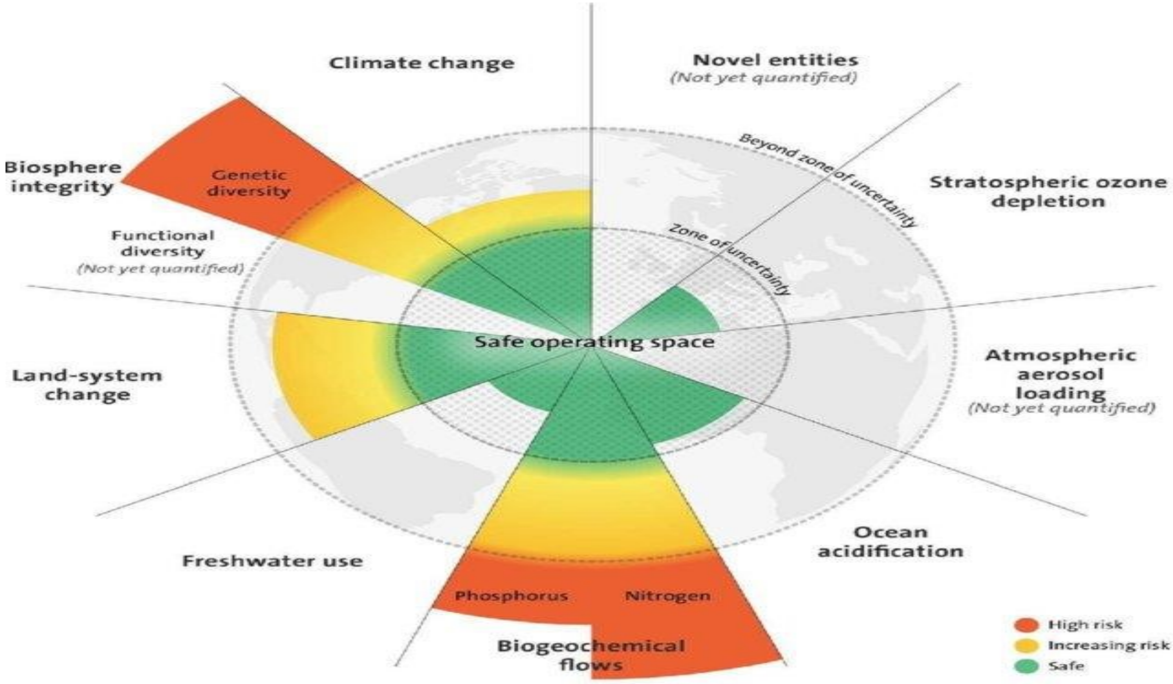



*Figure 5 Planetary boundaries [1]*

### *III.5* Release of Novel Chemicals

The first one is an assortment of human-made pollutants, we call it "novel entities", and it is everything from nuclear waste to persistent organic pollutants to loading of heavy metals to microplastics. Humans have created 100,000 new materials, any number of which could interact with the environment in catastrophic ways. As of yet, this boundary is not quantified. We simply don't know the long -term of cumulative impacts of these polluting substances. But most have the potential to cause planet-wide disruption; is not controlled.

### *III.6* Atmospheric Aerosol Pollution

There is one form of pollutants that is already having a global impact, so much so that it has a boundary of its own. Aerosols are basically particles in the atmosphere, they are what's called air pollution particulates, 75% of the aerosol pollution is from fossil fuel combustion. We see them as hazy sky, because they intercept sun light and just scatter it like mirrors. And they cause what's called "global dimming". **[1]**

The other way aerosols impact climate, is caused by cutting sunlight which is the major energy for driving the Temperature of the planet, and this have caused some cooling, because of this masking, we are still not seeing the full greenhouse beast. This cooling effect from aerosols is masking 40% of the effects of global warming, and it comes expensive. Air pollution kills over 7 million people every year and takes on average, 3 years of the life expectancy of each one of us. Where the boundary for air pollution lies has not yet been scientifically determined.

### *III.7 Stratospheric Ozone Depletion*

Finally, the 9th boundary is ozone layer; it has the unique distinction of being the only boundary where we're moving in the right direction. The ozone intercepts harmful ultraviolet radiation, which directly impacts our DNA and causes deadly diseases like skin cancer. That's why when the Antarctic ozone hole was discovered in the 1980s, there was global panic. The discovery of the ozone hole caused by chemical pollutants being released into the atmosphere persuaded nations to phase out these chemicals. It was quite fantastic how the scientific warnings translated into political action. This is the first and only example that we can actually manage the whole planet. We can actually return into a safe operating space, for a planetary boundary that we had seriously gone into the high-risk zone, then we returned back into a safe operating space.

## *CONCLUSION*

Together with the ozone layer, we are, at least for now, within the safe zone for ocean acidification and fresh water. We don't yet know how close we are to the danger zone for air pollution, or for all the other pollutants, the novel entities. But most worryingly, we have already exceeded at least four of the nine boundaries. (Climate, forest loss, nutrients and biodiversity). We are now crossing tipping points, and we are perilously close to tipping the earth into a state that is unable to support our own civilizations.

# CHAPTER IV
# ENVIRONMENTAL IMPACT STUDY USING AERMOD

# INTRODUCTION

The GP1/Z complex is one of the six liquefaction complexes belonging to the activity (AVAL) of the national company SONATRACH**.** The GP1Z site is certified ISO 14001 version 2004, ISO 9001 version 2008 and OHSAS 18001 version 2007. The objective of this complex is the processing of LPG coming from different sources in the south Algerian (Hassi Messaoud, Hassi R'mel) for the production of "Propane" and "Butane" gases liquefied. The GP1/Z complex is called JUMBO-GPL for its great capacities of production.

While this complex is one of the most important gases liquefied manufactories, it is one of the greenhouse gases source emissions. In this chapter, we are going to see a brief site description beside a simulation of gas dispersion in air using AERMOD view software in order to evaluation environmental impact of these emissions.

## IV.1 GP1Z Construction History

The construction history of the GP1Z complex is summarized in the following table:

*Table 1 Construction history of the GP1Z complex*

| ***Date*** | ***Event*** | ***Feedback*** |
|---|---|---|
| ***11/12/1978*** | *The construction contract with* ***IHI-ITOH JAPAN*** | - |
| ***11/10/1980*** | *Opening of the construction site* | - |
| ***10/11/1980*** | *Start of work* | - |
| ***12/12/1983*** | *Release of Phase 1* | *4 LPG processing trains producing a total of 4.8 Mt/year* |
| ***31/12/1983*** | *Official inauguration* | - |
| ***20/02/1984*** | *Loading the first refrigerated propane vessel* | - |
| ***24/02/1998*** | *Extension phase 2* | *2 additional LPG processing trains to increase to a total production of 7.2 Mt/year for (for 6 trains)* |

| | | |
|---|---|---|
| ***April 2010*** | *Extension phase 3* | *3 LPG processing trains bringing an additional production capacity of 3 Mt/year, allowing to move to a total production of 9 Mt/year for (for 9 trains).* |

## IV.2 Geographical Location and Vicinity of the Gp1z Complex

The GP1Z complex is located on the coast of western Algeria, approximately 40KM from the city of Oran and 8KM from the city of Arzew.

The complex is 120 hectares in size, is located in the Arzew industrial area; between the Marsa El Hadjadj thermal center on the east side and on the west side is the LNG complexes for liquefaction of natural gas (GL4/Z, G the ammonia complex and le complex (GP2/Z). L1/Z, GL2/Z)

## IV.3 Technical Sheet of the GP1Z Complex

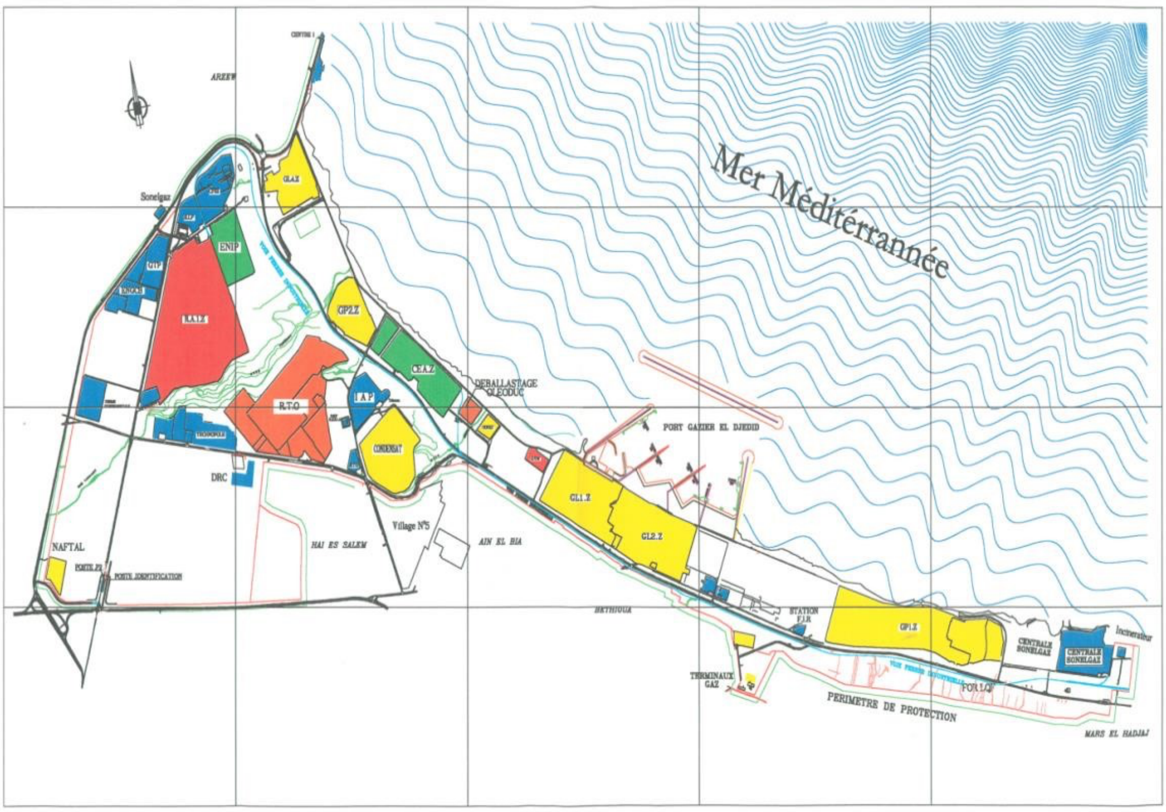



*Figure 1 Location and vicinity of the GP1/Z complex **[60]***

The complex's mission is the production of commercial LPG (Propane and Butane) for both the national and international markets.

✓ **Company name**: GP1Z Complex ✓ **Area:** 120 hectares.

- ✓ **Staff:** 777 staff.
- ✓ **Target:** 10.8 Mt/year of LPG.
- ✓ **Products:**
    - Commercial Propane
    - Commercial Butane
- ✓ **Process Used** :D pressurized instillation.
- ✓ **Number of Trains:** Nine (09) trains of 1.2 Mt /year each.
- ✓ **Manufacturer:** Japanese Consortium IHI (IshikawajimaArima Heavy Industries) and C.ITOH Companies.
- ✓ **Start date:** 10 November 1980
- ✓ **Date of Start of Production of the first Phase I train:** 12 December 1983.
- ✓ **Date of Start of Production of the first Phase II train:** February 24, 1998.
- ✓ **Date of Start of Production of the first Phase III train:** February 12, 2010.
- ✓ ✓ **Removals:** Two loading docks receiving Liquefier Oil Gas vessel with a capacity of 3,000 to 50,000 tons of LPG (D1.M6)
- ✓ **One truck loading ramp:** Six (06) trucks.
- ✓ **Destination of Production:** Export and Domestic Market. ✓ **Source of Supply:** Gas from gas fields in southern Algeria ✓
- ✓ **Storage capacity:**
    - Twenty-two (22) Load Storage Spheres: 22,000 $^{m3}$.
    - Four (04) Refrigerated Propane Storage Tanks: 280,000 $^{m3}$.
    - Four (04) Refrigerated butane storage bins: 280,000 $^{m3}$.

- Four (04) spheres, one (01) of propane and three (03) of ambient butane: 500 $^{m3}$ and 1500 m3.
    - One (01) Pentane storage sphere: 500 $^{m3}$

*Figure 2 Storage bins [60]*

*Figure 3 Storage spheres* ***[60]***

- **9** LPG processing trains, three of which are newly installed
- **02** propane and butane vapour recovery units (BOG propane and BOG butane).
- Depentasantisassions section for the three trains of phase III.
- Demercurization section.
- **02** electrical stations supply the complex via SONELGAZ.
- **05** control rooms.
- **06** backup generators
- **02** loading docks (D1 and M6) that can accommodate vessels with a capacity ranging from 4,000 to 45,000 tonnes of propane and butane.
- **01** truck loading ramp.
- **01** seawater station.
- **01** de-oiling unit.


*Figure 4 LPG Processing Trains* ***[60]***

*Figure 5 Ships loading [60]*

*Figure 6 Truck loading [60]*

- **01** liquid waste neutralization unit.
- **02** SIDEM units of seawater desalination.
- **01** remote monitoring system

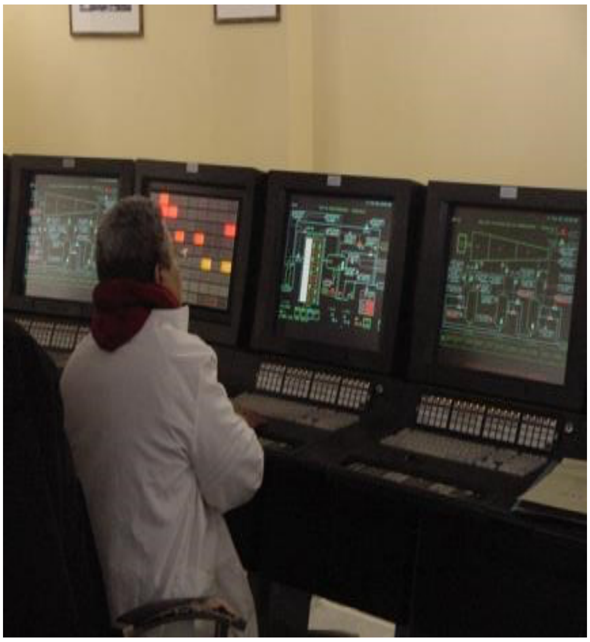


*Figure 7 Control room [60]*

*Figure 8 Seawater desalination [60]*

## IV.4 Process Treatment

### IV.4.1 Production steps

GPL processing goes through different section that consists of a closed loop. To process LPG, it must go through the following production line: **V.4.1.1 Power Storage Section:**

The supply is made from the gas and oil fields of HassiR'mel and Hassi-Messaoud by a 24" gas pipeline via the RTO terminal located on the Bathioua plateau. The supply of the dehydration section is carried out by eight (08) pumps.

The sixteen (16) spheres are divided into four (04) groups each comprising four (04) spheres and two (02) power pumps. Once introduced into the trains, the LPG must pass through the next 04 sections (identical for all trains).

### IV.4.1.2 B- Dehydration Section:

The purpose of this section is to reduce the content of water dissolved in LPG from 100 ppm to 5 ppm by weight, thus avoiding the formation of ice and frost plugs in the cold parts of the plant (refrigeration). This section includes three molecular sieve adsorption columns, at any time we have one column in service (in adsorption), the other in regeneration and the last one waiting.

The LPG passes through the dryer which is in adsorption from the bottom to the top, the moisture is extracted when the LPG passes through the molecular sieves. The duration of this operation is 36 hours, once this time is exceeded the dryer automatically goes into regeneration, the latter includes the following sequences:

- Drainage (duration 1h) The draining of the dryer is done by injecting natural gas under a pressure of 20kg/ $^{cm2}$. The remaining LPG is routed to the load spheres.
- Depressurization (duration 30 mN)

This sequence is used to reduce the pressure of the dryer from 20 kg/cm2 to 3 kg/cm2 and this is done by the evacuation of NG contained in the dryer to the fuel gas section. ▪ Reheating (duration 11h)

The reheating is done by the NG heated in the oven to a temperature of 280 ° C, it passes through the dryer from top to bottom to evaporate the water contained in the molecular sieves.

- Cooling (duration 5h)

The sector being hot after the reheating sequence, it is cooled by the NG brought to a temperature of 12 to 45 ° C and a pressure of 3kg/ $^{cm2}$ ▪ Pressurization (duration 30 mN)

Before the filling of the column by LPG, it is necessary to have its working pressure which is 20 kg / cm2, this operation is done by the introduction of NG at high pressure.

- Filling: This operation consists of putting the dryer on hold.

### IV.4.1.3 C- Separation Section:

This is the section that separates LPG into two finished products, propane and butane in addition to very small amounts of ethane and pentane.

The dehydrated LPG before passing to the fractionist, it must be brought to its boiling temperature (71 ° C), passing through three preheaters, the first is heated by the bottom product of the demethanizer, the second by the bottom products of the friction valve and the last by the hot oil from the oven. The LPG thus preheated to 71 ° C passes directly into the friction valve (it consists of 55 valve trays) where it is separated into (propane + ethane) at the head of the column and (butane + pentane) at the bottom of the column.

The column head products are condensed and recovered at the level of the reflux balloon.

The bottom products come out at a temperature of 110 ° C, preheat the LPG load and pass towards the depantanic.

- ***demethanize:***

In order to produce commercial propane more or less pure.

Column head products switch to demethanizer, the latter is a fractionation column equipped with 25 valve trays. The ethane-rich gas coming out of the upper part of the demethanizer is used as furnace fuel. Propane leaving the bottom of the column at a temperature of 62°C goes directly to the first friction heater.

- ***Depantaking:***

There is only one common Depanantiser for the 06 trains, its role is to eliminate traces of pentane contained in butane.

The Dépentaniser is a column consisting of 50 valve trays.

The butane coming out of the head of the Depentaniser, mixed with the rest of the nondepanantized butane, and is sent to the refrigeration section.

The pentane collected from the bottom of the Depentaniser will be cooled by cooling, and sent to the ambient storage.

**IV.4.1.4 D- Refrigeration Section:**

The purpose of this section is to cool the finished products to their storage temperature (-42°c for propane and -6°c for butane). The products are refrigerated by three (03) exchangers following a closed cycle forming a propane refrigeration loop (The fluid used as a refrigerant is pure propane). Propane is evaporated in heat exchangers; this evaporation causes the temperature of the product to be refrigerated to be lowered. Some of the refrigerated propane will be compressed and sent to the demethanizer of the separation section as column head refrigerant. The propane vapor generated in the suction balloons, demethanizer head condensers and butane refrigeration devices are compressed by a three (03) stage centrifugal compressor driven by a gas turbine. It is then condensed in the air cooler type condensers. The finished products are then channelled to the storage bins.

**IV.4.1.5 Hot Oil E-Section:**

This section is used as a heat source for the third heater, the reboilers and finally for the regeneration natural gas used in the dehydration section. The oil comes out of the oven at a temperature of 180°C.

**IV.4.1.6 F- Storage and Shipping Service:**

This service performs the following roles:

- Control of all storage and shipping activities, whether by tanker trucks or ships.
- Quality control of finished products and their storage conditions.

**IV.4.1.7 Recovery of Boil/off gas (BOG) evaporative gas:**

Evaporative gases from the plant's various capacities (storage tanks, evaporation of gases from tanks and ships under load) are recovered, liquefied by pressurization by means of a compressor, cooled through air coolers and returned to the storage tanks. The recovery section consists of two (02) independent sets. One for propane and one for butane.

**IV.4.1.8 GP1Z charging system:**

**IV.4.1.8.1 Loading of boats at low temperature:**

Two loading systems are installed respectively at the end of the D1 and M6 piers, the loading rate is as follows:

**Propane:**

- Max 10,000 m3/h.
- Substation D.1: 4,000 m3/h.
- Item M.6: 10,000 m3/h.

**Butane:**

- Max 10,000 m3/h.
- Substation D.1: 4,000 m3/h. ▪ Post M.6: 10,000 m3/h.

Gases produced by evaporation at the time of loading are directed to the Evaporated Gas Recovery Section (BOG).

**IV.4.1.8.2 Loading trucks at room temperature:**

The simultaneous loading of five (05) commercial propane trucks and one pentane truck can be performed at room temperature from five (05) spheres of 500 m3 by means of loading pumps. The loading of the spheres is carried out from the separation sections and also from the low-temperature storage bins through heaters.

## IV.5 Process diagram of the complex:

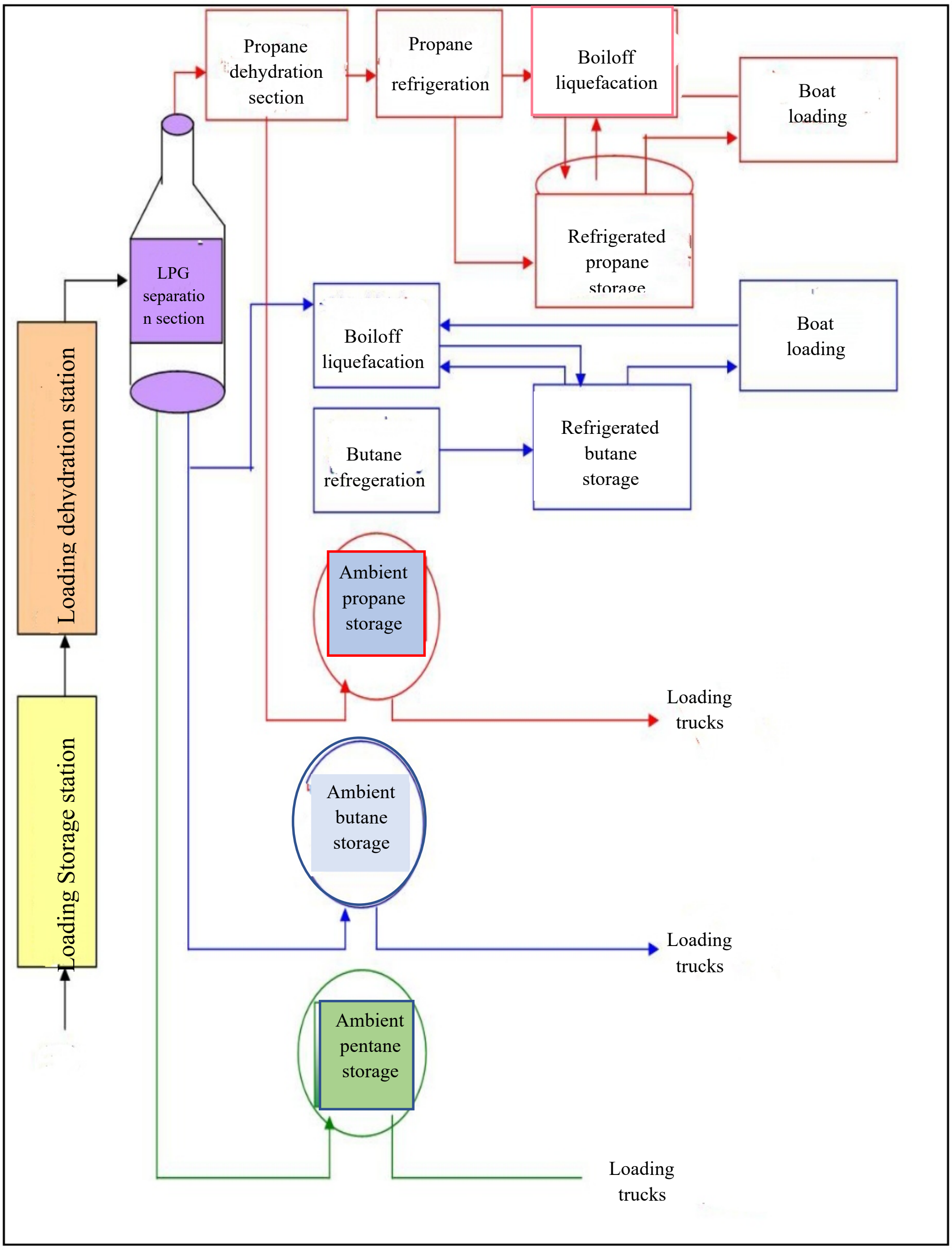



*Figure 9 schmatic diagram of the process*

### IV.6 The Characteristics of the Gp1z Complex

The plant includes the following main areas:

#### IV.6.1 Trial Zone

It includes Nine (09) Production Trains, three of which are newly installed.

Each train consists of the following sections:

- One (01) Dehydration Section
- One (01) Separation Section
- One (01) Refrigeration Section
- One (01) Hot Oil Section

#### IV.6.2 Utility Zone

This area is used to provide the energy necessary for the operation of the plant such as:

- Production of distilled water.
- Production of water vapor.
- Production of compressed air.
- A nitrogen supply.
- A supply of natural gas.
- A methanol supply.
- A diesel fuel supply.  A backup generator.

And it includes:

- LPG load storage section consisting of 22 spheres and a raw LPG load filtration system.
- Four (04) Boilers with a unit capacity of 10t/h
- Two (02) desalinators of 10t/h each
- Three (03) Compressed air production sections.
- Six (06) Generators providing backup power for the complex.
- One (01) section of nitrogen.
- Three (03) natural gas distribution sections.

#### IV.6.3 Storage And Loading Area

- Refrigerated products: Refrigerated propane and butane are stored at -42°C and -5°C respectively in four tanks each, with a unit capacity of 70,000 m3.

The loading of these products is provided by two loading docks that can receive LPG with a capacity of 3,000 to 50,000 tons. Each dock is equipped with Three (03) loading arms

- ✓ One arm (01) steam return (Boil Off)
  - ✓ An Arm (01) of blasting
- Ambient products: Propane and butane are stored at room temperature in four (04) spheres, with a unit capacity of 500 m3. Pentane is also stored in a sphere of 500 m3

The loading of these products is ensured by a truck loading ramp which is equipped with:

**Butane** :

- ✓ Three (03) loading arms
- ✓ Three (03) Steam Return Arm (Boil Off)

**Propane** :

- ✓ Two (02) loading arms
- ✓ Two 02) Steam Return Arm (Boil Off)
- ✓

**Pentane** :

- ✓ One (01) loading arm.
- ✓ One (01) Boil Off

One (01) Pipe Arzew - Sidi Bel abbots -Tlemcen known as AST entered into service on 14/10/2005 to supply from the GP1Z complex the three wilayas with bulk ambient butane at a rate of 125 m3 per hour.

**IV.6.4 Control and Security Facilities** The complex is equipped with:

- One (01) Main Control Room for Production Facility Control (RCM)
- One (01) Local Control Room for Storage (LCR)
- One (01) Local Control Room for Ship Shipments (JCR)
- One (01) Local Control Room for Truck Shipments (CCR)
- One (01) Security Control Room (SCR)

**V.6.5 e-Appendices:**

- A maintenance workshop  A supply store.
- A training center

**V.6.6 Human Resources:**

GP1Z training center, with a capacity of 226 trainees and the following educational premises:

- One (01) Conference room for forty (40) people

- Four (04) Application rooms of twenty (20) interns each

- Six Rooms (06) Classrooms of ten (10) trainees each
- One (01) language laboratory of twelve (12) booths
- One instrumentation laboratory (01) for eight (08) trainees
- One Chemistry Laboratory (01) for eight (08) trainees
- One (01) Synoptic panel room for twelve (12) trainees
- One DCS laboratory for six (06) Trainee

**IV.6.7 Organization of the GP1/Z complex:**

- The GP1/Z complex is composed of one directorate and two sub-directorates and control departments

**IV.7 Ground plan of the complex:**

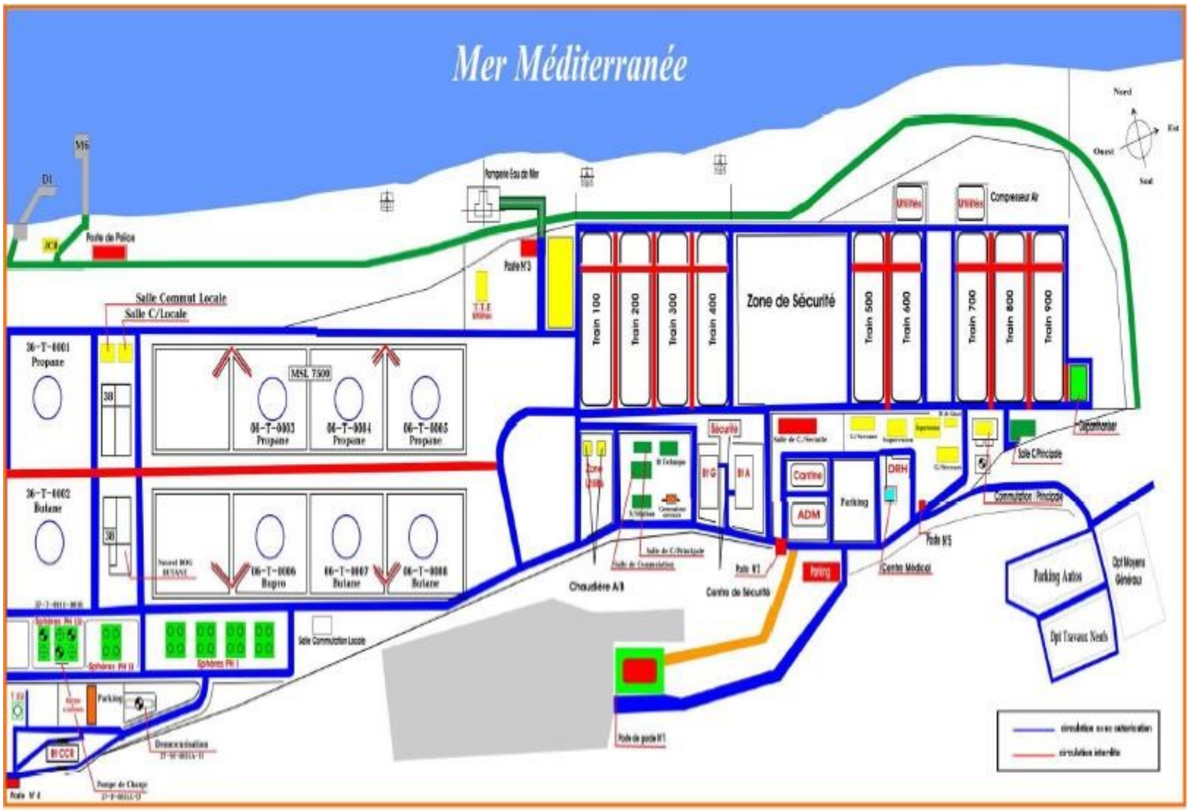



*Figure 10 Ground plan of the complex* **[60]**

## IV.8 Organizational Chart

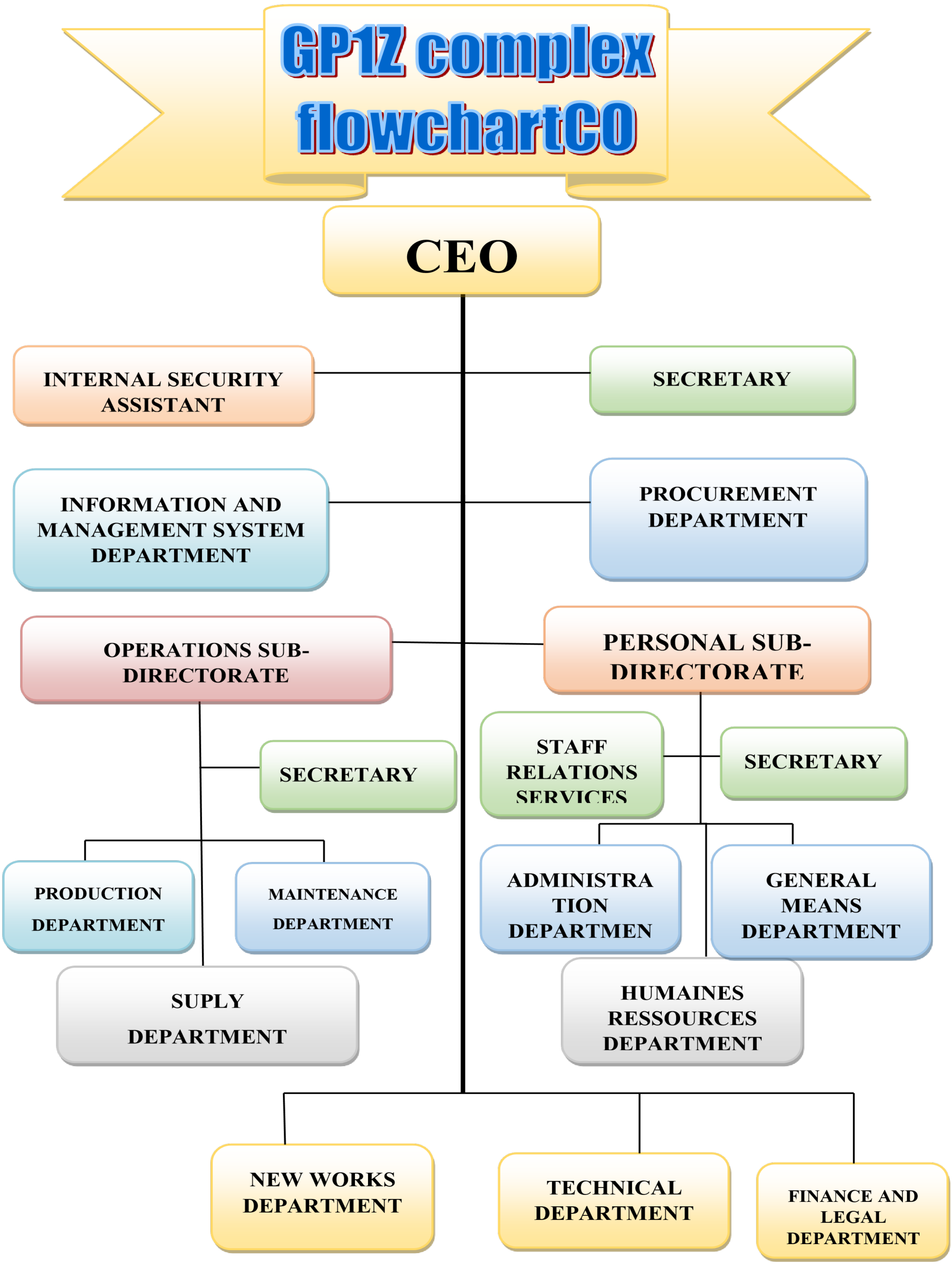



*Figure 11 Organizational chart of GP1Z* ***[60]***

## IV.9 The company's greenhouse gas emissions

Several greenhouse gases are either emitted by furnaces, turbines and boilers directly to the atmosphere or recovered by the BOG then flared, all this contributes strongly to the current greenhouse effect and climate change. To this end, the manual for measuring the emissions of gases leaving the machines in addition to the operation of the BOG will be explained.

### IV.9.1 Atmospheric Gas Measurement Manual

#### IV.9.1.1 Principle

The analysis of gas fumes released into the atmosphere by our facilities consists of analyzing the following components: NOx, SOx, $CO_2$, O2, CO.

#### IV.9.1.2 Purpose

Verify the compliance of the test results with the company's requirements for the preservation of the environment.

### IV.9.2 Equipment

Flue gas analyzer type TESTO 350XL

*Figure 12 TESTO 350XL [60]*


*Figure 13 Testo 350XL* ***[60]***

### IV.9.3 Mode of Operation

- Turn on the device by pressing i 0

Wait for the zero or the device counts 60 to 0 seconds.

-The menu appears on the screen containing boxes for measure.

To view all data windows, press the up or down keys.

⇧ ⇩

- Introduce the probe into the equipment concerned by this analysis and start the measurement by pressing Pump start

-once the temperature of the fumes is detected by the probe, take the results and keep the measurement results by pressing the **Hold** button.

-To print the displayed measurement results, press imp

- the bar imp will appear, pressing the arrow keys

-stop the measurement by pressing Pump shutdown

-Turn off the device by pressing i 0

## IV.10 Statistics Of Greenhouse Gases Emissions:

- **March 2021**

*Table 2 STATISTICS OF GREENHOUSE GASES EMISSIONS OF MARCH 2021*

| **Items Place** | **$CO_2$ mg/Nm3** | **NOx mg/Nm3** | **SO2 mg/Nm3** |
|---|---|---|---|
| **Four train 100** | 43,41 | 44,18 | 0 |
| **Turbine train 100** | 41,36 | 8,.78 | 0 |
| **Four train 200** | 61,09 | 29,37 | 0 |
| **Turbine train 200** | 77,37 | 185,80 | 0 |
| **Four train 500** | 57,11 | 66,24 | 0 |
| **Four train 700** | 48,96 | 21,13 | 0 |
| **Four train 800** | 33,37 | 28,89 | 0 |
| **Four train 900** | 120,36 | 188,92 | 0 |
| **35 M 0511** | 101,10 | 29,07 | 0 |
| **Limit values of DE No. 06-138** | **150** | **200** | **800** |

- **June 2021**

*Table 3 Table 8 8STATISTICS OF GREENHOUSE GASES EMISSIONS JUNE 2021*

| **Items Place** | **$CO_2$ mg/Nm3** | **NOx mg/Nm3** | **$SO_2$ mg/Nm3** |
|---|---|---|---|
| **Four train 100** | 64,92 | 70,01 | 0 |
| **Turbine train 100** | 77,75 | 171,87 | 0 |
| **Four train 300** | 62,69 | 64,07 | 0 |
| **Turbine train 300** | 64,25 | 163,21 | 0 |
| **Four train 400** | 62,80 | 82,39 | 0 |
| **Turbine train 400** | 51,47 | 164,99 | 0 |
| **Four train 800** | 43,68 | 43,16 | 0 |

| | | | |
|---|---|---|---|
| **Four train 900** | 35,50 | 31,60 | 0 |
| **35M0511** | 103,58 | 42.71 | 0 |
| **Limit values of the DE n° 06-138** | **150** | **200** | **800** |

- **DECEMBER 2021.**

*Table 4 STATISTICS OF GREENHOUSE GASES EMISSIONS DECEMBRE 2021*

| Items / Lieu | $CO_2$ mg/Nm³ | NOx mg/Nm³ | $SO_2$ mg/Nm³ |
|---|---|---|---|
| **Four train 100** | 51.79 | 50.96 | 0 |
| **Turbine train 100** | 19.75 | 133.85 | 0 |
| **Four train 200** | 78.34 | 48.87 | 0 |
| **Turbine train 200** | 26.83 | 125.61 | 0 |
| **Four train 300** | 65,98 | 54,10 | 0 |
| **Turbine train 300** | 56,21 | 164,08 | 0 |
| **Four train 400** | 79,51 | 77,06 | 0 |
| **Turbine train 400** | 55,46 | 181,91 | 0 |
| **Four train 600** | 760.63 | | |

| | | | |
|---|---|---|---|
| | | 13.40 | 0 |
| **Four train 900** | 49,30 | 37,49 | 0 |
| **35M0511** | 103,82 | 35,94 | 0 |
| **Normes** | **150** | **200** | **800** |

## IV.11 Greenhouse gases impact evaluation using AERMOD

### IV.11.1 Software Choice

For the purpose of performing our analysis we chose AERMOD view software because it is a comprehensive and powerful air dispersion modeling package that seamlessly integrates the United States Environmental Protection Agency's preferred regulatory air dispersion model into a powerful, user-friendly interface. It is widely used to estimate pollution concentrations and deposition from a wide range of sources in a variety of locations around the world.

AERMOD can simultaneously simulate many sources with different shapes, at ground or elevated, buoyant or non-buoyant, emitting one or more pollutants. AERMOD is capable to account for the non-homogeneous vertical structure of the boundary layer (also through the use of a vertical profile of meteorological variables). Vertical mixing is limited in case of stable conditions. The dispersion for unstable conditions is non-Gaussian, so to correctly describe the Source: from AERMOD training.com high concentrations of pollutants that can be observed close to stacks under convective conditions.

### IV.11.2 AERMOD view definition:

AERMOD is a Gaussian model for less than a 50 km reach to simulate the dispersion of the emissions of industrial activities. **[62]**

This model has been calibrated and adopted by US.EPA since 2005 to replace the ISC3 model. **[63] [6]**

AERMOD uses similarity theory of Planetary Boundary Layer or PBL to count the dispersion affected by the surface heating and friction.

The model needs information related to the surface such as roughness length, humidity and reflexivity. Moreover, it also needs comprehensive information about upper atmosphere to determine the mixing height and to construct partial plume penetration along the upper part of the mixing height. **[66]**

An AERMOD model is composed by a primary model or AERMOD, a meteorological processor or AERMET and a geomorphological processor or AERMAP. **[62]**

The AERMET is used to provide meteorological data, such as wind velocity and direction, temperature, cloud covering and to present surface data, such as albedo, surface roughness and Bowen ratio. All of this data is processed by AERMET to count the PBL surface parameters, such as friction velocity, convective velocity scale, temperature scale, mixing height, and surface heat. The PRIME building downwash algorithms, advanced depositional parameters, local terrain, and urban heat island effects, and advanced meteorological turbulence calculations are all fully integrated into AERMOD

Additionally, PBL upper air parameters are also counted; they are vertical profile of wind velocity, lateral and vertical profile of turbulent fluctuation, gradient and potential temperature. On the other hand, the AERMAP will provide topographic data of grid data chosen from Digital Elevation Model or DEM data. It also presents receptor position calculated from mean sea level. **[61] [62] [67]**

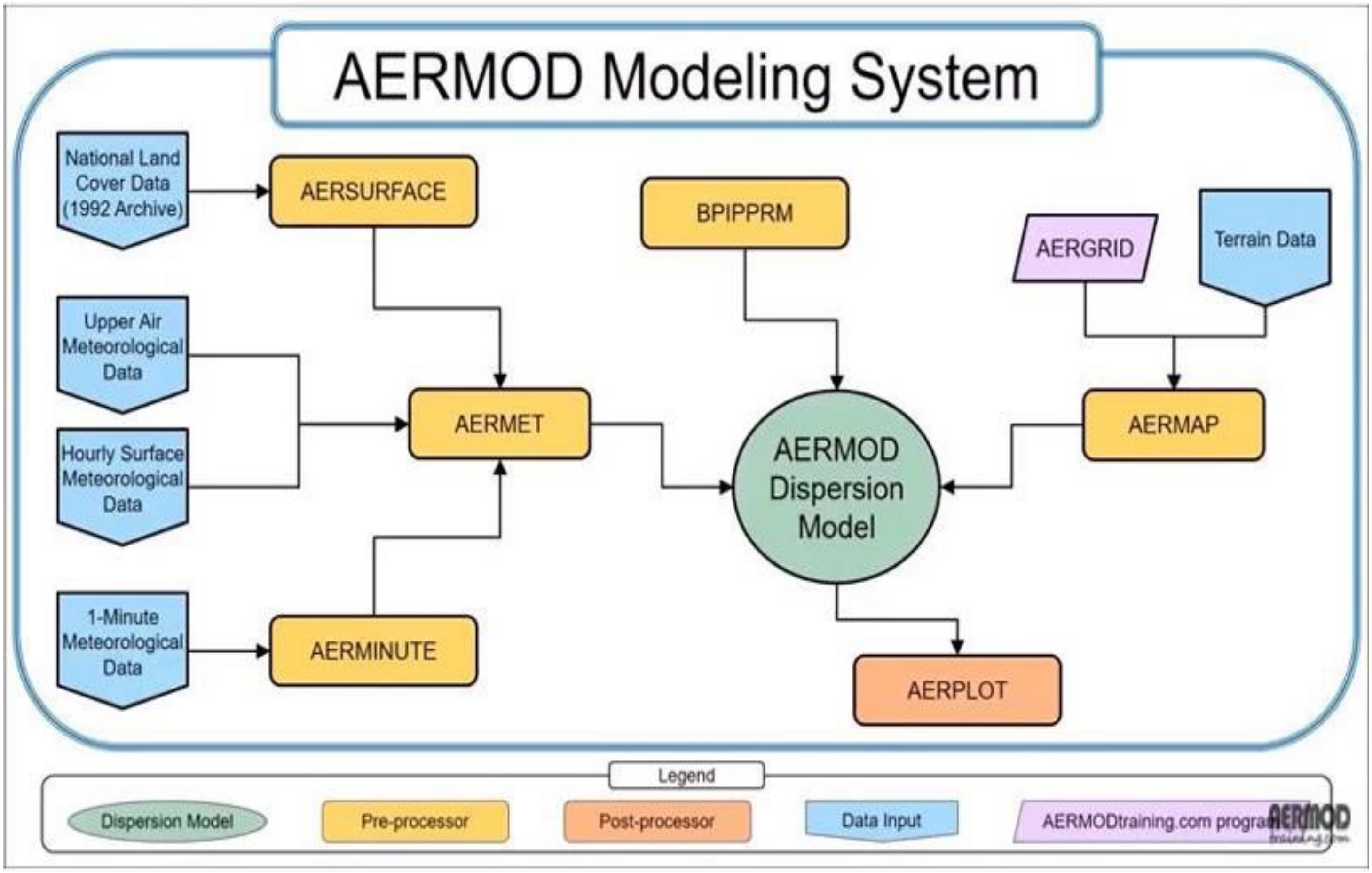



*Figure 14 AERMOD MODELING SYSTEM [61]*

### IV.11.3 The methods:

According to the User's Guide for the AMS/EPA Regulatory Model (AERMOD) 2016:"The AERMOD mode includes two methods for handling dry and/or wet deposition of particulate emissions. Method 1 is used when a significant fraction (greater than about 10 percent) of the total particulate ss has a ameter of 10 µm or larger, or when the particle size distribution is known. The particle size distribution must be too well in order to use the Method. Method 2 may be used when the particle size distribution is not well known and when a small fraction (less than 10 percent of the mass) is in particles with a diameter of 10 µm or larger. The deposition velocity for Method 2 is calculated as the weighted average of the deposition velocity for particles in the fine mode (i.e., less than 2.5 µm in diameter) and the deposition velocity for the coarse mode"

**IV.11.3.1 First Method:**

Method 1 requires (i) the mass-mean aerodynamic particle diameter for each particle size categories in microns, (ii) their mass fractions ranging from 0 to 1 and (iii) the corresponding particle density (g/cm³) as inputs of the sources particulate emissions. With those parameters specified, the model applies Equation 1 for each particle size category and sums the results. $vdp = 1\ (ra +\ \ +\ )+vg \qquad (Eq.1)$

$$vdp = 1\ (ra +\ \ +\ )+vg \qquad (Eq.1)$$

Where $vdp$ is the deposition velocity for particles (m/s) $ra$ symbolizes the atmospheric resistance (s/m), $rp$ the quasilaminar sublayer resistance (s/m) and $vg$ the gravitational settling velocity of the particle. The controlling input of source variables for particle deposition using Method 1 is composed of three keywords on the SO pathway: PARTDIAM, MASSFRAX, and PARTDENS. The particle variables can be applied to a single source or to a group of sources (see Figure 29).

| | |
|---|---|
| **Syntax:** | SO PARTDIAM Srcid (or Srcrng) Pdiam(i), i=1,Npd<br>SO MASSFRAX Srcid (or Srcrng) Phi(i), i=1,Npd<br>SO PARTDENS Srcid (or Srcrng) Pdens(i), i=1,Npd |
| **Type:** | Optional, Repeatable |
| **Order:** | Must follow the LOCATION card for each source input |

*Figure 15 Method 1 Sytax, Type and Order.* ***[61]***

Source: (USEPA, 2015).

The Srcid(Srcrng) array contains the mass-mean aerodynamic particle diameter (microns) for each of the particle size categories, and the Pdiam array contains the massmean aerodynamic particle diameter (microns) for each of the particle size categories. For each of the categories, the Phi array contains the corresponding mass fractions (between 0 and 1), while the Pdens array contains the corresponding particle density (g/cm$^3$).

**IV.11.3.2 Second Method:**

In Method 2, the user must specify for each source the fraction of fine mode particles emitted and the representative mass-mean aerodynamic diameter. The deposition velocity becomes a function of the weighted average of $vdp$ for particles in the fine mode (<2.5µm) and the coarse mode (2.5µm<d<10µm):

$$vdp = fpVdpf + (1 - fp)\ (Eq.\ 3)$$

Where $vdp$ is the overall deposition velocity for particles (m/s) $fp$ represents the fraction of particulates in the fine mode, $Vdpf$ the deposition velocity (m/s) of fine particulate matter ($vg$ = 0) and $Vdpc$ the deposition velocity (m/s) of coarse particulate matter ($vg$ = 0.002 m/s). Generally, Method 2 returns lower estimations of deposition fluxes than Method 1.

For Method 2, METHOD_2 keyword on the SO pathway inputs particles' emission information through the code (see Figure F).

| | |
|---|---|
| **Syntax:** | SO METHOD_2 Srcid (or Srcrng) FineMassFraction Dmm |
| **Type:** | Optional, Repeatable |
| **Order:** | Must follow the LOCATION card for each source input |

*Figure 16 Method 2 Syntax, Type and Order [61]*

where the Srcid or Srcrng identify the source or sources for which the inputs apply. FineMassFraction is the fraction (between 0 and 1) of particle mass emitted in the fine mode and Dmm is the representative mass-mean aerodynamic particle diameter in micrometers.

### IV.11.4 Concentration and deposition units:

The CONCUNIT and DEPOUNIT keywords in the AERMOD model allow concentration and deposition units to be quantified separately. The SOCONT option returns the average concentration (or total deposition) value (i.e., contribution) from each source for the source group for the period corresponding to the event.

The DETAIL option displays the basic contribution information from the source. It is also provides a summary of the hourly meteorological data for the event period, as well a Is the hourly average concentration (or total deposition) values for each source for every ho ur in the averaging period.

Table 10 lists the seven functions in AERMOD for modeling particle (and gas) removal from the atmosphere.

*Table 5 AERMOD functions for particle and gas removal*

| Functions | |
|---|---|
| DEPOS | Specifies that total deposition flux values (both dry and wet) will be calculated; |
| DDEP | Specifies that dry deposition flux values will be calculated; |
| WDEP | Specifies that wet deposition flux values will be calculated; |

| | |
|---|---|
| DRYDPLT | Option to incorporate dry depletion (removal) processes associated with dry deposition algorithms; this requires specification of dry deposition source parameters and additional meteorological |
| | variables; dry depletion will be used by default if dry deposition algorithms are invoked; |
| NODRYDPLT | Option to disable dry depletion (removal) processes associated with dry deposition algorithms; |
| WETDPLT | Option to incorporate wet depletion (removal) processes associated with wet deposition algorithms; this requires specification of wet deposition source parameters and additional meteorological variables; wet depletion will be used by default if wet deposition algorithms are invoked; |
| NOWETDEPLT | Option to disable wet depletion (removal) processes associated with wet deposition algorithms; |

The AERMOD outputs comes in the order of: (1) CONC, (2) DEPOS, (3) DDEP, and (4) WDEP. The model requires appropriate deposition parameters in order to output deposition fluxes using the keywords above mentioned. The use of the NODRYDPLT and/or NOWETDPLT options would result in a more conservative estimate of concentrations. Therefore, deposition fluxes for applications involving deposition processes would also be more conservative

## IV.12 Application of AERMOD for CO and $NO_x$ dispersion modeling

### IV.12.1 Meteorological and topographical data collection

Accuracy of meteorological data input to AERMOD is an important factor in getting an accurate prediction result. An hourly vertical meteorological profile is needed to simulate the wind field and mixing height. However, this data cannot be provided in Algeria, thus a substitution is needed.

The former data can be substituted with satellite data or data of the prediction of regional atmosphere. **[61] [68]**

Meteoblue or Accuweather provides daily prognostic meteorological data for the period of 2021. This output is reformatted to generate meteorological data of surface and upper air that is suitable for AERMET input format. The grid center is set at a coordinate point of 3965240, 19 N and 752062, 30 E with a cell area of 0,5 km coinciding with the main stack. The anemometer height and base elevation are 10 m and 0 m above sea level. Furthermore, DEM data is extracted from SRTM3 satellite imagery while land use is determined through visual observation.

### IV.12.2 Data of gases emission

The data of gases emission is derived from the mean emission in 2021 as shown in previous Tables . The raw data has a unit of mg/l which will be converted to a unit of g/s. To analyze the impact of gases emission, a national quality standard of air ambience is needed.

*Table 6 The monitoring of $CO_2$, NOx emission in Mars 2021*

| **Items Place** | **$CO_2$ mg/$^{Nm3}$** | **NOx mg/$^{Nm3}$** | **SO2 mg/$^{Nm3}$** |
|---|---|---|---|
| **Four train 100** | 43,41 | 44,18 | 0 |
| **Turbine train 100** | 41,36 | 8,.78 | 0 |
| **Four train 200** | 61,09 | 29,37 | 0 |
| **Turbine train 200** | 77,37 | 185,80 | 0 |
| **Four train 500** | 57,11 | 66,24 | 0 |
| **Four train 700** | 48,96 | 21,13 | 0 |
| **Four train 800** | 33,37 | 28,89 | 0 |
| **Four train 900** | 120,36 | 188,92 | 0 |
| **35 M 0511** | 101,10 | 29,07 | 0 |
| **Limit values of DE No. 06-138** | **150** | **200** | **800** |

*Table 7 The monitoring of $CO_2$, NOx emission in juin 2021*

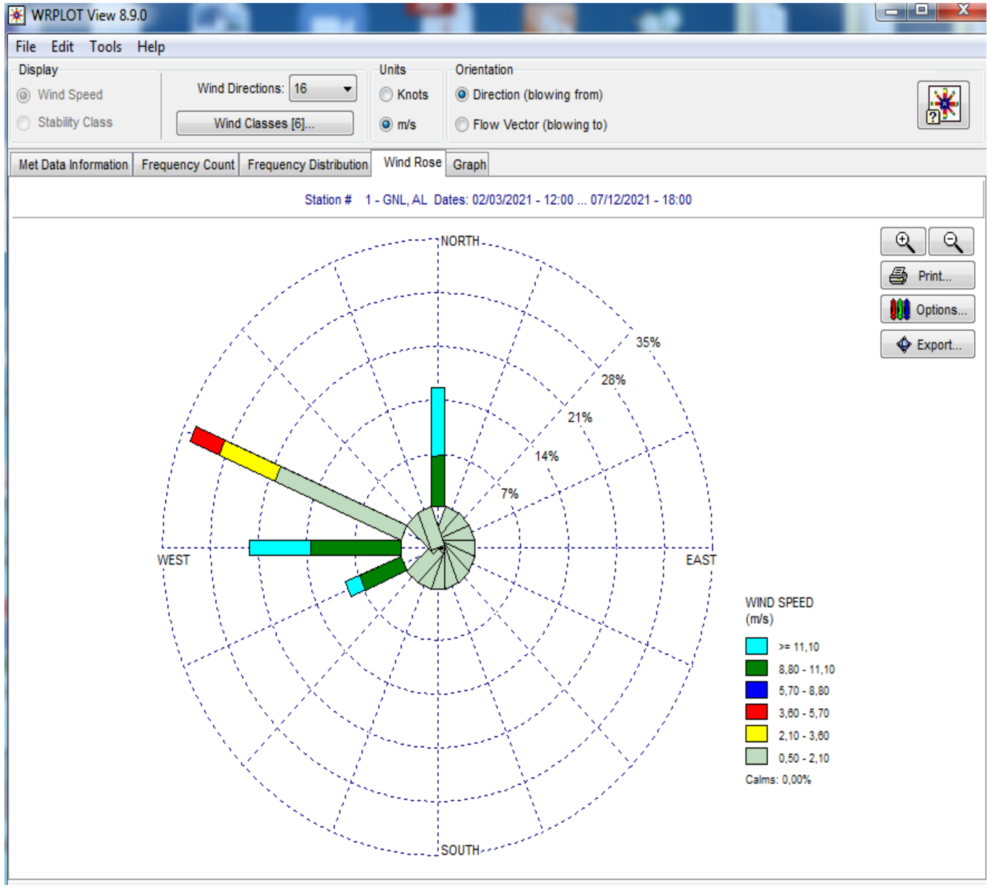
| **Items Place** | **$CO_2$ mg/$^{Nm3}$** | **Nox mg/$^{Nm3}$** | **SO2 mg/$^{Nm3}$** |
|---|---|---|---|
| **Four train 100** | 64,92 | 70,01 | 0 |
| **Turbine train 100** | 77,75 | 171,87 | 0 |
| **Four train 300** | 62,69 | 64,07 | 0 |
| **Turbine train 300** | 64,25 | 163,21 | 0 |
| **Four train 400** | 62,80 | 82,39 | 0 |
| **Turbine train 400** | 51,47 | 164,99 | 0 |
| **Four train 800** | 43,68 | 43,16 | 0 |

*Table 8 The monitoring of CO2, NOx emission in December 2021*

| Items Lieu | CO2 mg/Nm³ | NOx mg/Nm³ | $SO_2$ mg/Nm³ |
|---|---|---|---|
| **Four train 100** | 51.79 | 50.96 | 0 |
| **Turbine train 100** | 19.75 | 133.85 | 0 |
| **Four train 200** | 78.34 | 48.87 | 0 |
| **Turbine train 200** | 26.83 | 125.61 | 0 |
| **Four train 300** | 65,98 | 54,10 | 0 |
| **Turbine train 300** | 56,21 | 164,08 | 0 |
| **Four train 400** | 79,51 | 77,06 | 0 |
| **Turbine train 400** | 55,46 | 181,91 | 0 |
| **Four train 600** | 760.63 | 13.40 | 0 |
| **Four train 900** | 49,30 | 37,49 | 0 |
| **35M0511** | 103,82 | 35,94 | 0 |
| **Normes** | **150** | **200** | **800** |

### IV.12.3 Results and Analysis of meteorological data

The meteorological data analyzed in this paper consists of the surface and profile data. The analysis result of wind roses of the surface and profile wind shows that the wind tends to head from the North West to the east. With an average velocity of 0.5 and above 11 m/s; and a calm frequency of 22,8 %.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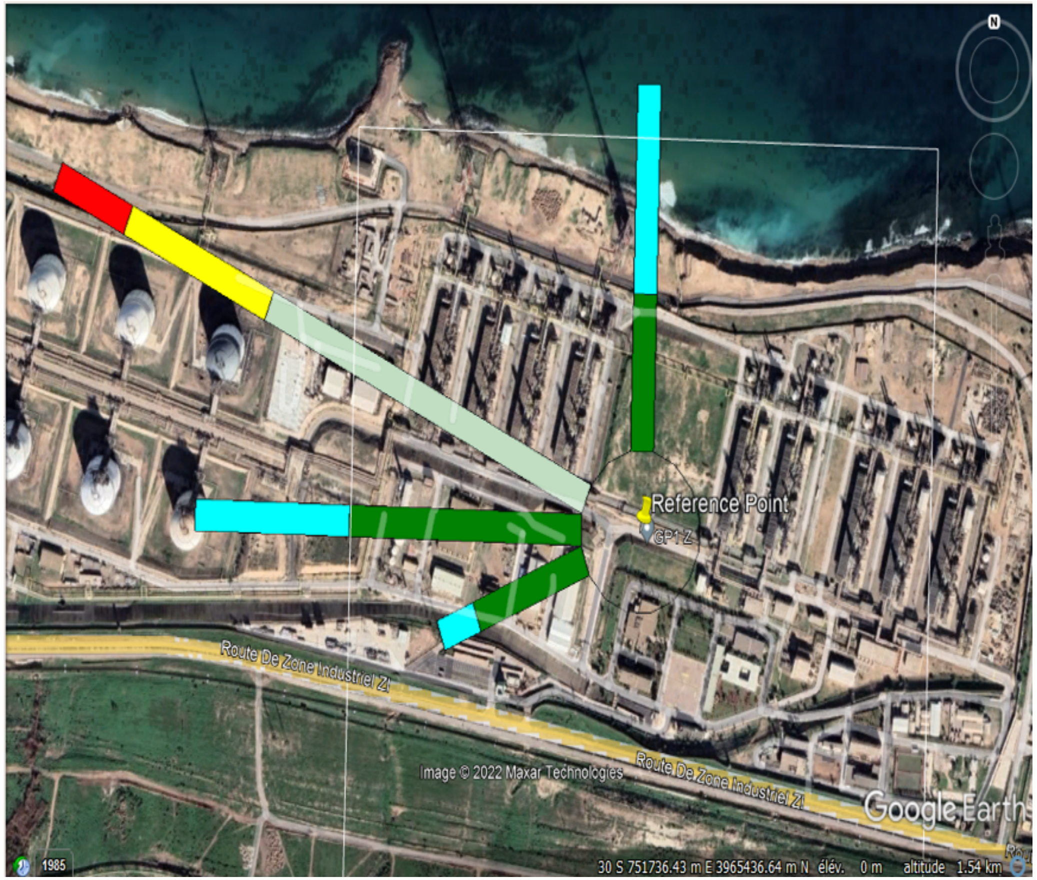
Display
Wind Speed
Stability Class
Wind Directions: 16
Wind Classes [6]...
Units
Knots
m/s
Orientation
Direction (blowing from)
Flow Vector (blowing to)
Met Data Information
Frequency Count
Frequency Distribution
Wind Rose
Graph
Station # 1 - GNL, AL Dates: 02/03/2021 - 12:00 ... 07/12/2021 - 18:00
NORTH
SOUTH
WEST
EAST
35%
28%
21%
14%
7%
Print...
Options...
Export...
WIND SPEED
(m/s)
>= 11,10
8,80 - 11,10
5,70 - 8,80
3,60 - 5,70
2,10 - 3,60
0,50 - 2,10
Calms: 0,00%

(a)


Reference Point
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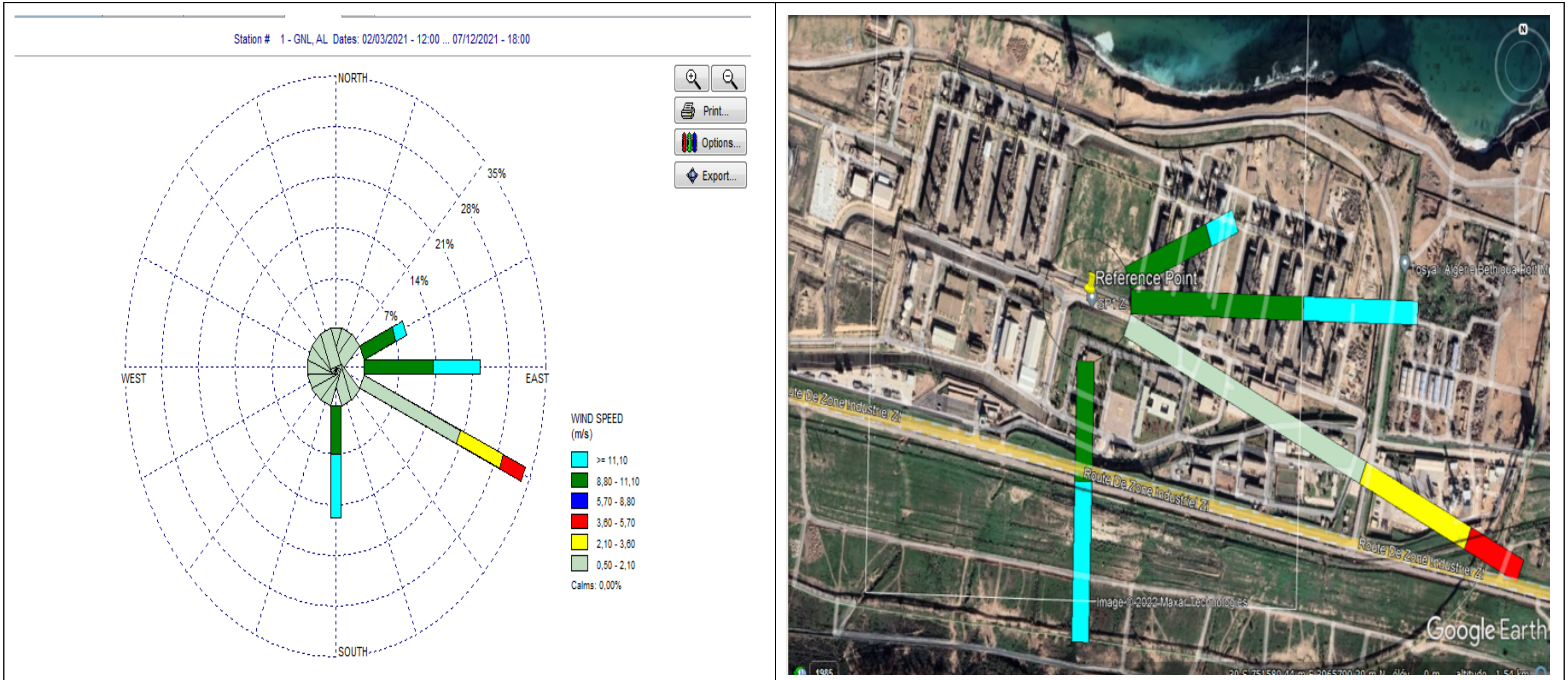
(a)




(b) (b)

*Figure 17 Figure 32 Wind rose of surface and profile from(a) blowing from (b) blowing to. [69]*

### IV.12.3.1 CO, $NO_x$ dispersion model

Based on the input of gases emission, topography data and model wind data, the AERMOD program is carried out for March, June and December. The modeling result of CO2 and NOx dispersion for the average of month shows that this gases dispersion is far below the quality standard. The peak value of the 1 hour peak and 24 hour is presented in the table below:

*Table 9 Peak Values of CO2*

| MONTH | 1 HOUR | 24 HOUR |
|---|---|---|
| **MARCH** | 9392958 µg/m3 | 8992584 µg/m3 |
| **JUNE** | 9387282 µg/m3 | 9098830 µg/m3 |
| **DECEMBER** | 9898261 µg/m3 | 9013158 µg/m3 |

*Table 10 Peak Values of NOx*

| MONTH | 1 HOUR | 24 HOUR |
|---|---|---|
| **MARCH** | 9943123 µg/m3 | 8818940 µg/m3 |
| **JUNE** | 9936094 µg/m3 | 9467143 µg/m3 |
| **DECEMBER** | 9962563 µg/m3 | 7842000 µg/m3 |

The direction of the emission dispersion is in accordance with the wind direction, which is from the North West to the East. The average concentration during the one-hour peak shows that it surpasses the quality standard. Thus, by discovering the dispersion pattern of these industry emissions, the area with increasing amounts of emission risk can be identified in order to find a solution for managing the environment and preventing people from getting diseases. All the analyses patterns are shows in appendice B in the section below an example of the dispersion after one hour in December 2021.

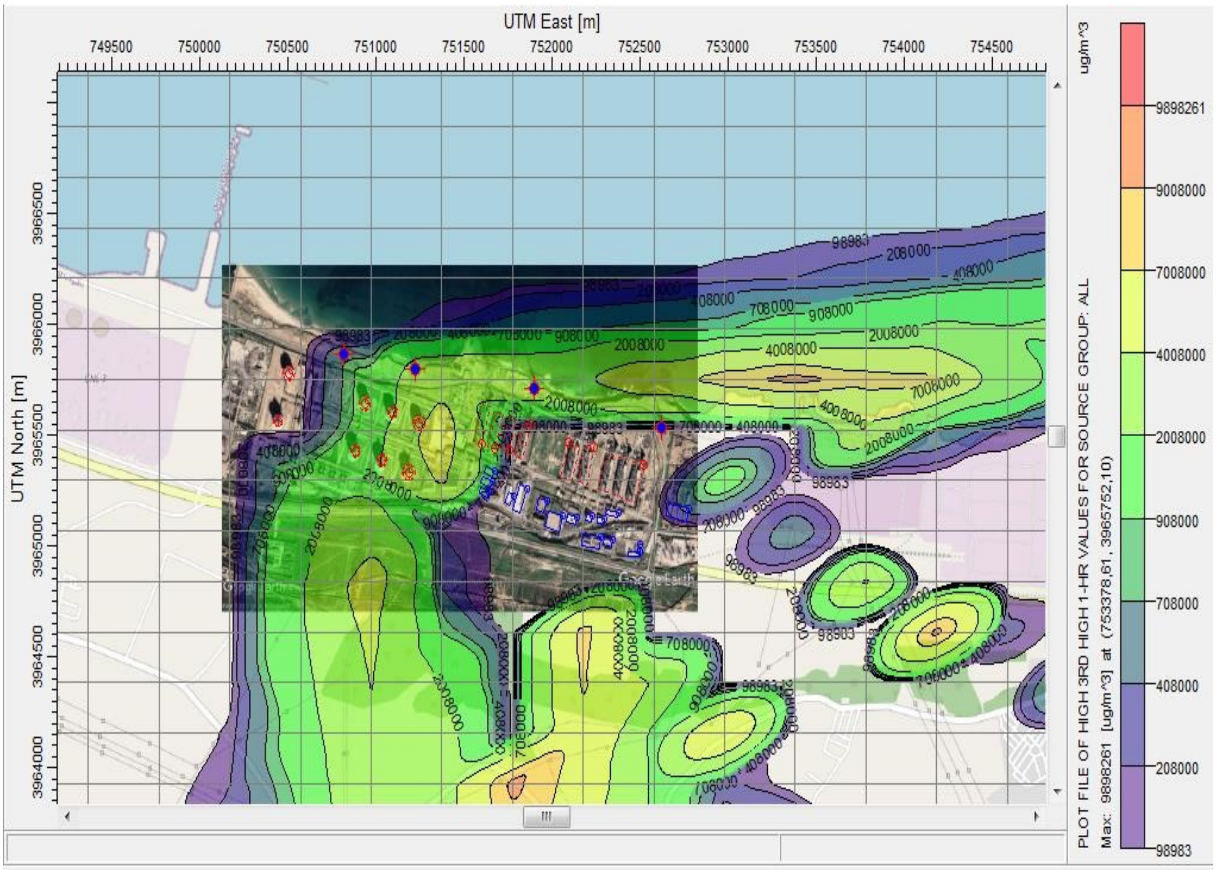



*Figure 18 Dispersion pattern of CO2* ***[69]***

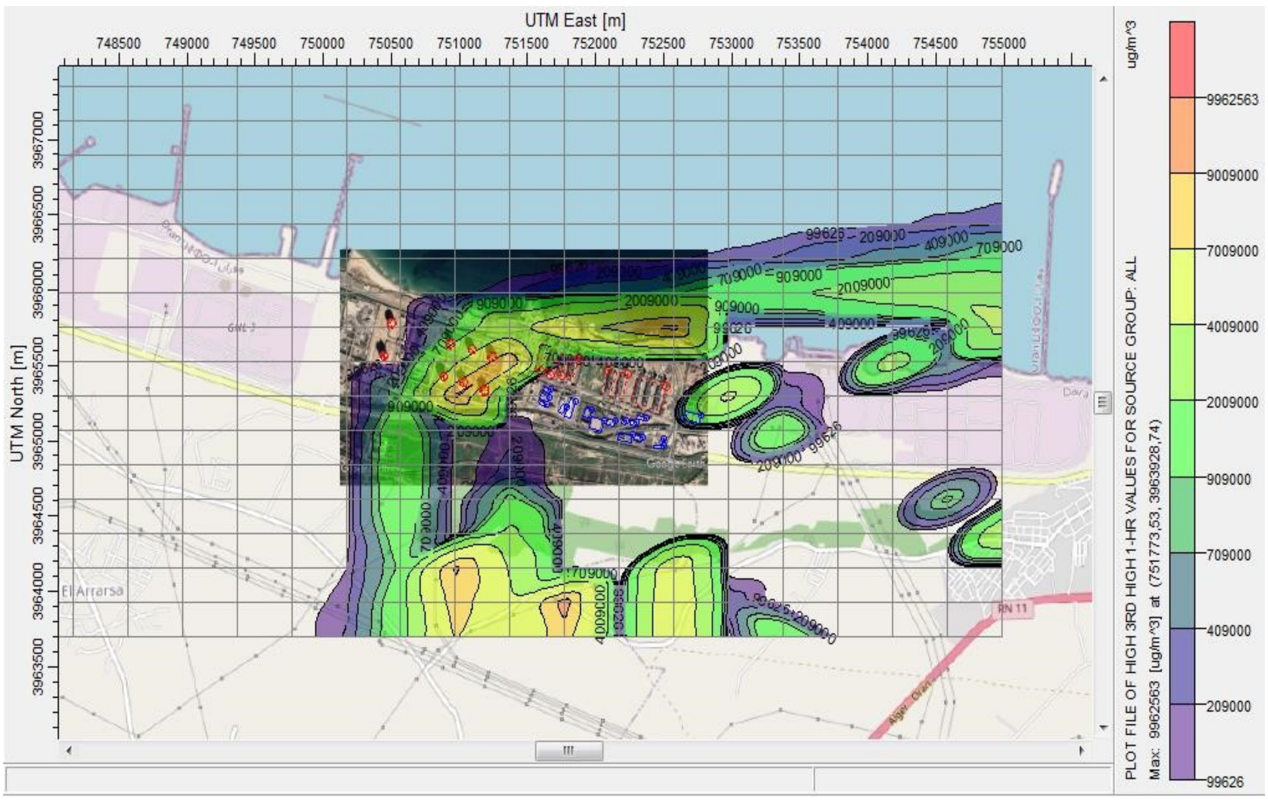



*Figure 19 NOx during the 1hour peak, averaging times (December)* ***[69]***

According to the analysis of meteorological and topographical data (SRTM3 satellite imagery) and the result analysis using AERMOD the movement of wind direction, as seen in wind rose picture, goes from the North West to the East with an average wind velocity of 22,8 m/s and with a calm frequency of 0 %. Topographical variation also contributes to the wind condition. In the research location; there are buildings on the eastern side of the source of gases emission which affect wind movement.

The wind around the buildings will go in circular path which increases the CO2 and NOx concentration moving from the North West to the East as we mention before. By using the AERMOD model, it is easy to identify the area at risk of these gases dispersion emission. As can be seen in Picture , the pattern of CO2 and NOx dispersion is found bigger around storage area of GP1Z and around the industrial area. It can be extended to all the city of Arzew.

The concentration of emission dispersion from GP1Z in this research is surprisingly higher than the quality standard 150 x $10^3$ for CO2 and 200x $10^3$ µg/m$^3$ for NOx, discussed in the executive decree n 06-138. Plus, continuing exposure of this emission has negative impact on the environment and health. Air pollution caused by emission lead to global climate change. Furthermore, continuing CO2 and NOx exposure can harm respiratory system or even lead to death due to several diseases, such as impaired respiratory function and bronchial hyperactivity. The AERMOD model will supply information about areas affected by CO and NOx exposure from GP1Z furnaces, turbines and even from torch emissions. This, efforts related to environmental management can be undertaken. These efforts are to prevent our planet.

## CONCLUSION

According to the AERMOD model, CO2 and NOx emission from furnaces, flare, storage tanks and turbines of the GP1Z complex tends to move toward the East. Peak concentrations are upper than the quality standard. Areas with higher risk of greenhouse effect exposure to CO2 and $NO_x$ emission are Bethiwa, Arzew, Oran, and Mostaganem. It is hoped that this manufactory and people who live around the area can make some serious efforts to prevent and minimize the impact of this emission.

# CHAPTER V
# MITIGATION ASSESSMENT

## INTRODUCTION

The Framework Convention on Climate Change commits Parties to the Convention to develop national programs and measures to respond to climate change. One of the key responses that countries can make is to adopt measures that can reduce atmospheric accumulation of greenhouse gases (GHG) and thereby delay the predicted impact of GHG on global climate. Such measures may either reduce GHG emissions (abatement) or increase terrestrial storage of carbon (sequestration). Because these measures can moderate GHG, they are termed "mitigation" options

A mitigation assessment involves a national-level analysis of the potential costs and impacts of various technologies and practices that have the capacity to mitigate climate change. Two key goals of an assessment are (1): to provide policy makers with an evaluation of those technologies and practices that can both mitigate climate change and also contribute to national development objectives, and (2) to identify policies and programs that could enhance their adoption. An initial mitigation assessment should be followed by more detailed evaluation of specific policies, programs, or projects designed to encourage implementation of selected technologies and practices.

### V.1 Preparing for A Mitigation Assessment

Key factors that need to be considered in preparing a mitigation assessment are discussed below:

#### V.1.1 Defining the Time Frame of the Assessment.

A mitigation assessment typically focuses on long-run opportunities for reducing GHG emissions or enhancing carbon sinks since it takes time for changes that could affect GHG emissions in a significant way to be adopted. In addition to a long-run focus, a country might also evaluate near-term policy and program options.

#### V.1.2 Defining the Scope of the Assessment.

A mitigation assessment may include a variety of areas. These include energy demand and supply, forestry, agriculture, rangelands, and waste management. Ideally, an assessment should include analysis of the impact of mitigation options (particularly in the energy sector) on the macro-economy. Countries should structure their assessment to address the topics of most importance, taking into consideration the resources available to perform the study. A mitigation assessment should include some consideration of policies and programs that can encourage adoption of mitigation technologies and practices. More detailed evaluation of particular policy/program options could follow an initial assessment.

#### V.1.3 Defining Primary Users of the Assessment.

Countries should design their assessments to satisfy the needs of the various possible users or stakeholders. The primary users of the assessment are likely to be policy decisionmakers who are responsible for evaluating and designing mitigation policies. The country's scientific community is likely to benefit from participation in the assessment process, and also from the compilation of data and access to new models, which will also be useful for other types of analysis. Other potential in-country users include the NGO community. In addition, the output of each assessment may be shared with interested groups in other countries, and regional and international organizations. **[70]**

### V.1.4 Defining Results that Meet the Users' Needs.

Defining the type of output desired from an assessment will help in selecting the areas where efforts should be focused. The output of a typical assessment will consist of economic, GHG, local environmental, and social impacts of mitigation options. It could also include a discussion of barriers to implementation of mitigation options and description of policies to overcome them. The importance to be placed on characterizing each type of output should be determined in consultation with the potential users of the assessment. Each team should also consider how best to present the results (e.g., journal articles, reports, briefings, workshops). **[70]**

### V.1.5 Selecting Approaches that are Consistent with Data Availability and Expertise of Researchers.

The sophistication of the analytical methods that will be used in the assessment will depend, in part, on the desired level of output detail. If approximate estimates of scenarios are sufficient, then detailed costing models may not be necessary.

## V.2 The Structure Of A Mitigation Assessment

The structure of a mitigation assessment will vary depending upon its goals and scope. The type of institutions involved in the study may also affect the structure. Studies in specific sectors such as energy or forestry can be conducted somewhat independently, yet it is important for all members of the study team to use common assumptions regarding basic parameters such as population and economic growth.

Although most of the work will be independent, interaction among the sector specialists can be beneficial. For example, the forestry specialists can provide the energy specialists with information on biomass resources that may be available for energy consumption in the future. **[70]**

The nature of a mitigation assessment will vary among sectors, but it is possible to describe a basic structure that illustrates the key components of an assessment and how they relate to each other (Figure 70)

Once the base year has been documented in some detail, the remainder of the assessment involves an evaluation of what might or could occur in the future. The development of scenarios of the future requires data on the activities that result in GHG emissions or shape opportunities for carbon storage. The types of data include production of key industrial products, the number of urban and rural households in the residential sector, the number of vehicles in transportation, and demand for land and forest products. Development of scenarios requires a projection of the future levels of each kind of activity. Such projections in turn draw on assumptions made about growth in population, GOP, and other macro variables.

For each type of activity or resource demand, there are generally a number of technologies or practices that can be employed, each having different implications for resource use and GHG emissions or carbon storage

Once options have been selected for inclusion in the assessment, it is necessary to characterize technologies and practices with respect to their costs and other features (e.g., performance, lifetime, environmental characteristics, labor and infrastructure requirements).

The information on future activity levels and potential technologies/practices is used to define scenarios that describe future resource use or production under a certain set of conditions .

A mitigation assessment should include at least two scenarios for each sector considered. A "baseline" or "reference" scenario is a description of a plausible future in which no specific policy actions are taken to encourage actions that reduce GHG emissions or enhance carbon sinks. A "mitigation scenario" describes a future that is essentially similar to that in the baseline scenario with respect to overall economic and social trends, except that it assumes that policies or programs are implemented that encourage adoption of measures that will reduce GHG emissions or enhance carbon sinks

In analyzing the merits of mitigation options, standard techniques of benefit-cost analysis may be applied, with some modification. However, some of the impacts of a mitigation option may be difficult to express in monetary terms or even to quantify. Thus, cost-benefit analysis should be supplemented with quantitative and qualitative assessment of other criteria such as complementary environmental effects (e.g., reduction in local air pollution), secondary economic effects (e.g., employment creation), and social and political considerations (e.g., the impact on societal equity). **[70]**

The combination of cost-benefit analysis and assessment of other criteria can be used to compare or rank mitigation options, which can support the definition of mitigation scenarios. A mitigation scenario may reflect only the technical potential of various options to reduce GHG emissions or to store carbon; or the analyst can estimate that part of the technical potential that may be achievable. Estimating the magnitude of GHG emission reduction or carbon storage that may be achievable within a given time frame requires identification and assessment of policies or programs that could be used to encourage adoption of mitigation options in each sector. A detailed evaluation of policies or programs may go beyond the scope of an initial mitigation assessment, however.

The scenarios provide estimates of the economic and other impacts within the sector being studied (e.g., investment requirements). It is important to also assess the impact of sectoral mitigation options (or of cross-sectoral options such as a carbon tax) on the overall economy, social goals, and the local environment. Various models may be used to analyze the interaction between the energy sector and the economy. Similar models have not been used to assess the impact on the economy of mitigation options in non-energy sectors, but models used for general analysis of agriculture and forestry could be modified for analysis of macroeconomic impacts of mitigation options in those sectors. In addition, methods that facilitate combined quantitative and qualitative assessment of multiple criteria may be used.

Once the full range of impacts of various mitigation options have been evaluated, the next step involves an assessment of policy and program options to encourage their adoption. This assessment may go beyond the rough assessment used to define mitigation scenarios. It might combine quantitative analysis with workshops that facilitate interaction between the analysts and relevant policy-makers, and other interested parties in a particular country.

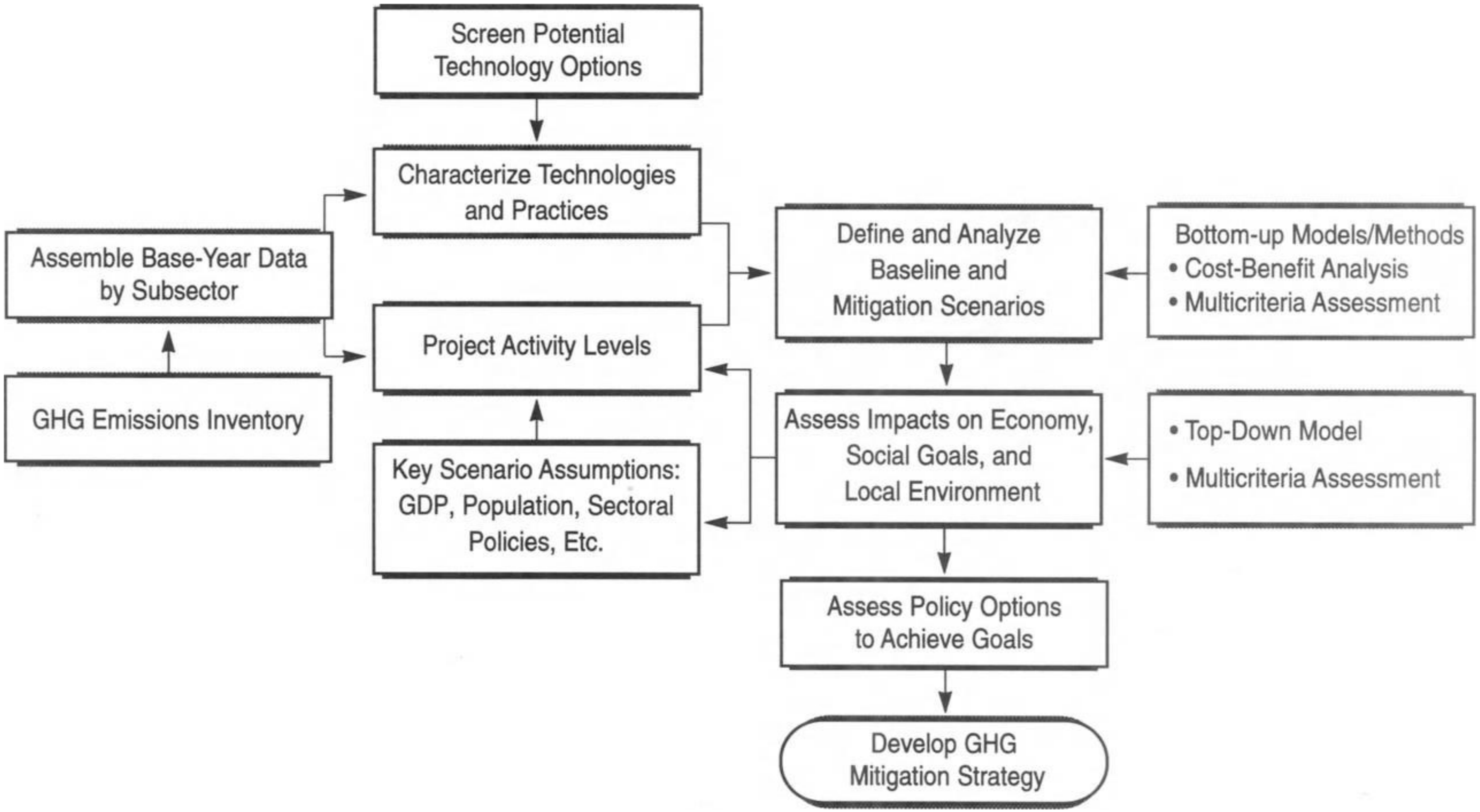



*Figure 1 Structure of a Sectoral Mitigation Assessmen **[70]** t*

The structure described above generally applies for the energy sector and the nonenergy sectors. However, the analysis of the energy sector is complicated by the fact that it requires an integration of energy demand and supply in order to estimate the GHG impacts of mitigation options in the energy demand sectors, and to compare demand-side and supplyside options. It also tends to be larger in scope, since the use of energy pervades the entire economy. **[70]**

### V.3 Time Horizon In Mitigation Assessment

The time horizon of the analysis plays a critical role in planning a mitigation assessment and selecting methods. For discussion purposes, it is useful to define time periods somewhat arbitrarily as near-term (1-5 years), mid-term (15 years), and long-term (15-50+ years).

A classic definition of the near term is that period of time during which the capital stock is fixed, while the technology mix and allocation of input factors across producing sectors is variable in the long term. Since the economy's structure and productive capacity are fixed in the short run, price changes are generated by fluctuations in variables reflecting seasonal cycles or transient impacts such as severe weather, oil spills, geopolitical conflicts, labor strikes, and so forth.

Extending the forecast horizon shifts the emphasis towards market clearing and relatively stable trends in variables. While the mid-term time frame extends far enough for innovations to occur in some sectors, the general characteristics of available technology, the capital stock of energy-consuming equipment, and demographic patterns can be anticipated with reasonable confidence. Although new technologies are continually emerging and their eventual market penetration is uncertain, gradual capital stock turnover implies that most of the capital equipment that will be used during the mid-term period is already in place, available on the market, or on the verge of commercialization.

Long-term modeling focuses on paths of key variables such as demographic patterns, cumulative impacts such as the depletion of nonrenewable resources, and changes in structural relationships between exogenous and endogenous variables due to capital stock turnover, the penetration of new technologies, emergence of alternative energy sources, and interindustry shifts in the composition of demand. In the short term, only minor changes to the energy system can be anticipated to take place. Even in a mid-term perspective, substantial deviations from the existing planned energy system are limited due to long lag times for construction of supply facilities, and similar considerations apply for technology innovations in other sectors. Hence, the usefulness of advanced integrated models is less if one is addressing short-term impacts only. In this case, careful study of recent trends and evaluation of existing plans (expansion of the supply side is usually planned for the next decade) and available retrofit options, together with use of simple sector-specific models, is sufficient. **[70]**

However, in GHG mitigation the real challenge is to be able to sustain reduced emission levels (orlower them further) in a long-term perspective. The goal of identifying opportunities for GHG mitigation that can have a significant impact in the future calls for long-term modeling of the energy and non-energy sectors. In the presentation of models in this book, we concentrate on models suited for addressing longterm development of the energy and non-energy sectors.

**V.4 Approaches For Analysis Of Mitigation Options**

Developing a national mitigation strategy requires identification and analysis of different actions that government could take to encourage adoption of technologies and practices that reduce GHG emissions or enhance carbon sinks. Based on the analysis, policymakers can then decide which options not only satisfy specific policy objectives but are also within institutional, political, and budget constraints.

Two general approaches have been used for mitigation assessment. The top-down method assumes a macroeconomic perspective wherein mitigation cos1s are defined in terms of losses in economic output, income, or GDP. A key assumption underlying many top-down analyses is that the baseline scenario represents the economy in equilibrium, with all factors of production employed efficiently given prevailing prices. The bottom-up approach focuses on individual processes such as end-use energy consumption, production of specific crops, and specific forest management schemes. For each relevant process

The fundamental difference between the two approaches is in the perspective taken by each on consumer behavior. The top-down approach assumes that consumers always act to maximize their utility or profit. According to this approach, if energy efficiency is less than it could be, it is because consumers see no economic gain in becoming more efficient. In contrast, the bottom-up approach assumes that various market barriers prevent consumers from taking actions that otherwise would be in their or the national economic self-interest.

In general, an assessment carried out using the bottom-up approach will very likely show significantly lower costs for meeting a given mitigation objective than will one using a top-down approach. To some extent, the differences may lie in a failure of bottom-up studies to accurately account for all costs associated with implementing specific actions. Top-down methods, on the other hand, can fail to account realistically for consumer and producer behavior by relying too heavily on aggregate data (Krause *et al.,*1993). In addition, some top-down methods sacrifice sectoral and technology detail in return for being able to solve for general equilibrium resource allocations. Finally, top-down methods often ignore the fact that economies depart significantly from the stylized equilibria represented by the methods (Boero *et al., 1991).* Each approach, however, captures costs or details on technologies, consumer behavior, or impacts that the other does not. Consequently, a comprehensive assessment should combine elements of each approach to ensure that most relevant costs and impacts are accounted for. **[70]**

**V.5 Tools for Mitigation Assessment**

A variety of models and methods can assist the analysis of mitigation options. The primary ones are listed in Table A . These range from bottom-up accounting models for the energy or forestry sector to top-down models of the whole economy in which energy or forestry are but one sector. For the energy sector, the models include accounting frameworks (LEAP and STAIR), optimization models (MARKAL and ETO), and an iterative equilibrium model (ENPEP). Each of these models may be used for integrated assessment of energy demand and supply although the approach and method varies among them. In addition to these quantitative models, a decision framework process (AHP) may be used for combined quantitative and qualitative evaluation of alternative technology options.

In industrialized countries, several top-down models have been developed for mitigation assessment, primarily to analyze the impact of carbon taxes. Similar models have not been widely applied to analyze changes in taxes, investment, or energy flows of developing and transition countries. Two top down models that have been developed primarily for the developing countries are the MIMEC and LBLCGE models. In addition, a recently developed hybrid model (MARKAL-MACRO) merges the bottom-up and topdown approaches. **[70]**

In the non-energy sectors, bottom-up analytical methods have largely focused on the estimation of carbon and other GHG flows. The COPATH model has been used for carbon accounting and scenarios in the forestry sector, while COMAP has been developed for estimating the impacts of mitigation options in the foresby sector. EPIC and CENTURY are plantlsoil simulation models which may be used to simulate carbon cycling dynamics in agricultural and rangeland ecosystems. For assessment of methane mitigation options in agriculture and waste management, simple spreadsheet models are available.

Top-down models have not been used in the non-energy sector for the assessment of GHG related impacts in the developing and transition countries. Countries where agriculture or forest products form a significant share of the monetized economy have models or methods that can analyze the GOP impact of changes in domestic or international prices of these products. Many countries, for example, have used computable general equilibrium (CGE) models for analyzing the impacts on GOP, income distribution, and rural employment. These models may be modified for the purpose of a top-down analysis of the impacts of GHG mitigation options. The LBL-CGE model could also be modified for this purpos

*Table 1 Examples of Analytical Tools Available for Mitigation Assessments*

| Topic | Analytical Tools |
| --- | --- |
| **Energy Sector** | |

| | |
|---|---|
| **Accounting Models** | |
| **Optimization Models** | LEAP, STAIR |
| **Iterative Equilibrium Model** | MARKAL, ETO |
| **Decision Analysis Framework** | ENPEP |
| | Analytical Hierarchy Process (AHP) |
| **Non-Energy Sectors** | |
| **Forestry** | |
| **Agriculture** | COPATH, COMAP |
| **Rangelands** | EPIC, CENTURY |
| **Waste Management** | CENTURY |
| | Landfill Gas Model |
| **Energy-Economy Interaction** | LBL-CGE, MARKAL-MACRO |

## V.6 Screening Mitigation Options

The nature and importance of the screening process varies depending on the modeling approach. For each sector being studied, one approach is to develop a list of mitigation options that may be of interest. Various criteria, such as those listed in Table B, are important for both screening and in-depth analysis of mitigation options. At the screening stage, one makes a rough assessment of the potential attractiveness of options, while the goal of the analysis is to quantify or carefully identify various impacts.

A useful approach for screening options is to prepare a matrix as shown in Table B for each sector. The matrix provides a qualitative indication of the attractiveness of each option by ranking it high, medium, or low, as judged according to each criterion. This matrix should be completed prior to conducting sectoral analyses in order to identify the options to be evaluated in depth.

Screening out the non-promising options requires careful judgement. An obvious reason for screening out options is if its wide-scale application is not viable. For example, location of options in environmentally or otherwise sensitive areas may rule them out for political reasons. The relationship between a mitigation option and development goals is important to consider. In addition, there may be options, such as reducing traffic congestion, which may be difficult to analyze since quantifying the impact on GHG emissions may be difficult to do. However, if the option is important for non-GHG reasons (e.g., as a measure to reduce urban air pollution), then simple assumptions may be made to roughly estimateits GHG impact. **[70]**

Screening of options may require consideration of likely future conditions. For example, electricitysaving options may have a very small impact on GHG emissions if much of the electricity is hydrogenerated. However, if the mix of generation is likely to shift toward more thermal generation, then electricity-efficiency options could become important.

*Table B Criteria for Screening of Mitigation Options*

*Table 2 Criteria for screen of mitigation options*

| CRITERIA | MITIGATION OPTION 1 | MITIGATION OPTION 2 | MITIGATION OPTION n |
|---|---|---|---|
| Potential for large impact on $CO_2$ or other GHGS | High | Low | Medium |
| Direct cost-benefit ratio of the option | Low | High | High |
| Indirect economic impacts | | Low | |
| - Increase in domestic employment | Medium | Medium | Low |
| - Decrease in import payments | Low | | Uncertain |
| Consistency with national environmental goals | | High | Medium |
| - Reducing emissions of air pollutants | Low | Low | |
| - Effectiveness in limiting other environmental impacts | Medium | | Low |
| Potential ease of implementation | Low | Medium | High |
| Long-term sustainability of option | High | Uncertain | Medium |
| Consistency with national development goals | High | Low | Medium |
| Data availability for evaluation | | | |
| - Technology characterization | Low | Uncertain | High |
| - Costs of implementation programs | High | Low | Uncertain |
| Other sector-specific criteria | Low | High | Uncertain |

## V.7 Defining Scenarios

What will happen in the future cannot be predicted, but it is possible to develop scenarios of the future that reflect the consequences of different, but plausible, economic and technological conditions. For the purpose of mitigation analysis, at least these two different scenarios are necessary.

### V.7.1 Baseline Scenario

A baseline scenario should represent a future in which there are no policies or programs designed to encourage or require actions that reduce GHG emissions or enhance carbon sinks. Defining a reasonable baseline scenario is a critical element in a mitigation assessment since the incremental costs and benefits of mitigation options will depend on the definition of the baseline scenario.

A baseline scenario should not simply extrapolate from recent and current trends but rather incorporate a judgement of the likely evolution of resource-consuming and producing activities and technologies. This type of scenario is sometimes called "business-as-usual." Such a scenario would include some degree of adoption of technologies or practices that improve the efficiency of resource use and thereby reduce GHG emissions. In transition countries in particular, a baseline scenario will be quite different from historical trends.

In both developing and transitional countries, where considerable economic and social change is expected over a period of the next several decades, it can be quite difficult to select a single image of the future as more likely than another. A study team might choose to define more than one baseline scenario. For example, alternate scenarios could reflect low, medium, and high economic growth. Obviously, there is a trade-off between keeping the assessment manageable and defining numerous baseline scenarios.

### V.7.2 Mitigation Scenario.

A mitigation scenario reflects a future in which climate-change mitigation is a primary motivation for adoption of technologies and practices that reduce GHG emissions or enhance carbon sinks. It may reflect only the technical potential for reducing GHG emissions or storing carbon, or it may incorporate estimates of what is achievable considering the many factors (institutional, cultural, legal, etc.) that may limit the implement ability of the technically available options. Ideally, both the technical and the achievable potential should be reported.

A study team could define and develop several mitigation scenarios. For example, alternate mitigation scenarios could reflect different degrees of emissions reduction or carbon storage relative to the baseline (e.g., 10%,20%,30%). A study team might also want to define mitigation scenarios that highlight particular types of technologies (e.g., renewable energy technologies).

For both the energy and non-energy sectors, scenarios developed using a bottom-up approach take into consideration end-users' needs for energy, forest products, and land. By explicitly taking these needs into account, end-use scenarios are less likely to over- or understate final demand for products.

### V.7.3 Setting Basic Parameters

In constructing scenarios, certain underlying parameters must be specified and treated consistently. Assumptions should be consistent with those used in GHG inventories and vulnerability and adaptation studies.

#### V.7.3.1 Selecting the Time Frame for the Assessment

The time frame for GHG scenarios is often quite long, extending from 50 to 100 years. For mitigation options analysis, however, it is usually better to consider shorter time frames since the projection of macro-economic variables and the characterization of technologies beyond 20-30 years become quite uncertain. Analysts have generally used the period up to 2020 or 2030 as a relevant time frame to analyze the economics of mitigation options. For the forestry sector, long-rotation tree plantations may need to be evaluated over a longer time frame. Projections of emissions in the near-term (e.g., 2000) may also be helpful in evaluating policy options. Analysis may be conducted for either a single end year or several forecast years. In a dynamic framework, each consecutive time period is linked to the other over the entire time horizon.

#### V.7.3.2 Socio-Economic Variables.

Projections of socio-economic variables such as economic and population growth rates, land-use patterns, economic structure, and urban-rural population proportions may be obtained from national planning ministries in each country. Most countries have multi-year plans that show both economic structure and population growth assumptions. If these are not readily available, World Bank or UN projections of population and economic growth may be used instead. Economic growth projections are usually for a relatively short time period (5-10 years), and these should be extrapolated as realistically as possible for subsequent periods.

### V.7.4 Land-use and Natural Resource Considerations.

Changes in land-use patterns will have an important bearing on GHG emissions from forestry, agriculture, and drylands, and they will also affect the vulnerability of the country to climate change. It is therefore important for both mitigation and vulnerability assessment staff to assess the current patterns of land use and their evolution over time. Changing the evolution of land-use patterns requires strong government policies and programs. Consideration should be made as to whether these types of policies are likely to occur as a mitigation option in each country. If only technical options are to be evaluated, then each "likely trends" scenario of land-use change should be used to evaluate both baseline and mitigation scenarios. If strong policies to modify evolving land-use patterns are plausible, then the mitigation scenario should consider a land-use pattern different from the one used for the baseline. **[70]**

## V.8 Cost-Benefit Analysis Of Mitigation Options

A key objective of a mitigation assessment is to identify those options that maximize economic benefits or minimize the economic costs of restraining GHG emissions growth. Cost-benefit analysis has traditionally been used for project evaluation, but it has also been applied to mitigation assessment to estimate and compare relevant costs and benefits in a consistent and comprehensive manner. Cost-benefit analysis suggests that mitigation options that produce the greatest net benefit be selected among competing options. Strict application of this rule to the evaluation of mitigation options is not possible, however, since the benefits of mitigation options with regard to climate change cannot be monetized with any certainty at this point in time and are likely to vary among regions.

The monetizable portion of the costs and non-GHG benefits may be stated in money terms. Since the carbon GHG benefits cannot be easily monetized, the benefits may be stated simply in terms of either tonnes of carbon abatement or storage, or for non-carbon GHGs, in terms of carbon-equivalent.

Cost-benefit analysis should be supplemented by assessment of non-monetizable costs and benefits other than GHG abatement. These might include reduced emissions of other pollutants or an improvement in biodiversity. These costs and benefits should be quantified or at least described so that decision-makers can take them into account. Similarly, the impacts of an option on different societal groups may also need to be considered.

**V.8.1 Discount Rate.**

Cost-benefit analysis typically expresses costs and benefits that occur over a period of time in terms of their present value, which is calculated using a discount rate. The discount rate reflects the return on foregone present consumption that is sacrificed to secure future consumption. Since foregone present consumption is invested to secure future consumption, analysts often use a discount rate equal to the after-tax realrate of interest or return on capital investment.

Much has been written about the estimation of discount rates for projects with longterm consequences (Lind *et al.,* 1982). For economic analysis of projects in the developing countries, real discount rates between 8 and 12% are commonly used by the World Bank.Each country should select an appropriate discount rate for evaluating the present value of monetary costs and benefits of mitigation options. A study team may wish to conduct sensitivity analyses at a higher and lower rate around the base rate. To evaluate options from the perspective of particular groups (such as households or farmers), analysts should use discount rates that are commonly used in their country for these groups.

In order to assess an option's cost-effectiveness, the discounted costs and benefits are related to its GHG savings or carbon storage. Should the avoided GHG emissions or carbon storage be discounted at the same rate as costs? We suggest that these GHG flows not be discounted. By not discounting them, one assumes that the future economic damage caused by GHG emissions increases at the real rate of discount, which is not unreasonable considering that the potential damage that atmospheric GHG concentrations might cause in the future is largely unknown. (For a discussion of discounting monetary versus GHG flows, see Sathaye *et al., 1993.)* **[70]**

**V.8.2 Cost Curves of GHG Mitigation**

A GHG-reduction cost curve relates the quantity of GHG which can be reduced by mitigation options to the cost per unit GHG reduction. Correspondingly, a cost curve for stored carbon relates the quantity of stored, or sequestered, carbon to the cost per unit carbon stored. Cost curves for GHG reduction and for carbon storage can be combined to express the relationship between total amount of "avoided" GHG and the cost per unit GHG avoided.

Two distinct forms of cost curves appear in the literature: (a) discrete step curves and (b) continuous curves. These two forms are derived differently and should be interpreted in different ways. Within each of the two forms there are also different methods of construction, different meanings, and different interpretations. Schematic versions of the two forms are shown in Figures B and C. The blocks in Figure B correspond to individual mitigation options or "baskets" of options, with widths representing the potential GHG reduction (or carbon stored) and heights representing the cost per unit GHG reduction. The points on the continuous curve (Figure 2-3) represent the increase in total system costs for a given scenario. The costs and the emission reductions represented by each point normally result from the contribution of a mix of several options, as opposed to the discrete step curve in which each option is analyzed separately! Continuous curves can be used to represent the aggregate output from models of the costs of reducing emissions by a given amount.

The aim of a cost curve is ideally to show the relationship between costs and GHG reduction (orcarbon stored) over a wide range where both small GHG emission reductions and large reductions are measured. Thus, a cost curve must by its nature be an aggregate of many different technical and structural changes in the energy system.

When investigating the specific cost of mitigation, i.e., cost per tonne of GHG reduced, it is important to distinguish between average, incremental, and marginal cost. The average cost of GHG reduction reflects the difference in total energy system costs when a specific mitigation scenario is compared to the baseline, divided by the difference in emissions between the two scenarios. The incremental cost can be defined as the increase in costs per unit of emission reduction when a specific mitigation scenario is compared to the previous scenario on the cost curve (rather than the baseline, as in the case for average costs). Thus incremental costs show how expensive each additional step becomes per unit of extra GHG reduced (see Figure D). The marginal cost of GHG abatement is the cost of not emitting the last unit of GHG from the system, or the cost of the last unit of carbon sequestered. In an optimization model, this unit is by definition the most expensive one. The marginal cost will in this case be equal to the shadow price of the imposed emission constraint (if any), or if a carbon tax is introduced in the model, the marginal cost is equal to the tax level.

The disadvantage of only presenting average costs is that increasing costs associated with increasing emission reduction levels are leveled out (see Figure D). An incremental cost curve gives a better picture of the cost consequences of each additional step of measures. Assuming that the average cost curve is increasing and convex, the incremental costs will always be equal to or higher than average costs. The marginal cost curve will then in turn always be equal to or higher than the incremental cost curve. The more model runs (mitigation scenarios) that are used to construct the incremental cost curve, the closer it will reflect the marginal cost curve. In non-optimization models, the marginal costs are not directly calculated. However, by carefully selecting mitigation scenarios when establishing the incremental cost curve, this can be used as approximation of the marginal costs. **[70]**

Another issue to consider when establishing cost curves is the representation of time dependence in the costing of mitigation options. Dynamic models include linkage between time periods over the time horizon considered, and thus allow for studying the development over time of different variables, and also allow for a time Hiependent description of technologies. In a dynamic model, the choice of mitigation options in one year (or time period) will depend on the choices made in previous years.2 Static models only give a "snapshot" representation of the costs, with no time dependency included.

When interpreting cost curves it is important to be aware of what the costs presented include. Cost curves derived from bottom-up models address direct technological costs but typically ignore non-technical market factors and cost impacts of structural changes. Hence, the costs calculated in these models do not reflect GOP losses, as is the case with macroeconomic models.

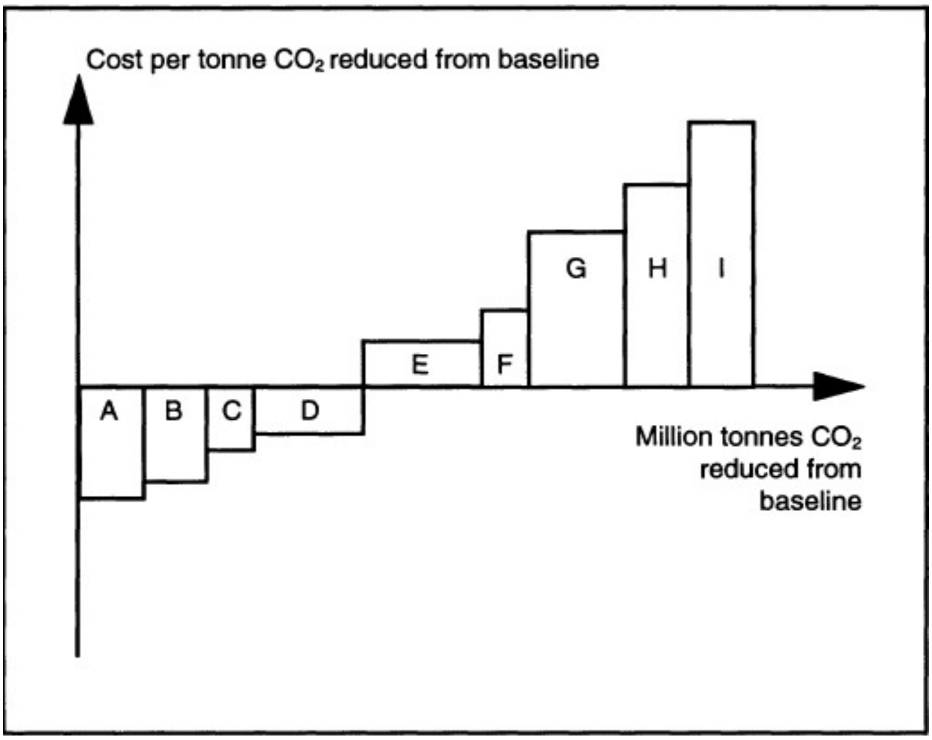



*Figure 2 Discrete Step CO2 - Reduction Cost Curve[70]*

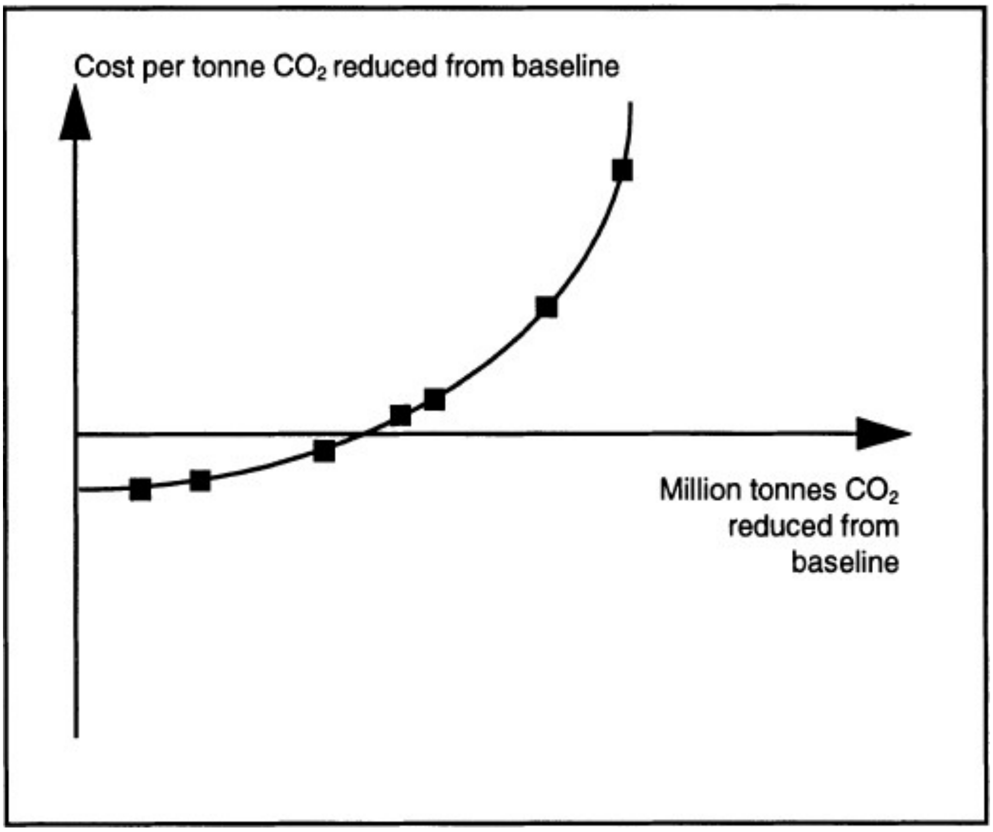



*Figure 3Continuous Cost Curve[70]*

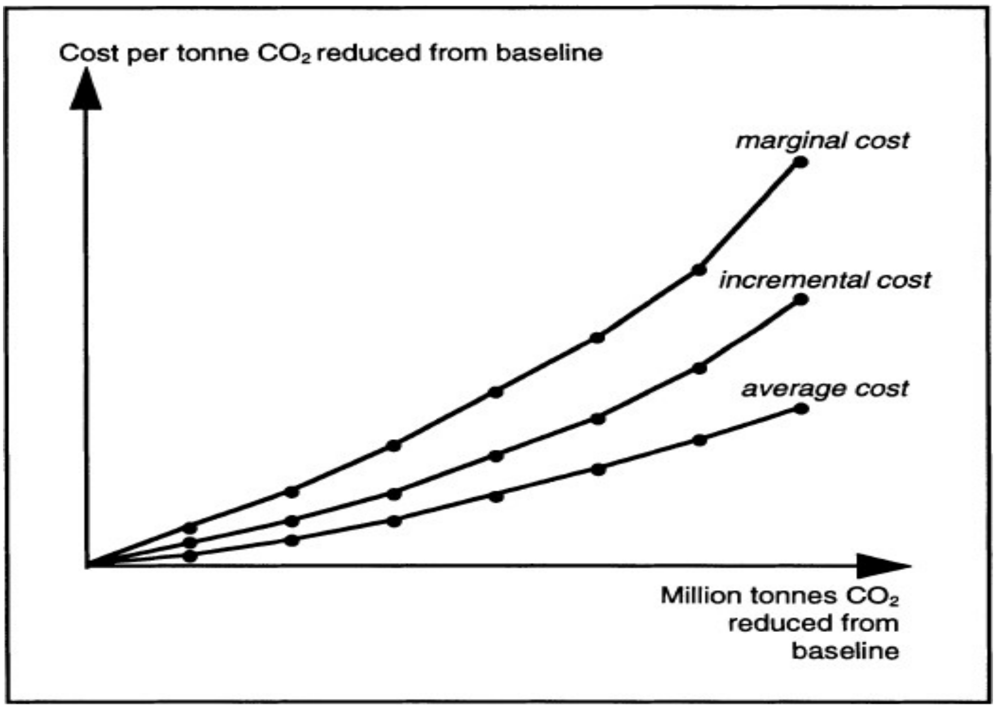



*Figure 4 Marginal, Incremental, and Average Cost Curves[70]*

### V.8.3 Accounting for Mitigation of Non-C02 Greenhouse Gases

Expressing the benefit of reducing emissions of different GHGs in a common unit is problematic since the effectiveness of greenhouse gases in trapping the earth's heat varies. Research on this topic has led to the development of the concept of a "global warming potential," or GWP. The GWP is intended to demonstrate the relative impacts on global warming of various gases compared with CO2. The research conducted to date has established that the effects of various gases are too complex to permit them to be summarized in a single number. The indirect effects of some gases have proven impossible to summarize in terms of GWPs, while the direct effect depends on the time horizon considered (since gases have different lifetimes in the atmosphere). The currently available numerical estimates of GWP relative to CO2 are given in Table C for the most important gases.

From a practical standpoint, the main issue is how to compare measures that affect methane with those that affect CO2 and how to aggregate emissions among GHGs. One option is to present the GWP of methane mitigation options in terms of a range of estimated GWPs. For example, if the chosen range for the methane GWP was 19-110, then the CO2 equivalent magnitude of GHG reduction for a measure that reduced methane emissions by 100,000 tonnes would be 1.9-11 million tonnes.

*Table 3 Numerical Estimates of Global Warming Potential*

| Greenhouse Gas (GHG) | Direct Effect for Time Horizons of | |
|---|---|---|
| | 20 Years | 100 Years |
| **Carbon dioxide (CO2)** | 1 | 1 |
| **Methane** | 56-110 | 19-43 |
| **Nitrous oxide (NOy )** | 290 | 320 |
| **CFC-11** | 5,000 | 3,900 |
| **CFC-12** | 8,000 | 8,300 |
| **HCFC-22** | 4,300 | 1,600 |
| **HFC-134a** | 3,100 | 1,200 |

### V.9 Integration Of Energy And Non-Energy Assessments

Integration of results from assessments of the energy sector and the various nonenergy sectors can be a challenging task in conducting a national mitigation assessment. The degree of integration that is desired depends on the goals of a national mitigation strategy and whether policy-makers want a ranking of options across sectors.

The most basic type of integration is to simply describe the GHG impacts, costs, and other effects of particular options as identified in each of the sectoral assessments. This is the approach that has been primarily used in the OECD countries for developing and reporting National Action Plans to address climate change. General impacts on the economy are then often addressed by incorporating the different sectors in a general equilibrium framework.

If a coherent ranking of specific options across sectors is desired, however, it requires careful planning of the overall assessment and development of an analytical framework to integrate results. It also requires close communication among the various analysts before, during, and after each of the sectoral assessments. Each of the sectoral studies should use common assumptions for basic macro-parameters and also have a reasonably consistent philosophy for defining a baseline scenario.

If marginal cost curves for GHG mitigation are available from the sectoral assessments, each sector's curve can in principle be combined into a national marginal cost curve. The marginal cost for achieving a specific GHG emission reduction target can then be estimated from the national curve. One can then identify options in each sector, up to the same marginal cost, that together satisfy the overall reduction target. This would provide a theoretically "least-cost' solution for a particular national reduction target, given the limitations in the analytical methods in establishing the sectoral cost curves.

A final ranking of options across sectors may be done by assembling a range of impacts, costs, and benefits for each option (such as the criteria listed in Table B). Options can be assessed in a consistent fashion using a decision analysis framework that allows for a weighting of various quantitative and qualitative criteria. Such a framework allows policymakers to define the importance that they attach to particular criteria.

### V.10 Integration With Emission Inventories And Vulnerability And Adaptation Assessments

The analysis of mitigation options should be closely linked to and integrated with the preparation of a GHG emission inventory and any vulnerability and adaptation assessments a country is performing. The mitigation analysis should be structured to take advantage of the information generated by these assessments, particularly the emissions inventory. It may also be beneficial to present the results of the inventory, vulnerability and adaptation, and mitigation assessments in one unified document so that conclusions can be drawn about the most important implications of climate change for a country. This will also allow decisionmakers to consider the tradeoffs between implementation of adaptation measures and mitigation measures in designing a country's national strategy.

Some of the obvious points of integration between the inventory, vulnerability and adaptation, and mitigation assessments are presented below.

The results of the emission inventory and vulnerability and adaptation assessment provide useful information on GHG emissions and natural resource conditions that should be reflected in the mitigation baseline scenario. The emission inventories will provide a current estimate of GHG emissions, an accounting procedure, and a format that can be helpful in preparing emission projections for future years. The vulnerability assessment will identify likely changes in agricultural, coastal, water, forests, and other resources in the future that will affect the baseline characteristics of these resources.

The inventory results will identify the sectors and sources that have the highest emissions and contributions to global warming or the degree of removal of gases by sinks. This information on the relative current importance of sources and sinks should be considered in determining the scope and emphasis of the mitigation assessment. In addition, the emission factors (and carbon uptake factors) developed and used in the inventory should be used in the mitigation assessment in evaluating the emissions or removals associated with different mitigation options. The results of the vulnerability assessment will identify possible changes in natural resource conditions and management practices that could affect the effectiveness of mitigation options. For instance, climate-induced changes in river basin flow may affect hydroelectric potential; changes in forest growth could affect the effectiveness of reforestation programs; and changes in agricultural productivity and production practices may alter strategies for reducing agricultural emissions.

The basic assumptions about population and economic growth and natural resource conditions used in the emission inventory and the vulnerability and adaptation assessment should be consistent with the assumptions used in the mitigation analysis. **[70]**

### V.11 National Metigation

Algeria’s mitigation strategy covers mainly energy, forests, housing, transport, industry and waste sectors. It is based in particular on the national programs for renewable energy and energy efficiency. This reflects its willingness to pursue its efforts in combating the adverse impacts of climate change. Such programs shall be pursued and sustained so long as Algeria benefits from international support in terms of new and external financial resources, and technology transfer, and capacity building.

Algeria’s contribution in mitigation is based on the three most important greenhouse gases: carbon dioxide gas (CO2), methane (CH4) and nitrous oxide (N2O).

At the meeting held on May 24th, 2015, under the chairmanship of His Excellency President of the Republic Mr. Abdelaziz BOUTEFLIKA, the Council of Ministers adopted the new national programs for renewable energy and energy efficiency.

These ambitious programs aim at reducing by 9% the global consumption of energy by 2030. It aims to engage thermal insulation of an important housing program, as well as to convert to LPG a million of light-duty vehicles and more than 20.000 buses.

By 2030, it aspires to the deployment, on a large scale, of photovoltaic and wind power as well as thermal solar energy, and the integration of cogeneration, biomass and geothermal energy. This program ultimately aims to reach the target that 27% of the electricity produced nationally is derived from renewable sources of energy.

In fact, Algeria, being the largest country in Africa, in the Mediterranean and in the Arab world, has one of the highest solar deposits in the world, estimated to exceed five billion GWh/yr. The annual sunshine duration is estimated to be around 2 500 hours on average, and could exceed 3 600 hours in some parts of the country.

In addition to its 200 thermal cities, Algeria, the tenth largest country in the world, has a geothermal reservoir composed of Albian groundwater, which extends over 700 000 km². **[70]**

The action plan of the government aspires also to reduce gas flaring to less than 1%, by 2030.

Regarding methane emissions reduction, Algeria intends to give priority to the management of household solid waste, with the objective to achieve, by 2030, a full coverage of wastes dumps in its territory.

Regarding carbon capture, the country aims to accelerate and intensify its National Reforestation Plan with a global objective of reforestation of 1 245 000 ha.

### V.11.1 The mitigation actions to be implemented by Algeria, planned for the 20212030 period, will lead to the following contribution:

Reduction of greenhouse gases emissions by 7% to 22%, by 2030, compared to a business as usual -BAU- scenario, conditional on external support in terms of finance, technology development and transfer, and capacity building. The 7% GHG reduction will be achieved with national means.

### V.11.2 The Algerian contribution regarding mitigation is defined as follows:

#### V.11.2.1 Type of INDC:

Relative reduction compared to Business as usual (BAU) scenario

#### V.11.2.2 Implementation period:

2021-2030

#### V.11.2.3 Methodological approach:

combined approach: Bottom-Up concerning sectors and Top-Down concerning national objectives.

#### V.11.2.4 Sectors covered:

Energy (Generation, Transport, Building and Industry); Industrial processes; Agriculture, Forests, Land use and Waste

#### V.11.2.5 Estimating GHG emissions:

Directives of IPCC -2006- and Global Warming Potential, as agreed in the IPCC 4th Assessment Report on Climate change.

#### V.11.2.6 Coverage of Greenhouse Gases:

Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O).

#### V.11.2.7 Global Warming Potential (GWP):

the used GWP are those of the IPCC 4th Assessment Report: GWP ($CO_2$) = 1, GWP ($CH_4$)= 25, GWP ($N_2O$)= 298.

**V.11.2.8 Implementation, monitoring and readjustment instruments:**

- National Climate Committee;
- National Climate Change Agency;
- National Climate Plan;
- National Actions Plan for Environment and Sustainable Development ;
- Legal framework;
- National system of Measurement, Reporting and Verification -MRV- (2016-2020).

**V.11.2.9 Main planned actions:**

Conditional on support in terms of external finance, technology development and transfer and capacity building.

Operate an energy transition and an economic diversification to achieve Algeria's sustainable development goals.

**V.11.2.9.1 Main Actions in Energy Sector:**

- Reach 27% of electricity generated from renewable sources of energy by 2030;
- Generalize high-performance lighting;
- Thermal insulation of buildings between 2021 and 2030;
- Increase the share of liquefied petroleum and natural gas in the consumption of
- fuels between 2021 and 2030;
- Reduce the volume of gas flaring to less than 1 % by 2030. **V.11.2.9.2 Main Actions in Waste Sector :**

- Waste valorization ;
- Composting organic waste and green waste;
- Energy recovery and recycling of methane from landfill sites and waste water o treatment plants

**V.11.2.9.3 Main Actions in forestry Sector:**

Afforestation, reforestation and prevention of forest fires as well as improving means to fight them.

**V.11.2.9.4 Awareness, Information and Education Actions:**

Information, awareness and communication on issues and climate change challenges and implementation of an education, training and research climate change national program.

### V.11.2.10 Considerations of fairness and ambition of the INDC based on national circumstances

- Algeria, as a low GHG emitting country, has already invested heavily in adaptation to climate change impacts as well as in mitigation and intends to pursue its efforts in this regard;
- Algeria has been participating since a long period of time in the greenhouse gas mitigation, by virtue of its high share of natural gas in its energy mix;
- The Algerian economy is highly dependent on petroleum export revenues. This situation makes Algeria vulnerable to climate change adverse effects, as well as to the negative impacts of response measures;
- Algeria faces significant and growing development and adaptation needs given its high population growth, increasing demand for energy, goods and services. **[70]**

### V.11.2.11 How INDC will contribute to the accomplishment of article 2 of the Convention on Climate Change

Through its mitigation actions for by 2030, considering its socio-economic development objectives, and taking into account its national circumstances, Algeria will contribute, on an equitable basis, to the achievement of the objective of article 2 of the Convention.

## CONCLUSION

The mitigation of greenhouse gases and specially carbon emissions is a long process , nevertheless it is essential if we are to get ourselves out of this crisis . In the following chapter we will discuss some new technologies and solutions developed for the purpose of mitigating the GHG gases.

# CHAPTER VI
# GREENHOUSE GASES MITIGATION TECHNOLOGIES

## INTRODUCTION

If we began to talk about industrial revolutions we're going back to the late 18$^{th}$ century in Britain, the first industrial revolution helped enable mass production by using water and steam power. A century later, the second industrial revolution introduced assembly lines and the use of oil, gas and electric power. In the middle of the 20th century, the third one added computers, advanced telecommunications and data analysis to manufacturing processes and we are now in the fourth industrial revolution, also referred to as Industry 4.0. Characterized by increasing automation and the employment of smart machines and smart factories, informed data helps to produce goods more efficiently and productively across the value chain. Flexibility is improved so that manufacturers can better meet customer demands using mass customization—ultimately seeking to achieve efficiency with, in many cases, a lot size of one. By collecting more data from the factory floor and combining that with other enterprise operational data, a smart factory can achieve information transparency and better decisions and it could be a key player in mitigating climate change and therefore reducing greenhouse gases.

After analyzing gases emission dispersion in the last chapter then discussing the environmental effects of this emissions and according to the bibliographic research in the early parts of this work; In this chapter we are going to propose techniques and some resolution that could help in environmental protection and gases emission mitigation.

### VI.1 6 Key Design Principles of an Industrial 4.0 (the smart factory)

The smart factory is the name given to the new revolutionary industries and each smart factory has functional requirements that each one should include or use, which emphasize what is possible today with existing technology, are based on six basic factory design principles; presented in the figure below and defined in appendice C .

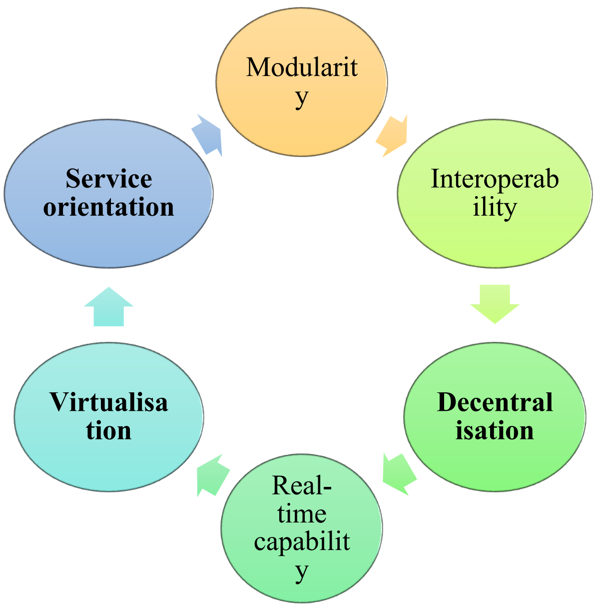



*Figure 1 Principal design keys for industry 4.0 [71]*

### VI.1.1 The industry 4.0 technologies and Triple Bottom Line Sustainability

There has been an increased awareness in society regarding the manufacturing industry and its impact on the environment. From a sustainability perspective, apart from profit-making, stakeholders and their interests were also given due importance resulting in several corporate social responsibility measures in the organizations. Sustainability has drawn global interest and attention because of its meaningful suggestions and solutions especially regarding the environment and changes in climatic conditions. Economic sustainability focuses on profit achievement; social sustainability aims at the advancement of mankind and society and environmental sustainability strives to preserve natural resources. All three interact and in order to avoid conflict, a progressive relationship is expected within the triple bottom line (TBL). In order to achieve sustainability, all three dimensions are crucial and it has to be included in the organizational strategy Industry 4.0 and sustainability, which are popular organizational trends that are vital to increasing sustainable production. Industry 4.0 technologies create a foundation to face the challenges arising from intense competition, fluctuating market demands, customizations, and the short span of the product life cycle, and contribute significantly to the sustainable development of the society. Industry 4.0 technologies include substantial contributions to organizational and social sustainable development. Economic aspects help to decrease set-up times, labor cost, lead times, and enhance organizational profit. From the environmental perspective, these technologies help to minimize energy consumption, minimize waste, increase energy savings, and encourage reuse and recycling. From a social sustainability perspective, digital and smart technologies protect the health and safety of workers by minimizing boredom and repetitive tasks, which motivates employees and increases their job satisfaction. In order to use the resources efficiently, organizations should adopt environmentally-friendly industry 4.0 technologies for sustainable production practices. **[71]**

## VI.2 Carbone Capture Storage and Utilization (CCUS) Definition and Purpose

Carbon capture, utilization and storage (CCUS), also referred to as carbon capture, utilization and sequestration, is a process that captures carbon dioxide emissions from sources like coal-fired power plants and either reuses or stores it so it will not enter the atmosphere. Carbon dioxide storage in geologic formations includes oil and gas reservoirs, unmineable coal seams and deep saline reservoirs -- structures that have stored crude oil, natural gas, brine and carbon dioxide over millions of years .**[72]**

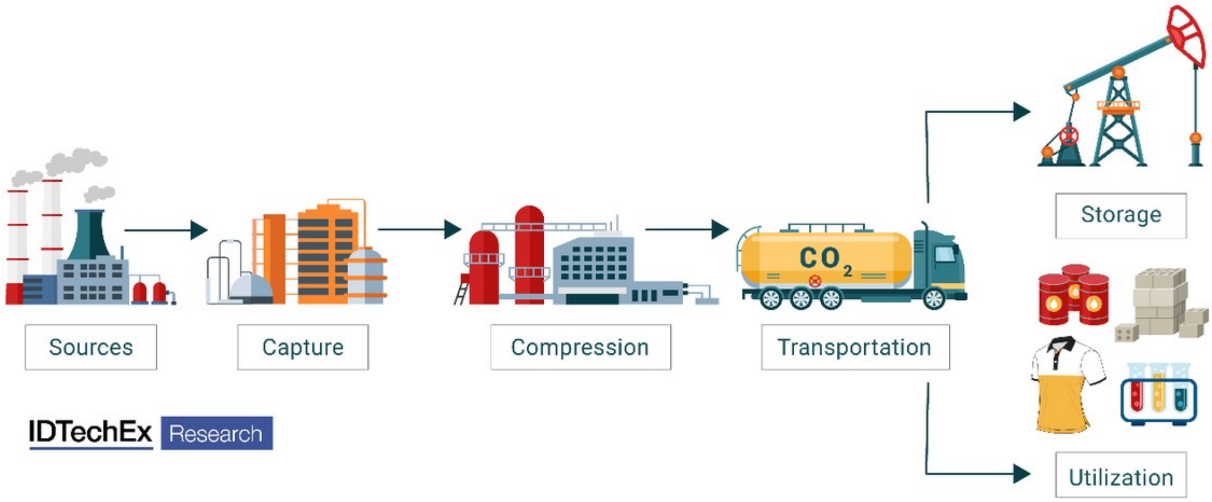



*Figure 2 carbon capture process* ***[72]***

### VI.1 Carbon Capture Main Steps

CCUS involves three major steps; capturing CO2 at the source, compressing it for transportation and then injecting it deep into a rock formation at a carefully selected and safe site, where it is permanently stored.

a) **Capture:** The separation of CO2 from other gases produced at large industrial process facilities such as coal and natural-gas-fired power plants, steel mills, cement plants and refineries.

b) **Transport:** Once separated, the CO2 is compressed and transported via pipelines, trucks, ships or other methods to a suitable site for geological storage.

c) **Storage:** CO2 is injected into deep underground rock formations, usually at depths of one kilometer or more.

### VI.2 Carbon Capture Principle

A fossil fuel power plant generates power by burning fossil fuel (coal, oil or natural gas), which generates heat that turns into steam. That steam turns a turbine connected to an electricity generator. Another word for the burning process is combustion, this results in the emission of CO2 as a by-product. In systems where the coal is pulverised to a powder, which makes up the vast majority of coal-based power plants through North America, Europe and China, the CO2 must be separated at diluted concentrations from the balance of the combustion flue gases. In other systems, such as coal gasification (where coal is converted to chemicals, natural gas or liquids), the CO2 can be more easily separated. There are three basic types of CO2 capture: pre-combustion, post-combustion and oxyfuel. **[72]**

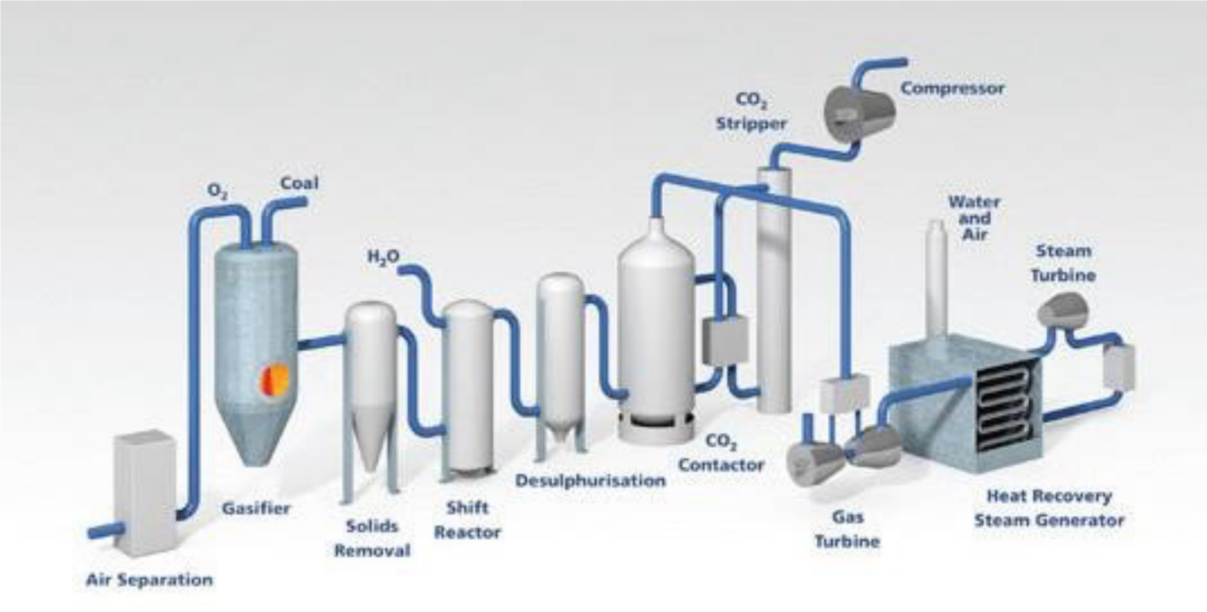



*Figure 3Carbon Capture Principle* ***[72]***

### VI.2.1 Pre-combustion

With precombustion carbon capture, carbon is trapped and removed from fossil fuels before the combustion process ends. Coal, oil or natural gas is heated in steam and oxygen, resulting in a synthesis gas, or syngas. The gas mostly contains CO2, hydrogen (H2), and carbon monoxide (CO). Later, a separate reaction converts water (H2O) into hydrogen. While that's going on, some of the carbon monoxide is transformed into carbon dioxide. The end result is a gas mixture loaded with H2 and CO2

It's easy to isolate, capture and sequester the CO2 from that mix. Meanwhile, engineers can use the hydrogen for other energy production processes.

Precombustion carbon capture is usually more efficient than the postcombustion strategy. However, the equipment comes with a higher price tag. Besides, older power plants tend to be less suited for this technique than some new ones

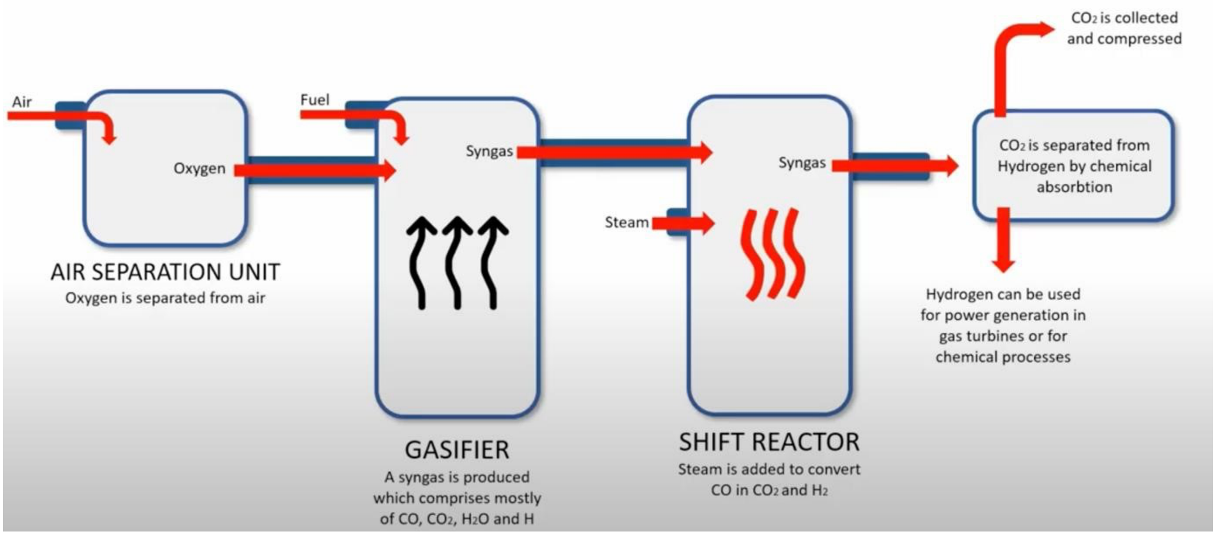



*Figure 4 pre-combustion carbon capture* ***[72]***

### VI.2.2 Post-combustion

With post-combustion carbon capture, the CO2 is grabbed after the fossil fuel is burned. The burning of fossil fuels produces something called flue gases, which include CO2, water vapor, nitrogen and sulfur dioxide. Post-combustion processes separate CO2 from combustion exhaust gases. CO2 can be captured using a liquid solvent or other separation methods. In an absorption-based approach, once absorbed by the solvent, the CO2 is released by heating to form a high purity CO2 stream. This technology is widely used to capture CO2 for use in the food and beverage industry.

In a post-combustion process, CO2 is separated and captured from the flue gases that result from the combustion of fossil fuel. CO2 can be captured using a liquid solvent or other separation methods. In an absorption-based approach, once absorbed by the solvent, the CO2 is released by heating to form a high purity CO2 stream. This technology is widely used to capture CO2 for use in the food and beverage industry.

This process is the most commonly used technique in carbon-capture technology. It's a convenient strategy because it can be deployed at both new and preexisting coal-fired power plants. However, there are some drawbacks. In order to work, post-combustion carbon capture requires some physically large equipment — and it can make turbines less efficient.

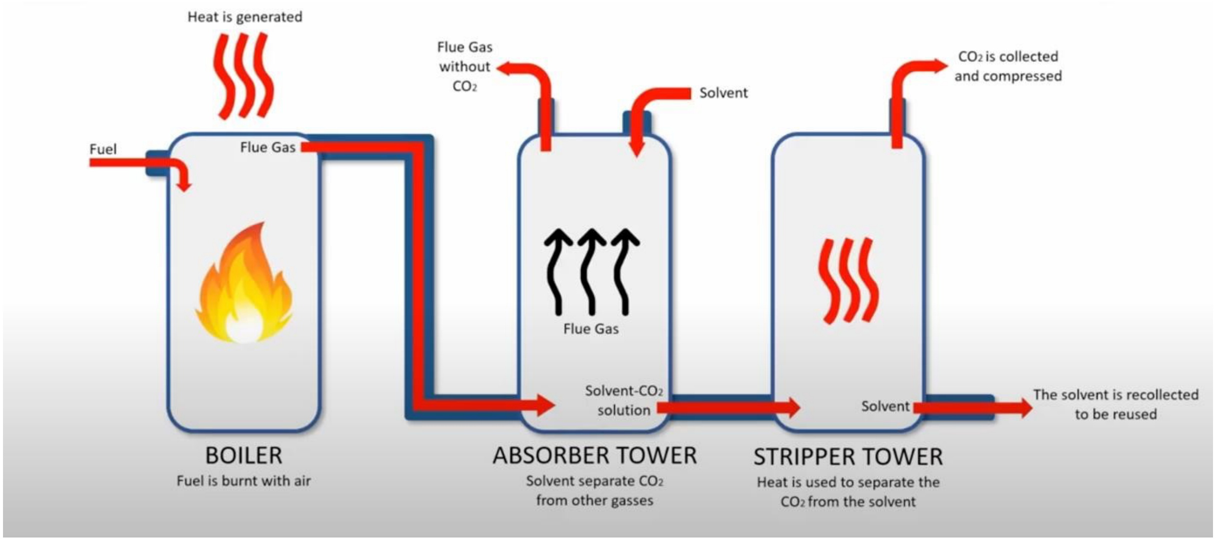



*Figure 5 post-combustion carbon capture* ***[72]***

### VI.2.3 Oxy-fuel combustion

With oxy-fuel combustion carbon capture, the power plant burns fossil fuels — but not in ordinary air. Instead, the fuels are burned in a gas mixture containing lots and lots of pure oxygen. This results in a flue gas whose two main components are CO2 and water. Afterward, it's possible to separate out the CO2 by compressing and cooling the water

Certain aspects of oxy-fuel combustion carbon capture are inexpensive, but the process has a high cost overall. (Pure oxygen isn't cheap.) Also, there are some concerns about its applicability. A 2020 review published in the journal Catalysts argued that the relevant technology "needs to be proved for large scale operations" On the positive side, oxy-fuel combustion capture can be used at both old and new coal-burning power plants

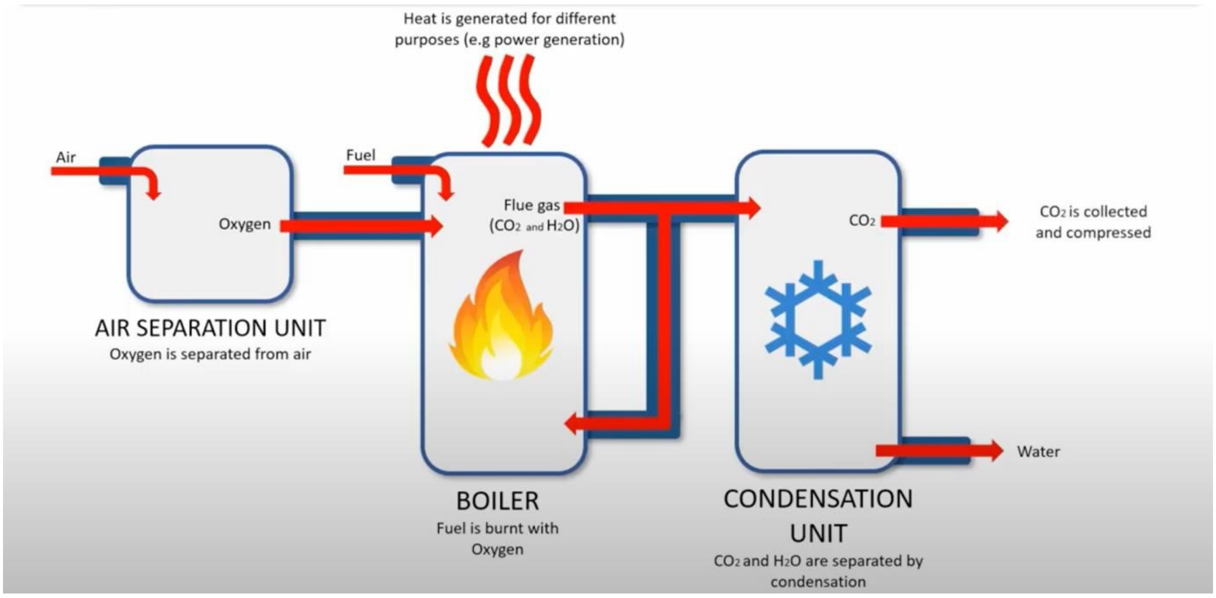



*Figure 6 oxy-fuel-combustion carbon capture* ***[72]***

*Table 1 advantages and disadvantages of each process*

| Process | Advantages | Disadvantages |
|---|---|---|
| **Pre-combustion** | Allows to capture about 90% of $CO_2$.<br>Shift reactor can be omitted to save considerably on initial investment: yet this leads to limited capture efficiency , only 18-30% | -High capital investment.<br>-Needs to be built simultaneously with the facility.<br>-Cannot be retrofitted to old coal power plants. |
| **Post-combustion** | -Allows to capture 90% of $CO_2$.<br>-Highest degree of purity in the $CO_2$ captured.<br>-Does not require fundamental changes to the processes of power plants and industrial plants. | -High capital investment.<br>-Energy penalty: generally higher than 30%.<br>-Electricity unit generation cost can be increased by up to 140% in coal-fired plants and 60% in gas-fired plants |
| **Oxy-fuel combustion** | -Low emission of nitrogen oxides.<br>-No need for major chemical processes.<br>Allows to capture up to 100% of $CO_2$ . | -Very High investment.<br>-Air separation unit very energy intensive.<br>-Retrofitting to old plants can be very difficult and expensive . |

### VI.3 Carbon capture and storage (CCS)

Nowadays, with this technology we can permanently store huge amounts of $CO_2$, which makes it an essential part of climate action worldwide. The technology also has the potential to create "negative emissions", which is actually a good thing.

CCS is a key tool for reducing emissions from industries, such as cement, steel, chemicals and fertilisers. These industries create $CO_2$ as part of their processes and for thermal energy (heat) generation. CCS is currently the only technology that can realistically reduce process emissions and those from high temperature generation by mid-century at scale.

$CO_2$ capture works by separating the greenhouse gas from the exhaust gases of industrial processes. This separation can be achieved through the use of $CO_2$-absorbing chemicals, pressure changes or membrane filters. Capturing $CO_2$ also uses energy and investments in the technology are quite considerable, but work is ongoing by companies, universities and research institutes to reduce this energy use and the costs associated with capture technologies. New innovative industrial processes are tying $CO_2$ separation and capture into the heart of industrial manufacturing, thereby cutting costs and increasing efficiency. **[72]**

### VI.3.1 CO2 transport

As a gas, $CO_2$ is commonly transported by steel pipeline, similar to how we transport the natural gas used to heat our homes. $CO_2$ can also be transported by truck, train or ship. In this case, the $CO_2$ is cooled and compressed into liquid form to take up less space and allowing more to be transported in each batch. Most people are familiar with $CO_2$ as an ingredient in fizzy drinks, and $CO_2$ is already being transported across Europe for various uses. Since most of Europe's emitters are clustered in industrial hubs close to major transport waterways, an efficient and flexible way of transporting $CO_2$ from source to offshore storage site is by ship and river barge. Existing oil and gas industry infrastructure facing decommissioning can even be repurposed to transport $CO_2$ to geological storage sites.

Pipelines have been in use for decades, and large volumes of gases, oil and water flow through pipelines every day. Carbon dioxide pipelines are an existing part of the infrastructure in the U.S. and many other countries. In fact, there are now more than 4,039 miles (6,500 kilometers) of $CO_2$ pipelines distributed across Africa, Australia, the Middle East and North America. Most were created for a process called Enhanced Oil Recovery (EOR), but some are connected to CCS projects

Pipelines may be connected to processing plants or power plants that rely on fossil fuels, as well as natural sources of $CO_2$. The purity of a line's $CO_2$ supply may be affected by the kinds of technology used at its source

In some cases, the $CO_2$ might travel as far as it can in the pipe, then transition to a tanker truck, tanker ship or pressurized cylinders to finish its journey. Note that there's an asphyxiation risk if a massive amount of $CO_2$ escapes into the atmosphere. As with tanks that transport natural gas and other hazardous materials, good construction is key. That, and good driving.

The transport of $CO_2$ can be done in three states: gaseous, liquid and solid. Solid $CO_2$ is commonly known as dry ice, and it's not cost-effective to transport $CO_2$ as a solid.

Pipelines commonly transport carbon dioxide in its gaseous state. Said gas needs to be compressed before it's moved from Point A to Point B. According to the Canadian National Energy Technology Laboratory, the ideal pressure range is between 1500 and 2200 PSI (or 10,342 and 15,168 KPA). Engineers must be on guard against impurities in the $CO_2$ stream, like hydrogen sulfide and water. The latter has been known to corrode pipelines, but that's just the tip of the iceberg. Under high pressure and low temperatures, the water in these pipes may form natural-gas hydrates, solid crystals that can clog up your lines. Scientists are still devising ways to handle such impurities

In the world of construction, safety is a top priority. If a pipe ruptures near a populated area, the sudden release of $CO_2$ gas in large quantities could have serious repercussions for both the public health and the environment. To keep industrial digging equipment from accidentally striking the pipes, planners can bury them deep underground. Also, when possible, laying pipelines down far away from cities, towns and the like might be advisable

Det Norske Veritas (DNV), a prominent risk management and quality assurance company based in Norway, released new safety procedures for CO2 transport pipelines in 2021. Meanwhile, the United Kingdom's Health and Safety Executive now has an extensive list of guidelines covering everything from corrosion to land usage.

Pipeline costs fluctuate depending on the route of the pipeline (through heavily congested areas, mountains, offshore); the quality of the materials; the equipment involved; how much labor is required; and other expenses. **[73]**

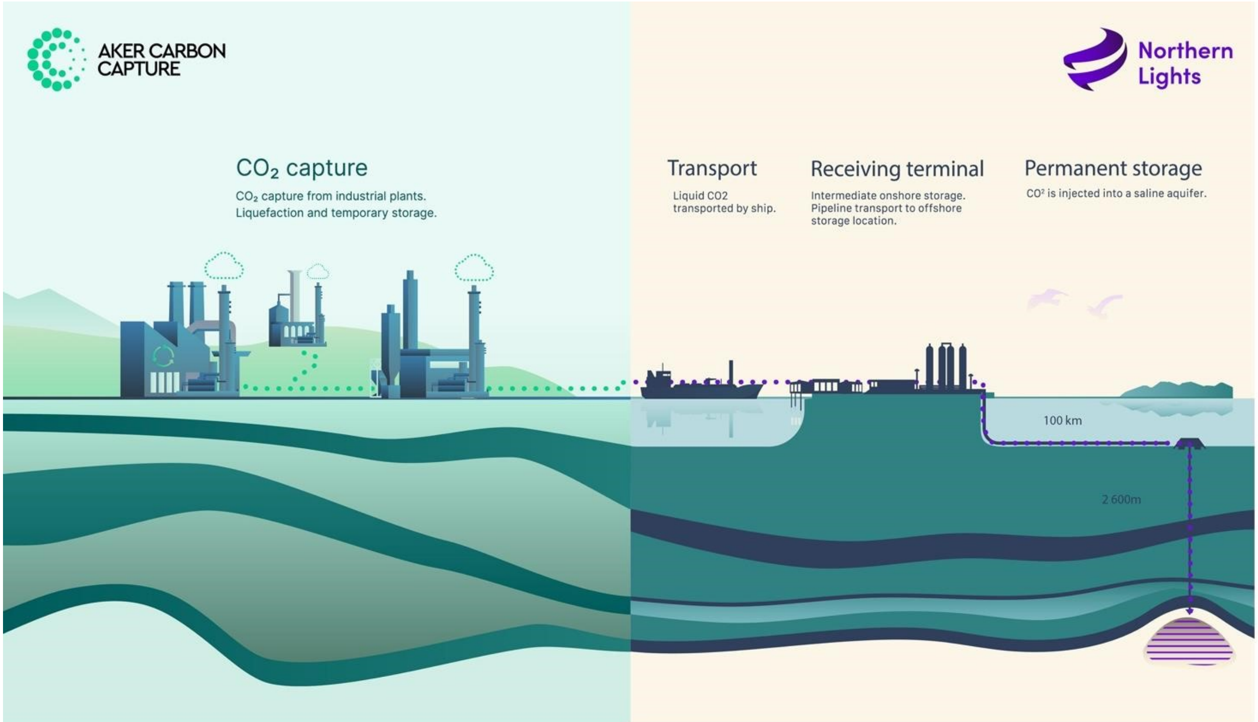



*Figure 7 Carbon transport[73]*

### VI.3.2 CO2 storage

Takes place in porous and permeable rock layers at a depth of several thousand metres. The storage sites are located beneath a non-permeable barrier rock that prevents the CO2 from expanding upwards. Wells, akin to those used for oil and gas production, are accurately drilled to access the porous layers through which the CO2 is injected. Once injection has finished, the well is removed and ‘plugged’ using cement, which prevents the CO2 from escaping. The CO2 eventually binds with the surrounding salty water molecules and remains stored between impermeable layers of rock indefinitely.

The potential for CO2 storage is greatest in offshore saline aquifers and depleted oil and gas fields. Effectively, this represents a return of carbon into formations from where carbon-intensive fossil fuels had been extracted before. In fact, there's research that suggests the

United States alone has enough subsurface space to potentially hold 1.8 trillion tons (1.71 trillion metric tons) of carbon dioxide in deep aquifers, permeable rocks and other such places

The logistics of underground storage, deep underground, CO2 can be kept at pressures of over 1,057 PSI (72.9 atm) and at temperatures above 88 degrees Fahrenheit (31.1 degrees Celsius). When those specific conditions are met, CO2 becomes supercritical. In that state, carbon dioxide takes on properties normally associated with both gases and liquids. Supercritical CO2 has a low viscosity, just like a gas. But at the same time, it's also got the high density of a liquid

Because it can seep into the spaces in porous rocks, a great amount of CO2 can be stored in a relatively small area. Oil and gas reservoirs are well suited to store CO2 as they consist of layers of porous rock formations that have trapped oil and gas for years [source: Center for Science Education]. **[73]**

CO2 is artificially injected into underground rock formations below the earth's surface. These natural reservoirs have overlying rocks that form a seal, keeping the gas contained

Basaltic rock formations also make attractive CO2 storage spots. Volcanic in origin, basalt is one of the most common types of rock in the Earth's crust. Researchers have found that when CO2 reacts with the magnesium and calcium basalt naturally contains, it can be transformed into solid minerals, specifically dolomite, calcite and magnesite [source: Cartier]. Then we have coal deposits. Sometimes, the ones that have been written off as "unmineable" can hold very large quantities of captured CO2. Inside, it's possible to store the gas at lower pressures and thereby save money

In addition to underground storage, scientists are also looking at the ocean for permanent CO2 storage. Historically, there's been a lot of discussion about potentially dumping CO2 straight into the ocean at depths greater than 9,842 feet (3,000 meters). That far below the surface, carbon dioxide is actually denser than water. So hopefully, the dumped CO2 would be trapped in place for some time [source: Center for Science Education]. Ocean carbon storage is largely untested, and there are many concerns about the safety of marine life and the possibility that the carbon dioxide would eventually make its way back into the environment.

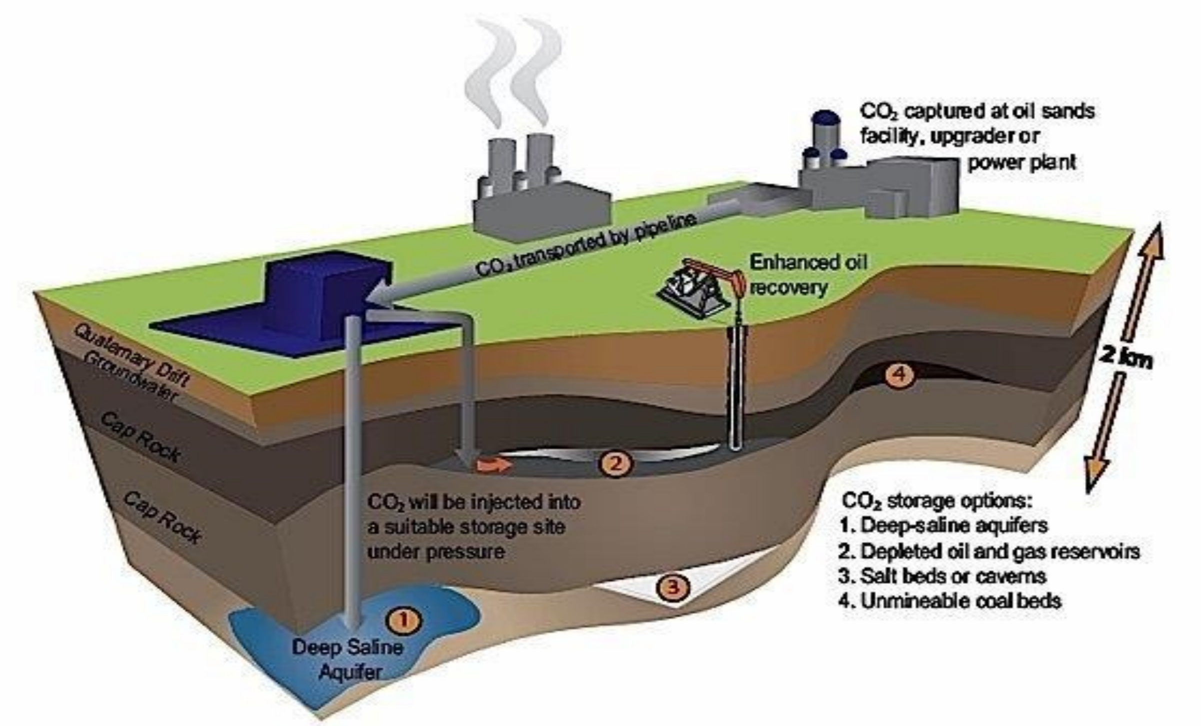



*Figure 8 Carbon storage* ***[74]***

### VI.4 Carbon capture and utilization (CCU)

The captured CO2 is used to make useful substances or products with an economic value. However, as a non-reactive (inert) molecule, CO2 has limited use on its own and cannot be used to produce energy. Generally speaking, a lot of energy is needed to convert CO2 into useful products, which can also lead to more or fewer CO2 emissions, depending on where the energy comes from.

Several technologies are currently in use or being developed, including those to make plastics, concrete, chemical reactants and synthetic fuels. In order for CCU processes and products to have a climate benefit in line with the Paris Agreement and be climate neutral, two aspects need to be considered.

Firstly, the carbon footprint of the required electricity needs to be zero so CCU should only be run with climate-neutral energy sources. Secondly, it is important that CO2 is kept away from the atmosphere for as long as possible, if the CO2 cannot be circulated. If the final product re-emits CO2 at “end of life” (e.g. plastics, fuels), then the the CO2 must be captured from the air through biogenic processes or direct air capture. In this case, the carbon moves in a circle to ensure the CCU chain approximates carbon neutrality.

While climate-neutral CCU processes cannot lock away the volumes associated with large-scale geological CO2 storage, it can form part of a low-carbon economy by reducing the carbon footprint for products. Decoupled from the climate discussion, CO2 represents a new carbon source for the process industries that can substitute fossil carbon. **[73]**

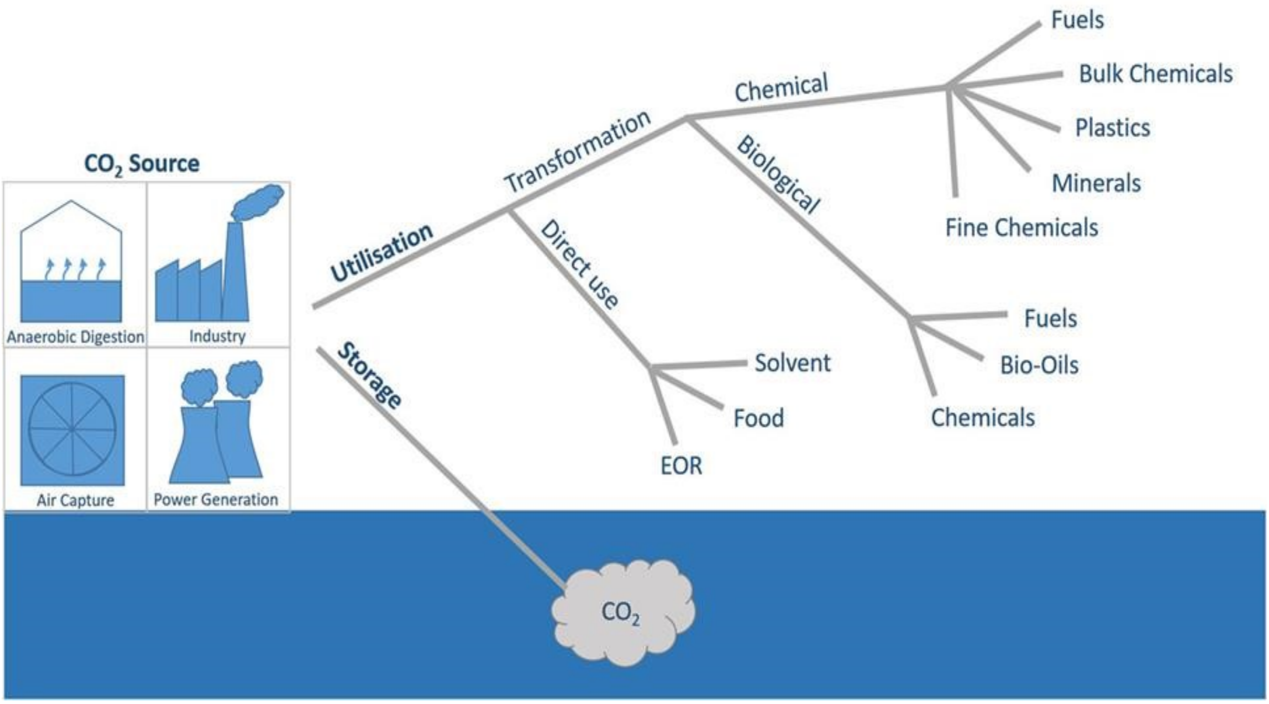



*Figure 9 Carbon CCU processes [73]*

### VI.5 Carbon Capture and Climate Change

Carbon capture and storage (CCS) is one of the most important technological solutions that can contribute to a significant reduction in emissions from industrial operations based on coal or gas power, keeping CO2 out of the atmosphere that would otherwise worsen climate change.

Technology development within bioenergy with carbon capture and storage (BECCS) can make it a negative emissions technology. By extracting bioenergy from biomass and capturing and storing the carbon, historic CO2 emissions can be removed from the atmosphere. **[73**

### VI.6 Climate and energy scientists on CCS

The International Energy Agency says that billions of tonnes of CO2 need to be stored every year to reach the UN climate goals. It's also one of the key measures that the Intergovernmental Panel on Climate Change regards as necessary to keep global warming to 1.5 degrees Celsius. CCS is recognized as an important, proven technology for reducing greenhouse gas emissions around the world. **[74]**

### VI.7 CCUS Facilities Worldwide

The industry and fuel transformation sectors currently have just under 30 commercial CCUS facilities in operation, with a growing pipeline of projects in development. Many planned projects target industrial hubs and low-carbon hydrogen production, and if all were to proceed, CO2 capture capacity from industry and fuel transformation would almost quadruple.

Although **a** more inviting investment environment and net zero goals are raising interest in CCUS, its deployment remains woefully below the level required in the Net Zero Emissions by 2050 Scenario. Targeted support for lower-cost and less complex industrial CCUS applications, along with greater investment in CO2 transport and storage infrastructure, could unlock significant near-term emissions reductions. **[73**

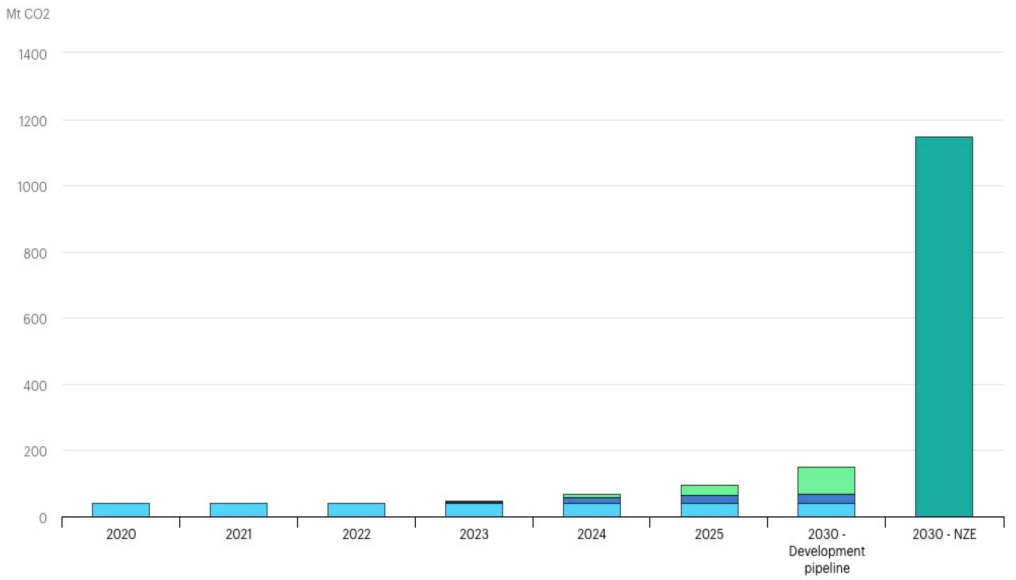



*Figure 10 Large-scale CO2 capture projects in industry and transformation, actual vs. Net Zero Scenario, 2020-2030[74]*

### VI.8 CCUS facilities currently capture close to 40 Mt CO2 annually in industry and fuel transformation

With the two Alberta Carbon Trunk Line projects that came online in Canada in 2020, there are now just under 30 commercial CCUS projects in industry and fuel transformation (with capture capacity greater than 100 000 tCO2 per year). These projects capture CO2 from fertilizer production (0.5 Mt CO2 per year) and oil refining (1.3 Mt CO2 per year). The commercial projects operating today have an annual capture capacity of around 40 Mt CO2. In 2019, the Gorgon CO2 injection project was launched in Australia, with capacity to capture up to 4 Mt CO2 per year from natural gas processing at the Gorgon LNG plant. Additionally, the 2 Mt CO2 per year capture facility at the Qatar LNG natural gas processing plant started operations in 2019.

In 2018, the 0.6Mt CO2 per year CNPC Jilin Oil Field CO2 enhanced oil recovery project started commercial operations in China, also capturing CO2 from a natural gas processing plant. **[73**

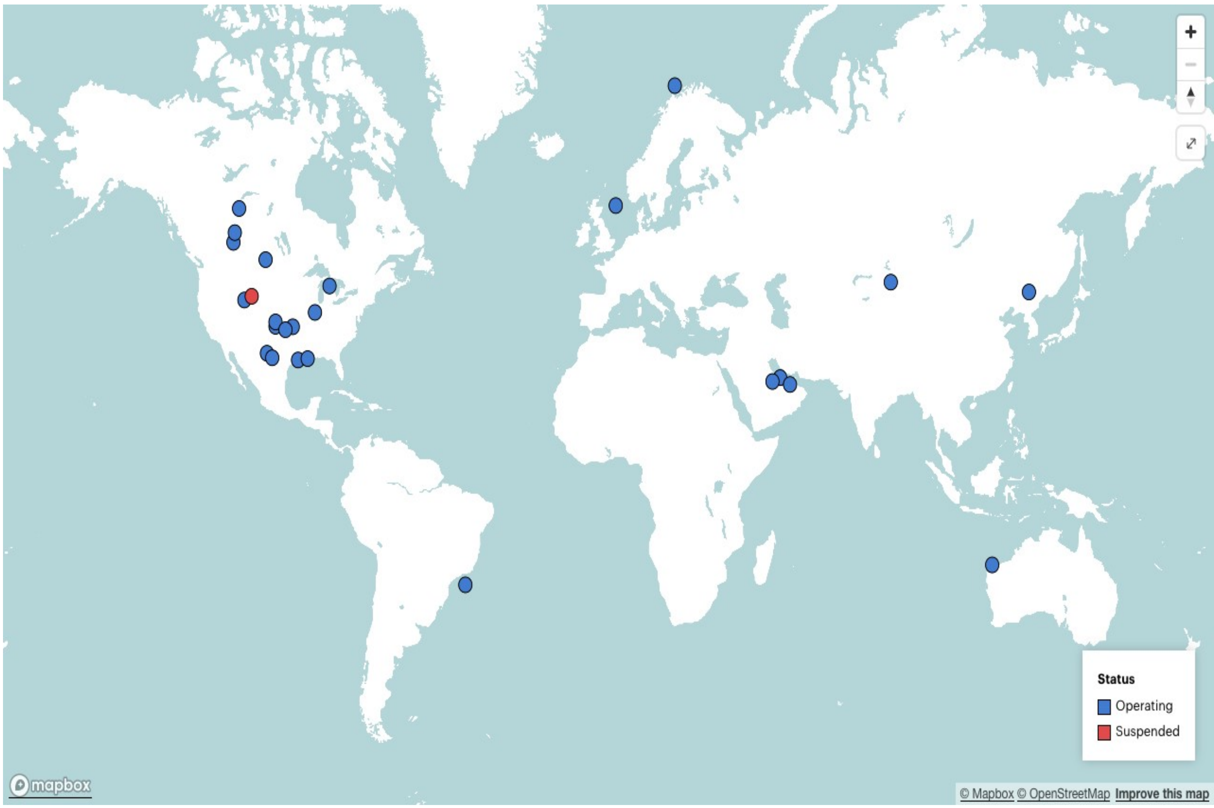



*Figure 11 Operating CO2 capture projects in industry and fuel transformation [74]*

**VI.9 Momentum for CCUS is growing in all industrial sectors and region**

Climate goals and a more attractive investment environment have spurred plans for over 120 new industrial CCUS projects (including industrial hubs) in recent years. Projects in planning cover an increasingly diverse mix of applications and regions globally.

In China, the Sinopec Qilu Petrochemical project, currently under construction, will capture up to 1 Mt CO2 per year from Qilu's refineries for transport and use in enhanced oil recovery in central China's Ordos Basin. In September 2021, China also launched its first offshore CCUS project.

In Europe, an improved investment environment has helped increase the number of CCUS projects under development, particularly in the form of industrial hubs to mutualize the costs of CO2 transport and storage infrastructure. In Norway, construction is under way on the world's first application of CCUS at a cement facility (Norcem's Brevik plant).

As part of the same project (Longship), an Equinor, Shell and Total partnership is developing offshore CO2 storage in the North Sea ,the Northern Lights project, to support Norway's plans for a fully integrated industrial project. Northern Lights will provide CO2 transport and storage infrastructure for multiple industrial hubs located around the North Sea.

Further projects under development in Europe include the Porthos and Aramis projects in the Netherlands. In the United Kingdom, East Coast Cluster and HyNet were selected out of five proposed industrial clusters (eligible clusters also included Scottish Cluster, DelpHYnus, and V Net Zero) for the GBP 1 billion (USD 1.4 billion) CCS Infrastructure Fund. Several of these clusters are developing CCUS infrastructure for lowcarbon hydrogen production, and an industrial CCUS hub is also planned for Ireland (Ervia).

In the United States, close to 50 new carbon capture projects in the industry and fuel transformation sectors were announced between January 2020 and August 2021. These projects could benefit from the 45Q tax credit and other complementary policies, including the California Low Carbon Fuel Standard. If all proceed, they will more than double US industrial CCUS capacity, and close to double global industrial CCUS capacity.

Interest in industrial CCUS is also increasing in Southeast Asia, with four projects announced in 2020-2021. In Indonesia, Repsol could be capturing up to 2 Mt $CO_2$ per year at the Sakakemang gas platform by 2027, while the Indonesian oil and gas regulator recently approved a CCUS project at the Tangguh LNG terminal. In Malaysia, Petronas is assessing

$CO_2$ capture and geological storage at the Kasawari gas platform, with plans to capture over 4 Mt $CO_2$ per year by 2025.

Importantly, the adoption of economy-wide decarbonization targets for 2050 is stimulating greater CCUS project diversity for industrial applications. While natural gas processing makes up three-quarters of operating industrial CCUS capacity, roughly 50% of projects under development are dedicated to hydrogen and biofuel production. CCUS deployment in iron, steel and cement facilities is also increasing, totalling 8% of the development pipeline. **[74]**

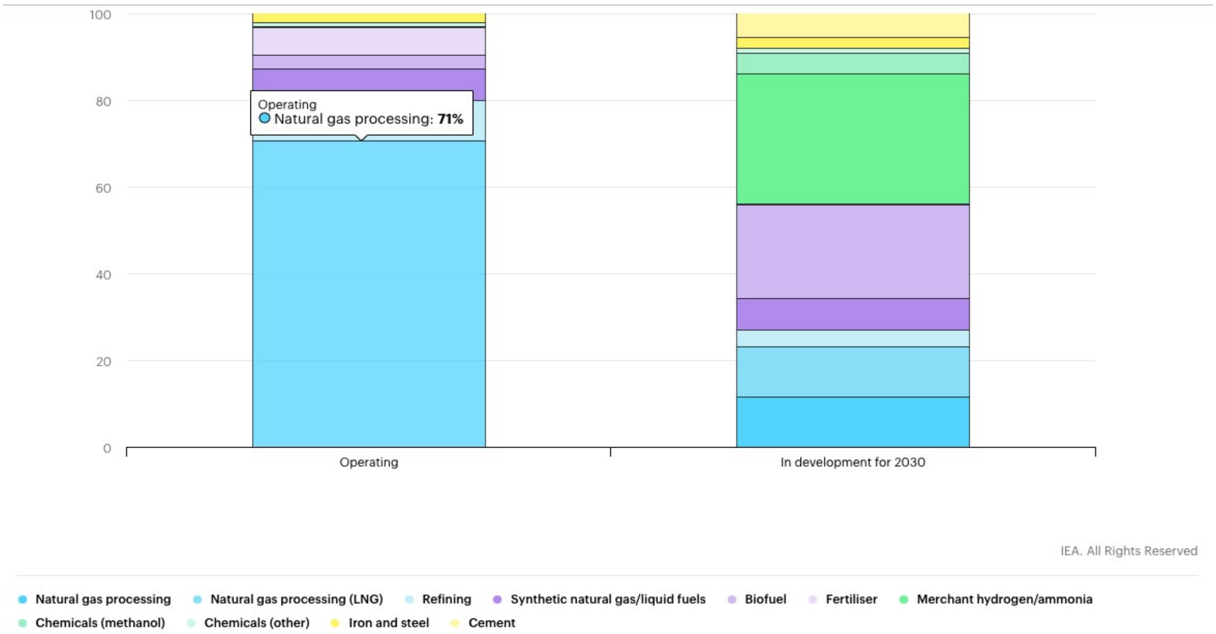



*Figure 12 Capacity of $CO_2$ capture projects in operation and under development in the industry and fuel transformation sectors by application[74]*

### VI.10 Net zero targets drive new momentum for CCUS

Strengthened climate goals and new investment incentives are delivering unprecedented momentum for CCUS, with plans for more than 100 new facilities announced in 2021. CCUS technologies will play an important role in meeting net zero targets, including as one of few solutions to tackle emissions from heavy industry and to remove carbon from the atmosphere. Although recent progress is encouraging, the planned pipeline of projects would fall well short of delivering the 1.7 billion tonnes of CO2 capture capacity deployed by 2030 in the Net Zero by 2050 scenario. **[74]**

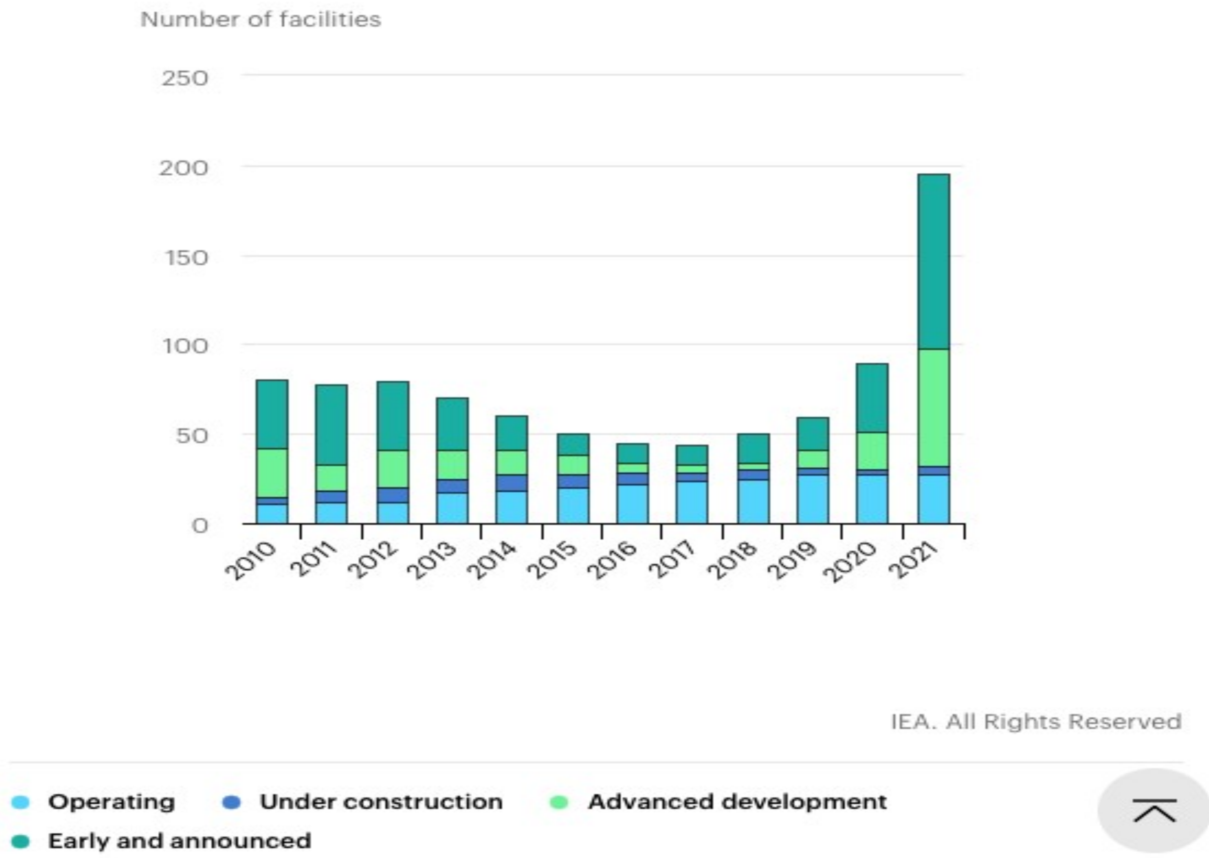



*Figure 13Global pipeline of commercial CCUS facilities operating and in development, 2010-2021[74]*

### VI.11 Direct Air Capture

#### VI.11.1 Direct Air Capture Principle

Direct Air Capture is a technology that captures carbon dioxide directly from the air with an engineered, mechanical system.

The Direct Air Capture (DAC) technology does this by pulling in atmospheric air, then through a series of chemical reactions, extracts the carbon dioxide (CO2) from it while returning the rest of the air to the environment. This is what plants and trees do every day as they photosynthesize, except Direct Air Capture technology does it much faster, with a smaller land footprint, and delivers the carbon dioxide in a pure, compressed form that can then be stored underground or reused. **[74]**

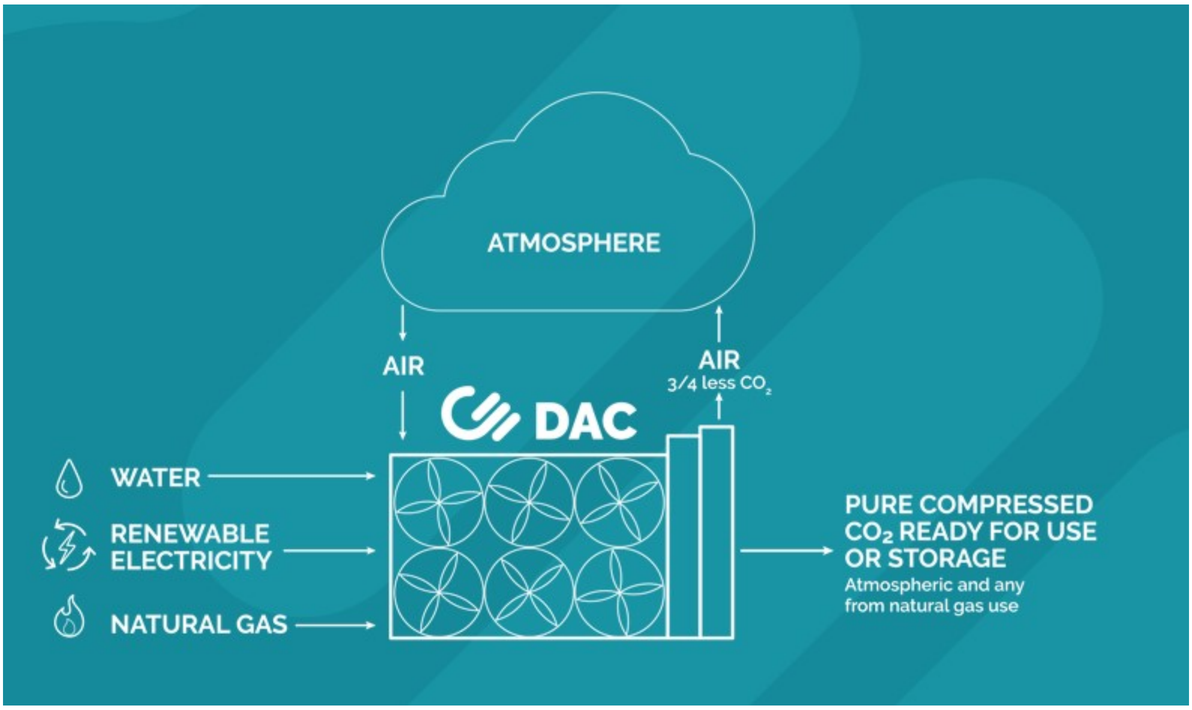



*Figure 14 Carbon direct air capture process[74]*

### VI.11.2 How DAC Works

The Direct Air Capture technology has been designed to continuously capture CO2 from atmospheric air and deliver it as a purified, compressed gas for use or storage.

The Direct Air Capture technology has four major pieces of equipment that each have industrial precedent and have been widely used in large-scale industries for years. This is how this technology is capable of achieving megaton scale with low scale-up risk and improved cost estimations.

The process starts with an air contactor; a large structure modelled off industrial cooling towers. A giant fan pulls air into this structure, where it passes over thin plastic surfaces that have potassium hydroxide solution flowing over them. This non-toxic solution chemically binds with the CO2 molecules, removing them from the air and trapping them in the liquid solution as a carbonate salt.

The CO2 contained in this carbonate solution is then put through a series of chemical processes to increase its concentration, purify and compress it, so it can be delivered in gas form ready for use or storage. This involves separating the salt out from solution into small pellets in a structure called a pellet reactor, which was adapted from water treatment technology. These pellets are then heated in the third step, a calciner, in order to release the CO2 in pure gas form. The calciner is similar to equipment that’s used at very large scale in mining for ore processing. This step also leaves behind processed pellets that are hydrated in a slaker and recycled back into the system to reproduce the original capture chemical.

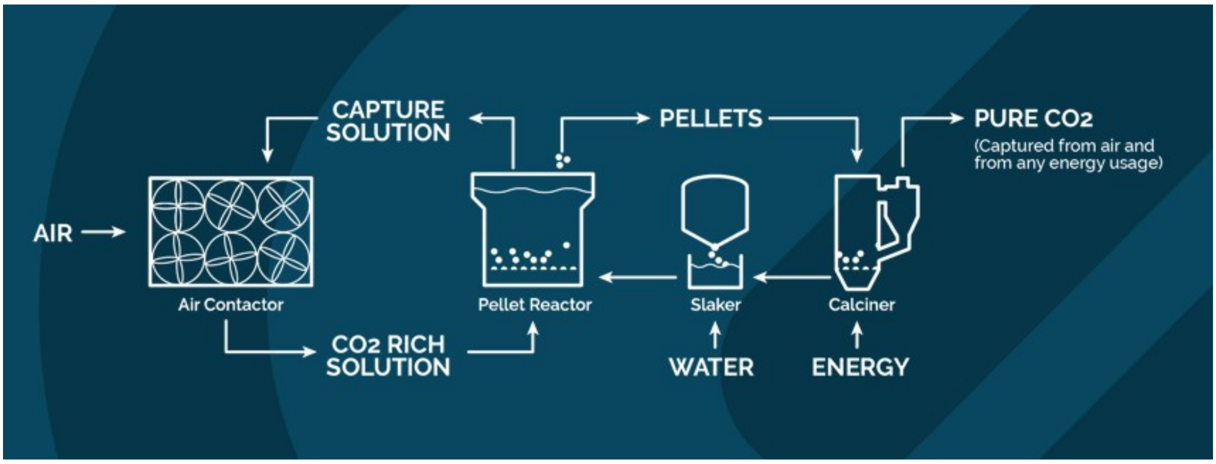



*Figure 15 pellet process for direct air capture [74]*

There are currently 19 direct air capture (DAC) plants operating worldwide, capturing more than 0.01 Mt CO2/year and a 1Mt CO2/year capture plant is in advanced development in the United States. The latest plant to come online, in September 2021, is capturing 4 kt CO2/year for storage in basalt formations in Iceland. In the Net Zero Emissions by 2050 Scenario, DAC is scaled up to capture more than 85 Mt CO2/year by

2030 and ~980 Mt CO2/year by 2050. This level of deployment will require several more large-scale demonstrations to refine the technology and reduce capture costs.

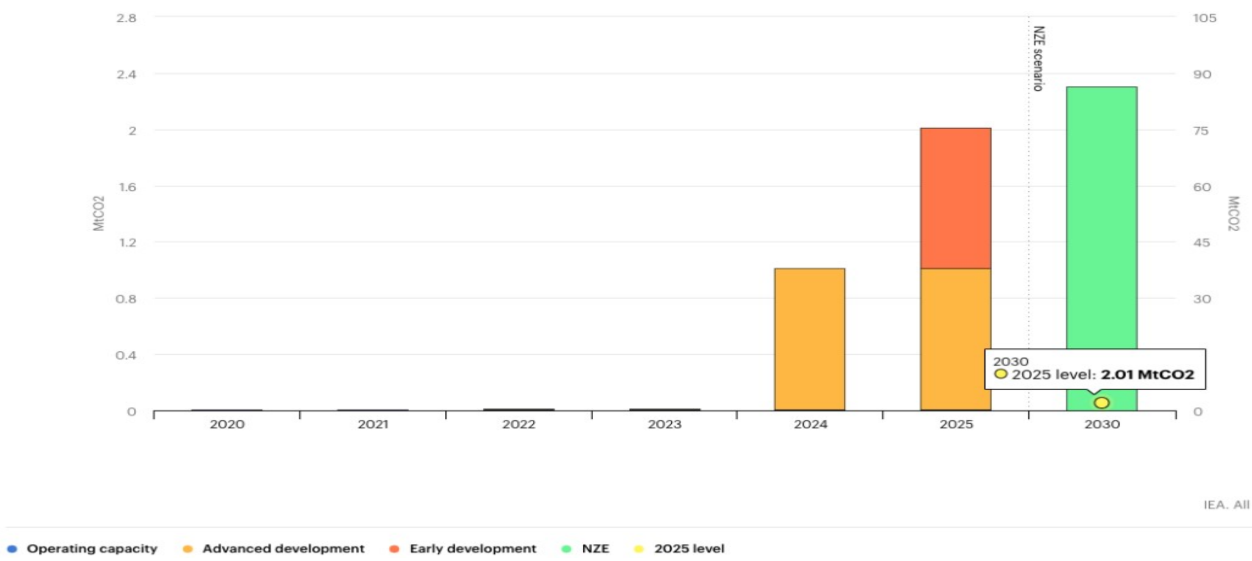



*Figure 16 Direct air capture rate [74]*

### VI.12 The difference between CCS and DAC

CCS is a technology that helps to reduce emissions at the point source because it prevents new fossil $CO_2$ from entering the atmosphere. DAC+S, on the other hand, is a technology that goes beyond reducing: it removes carbon dioxide from the air, which produces so-called negative emissions

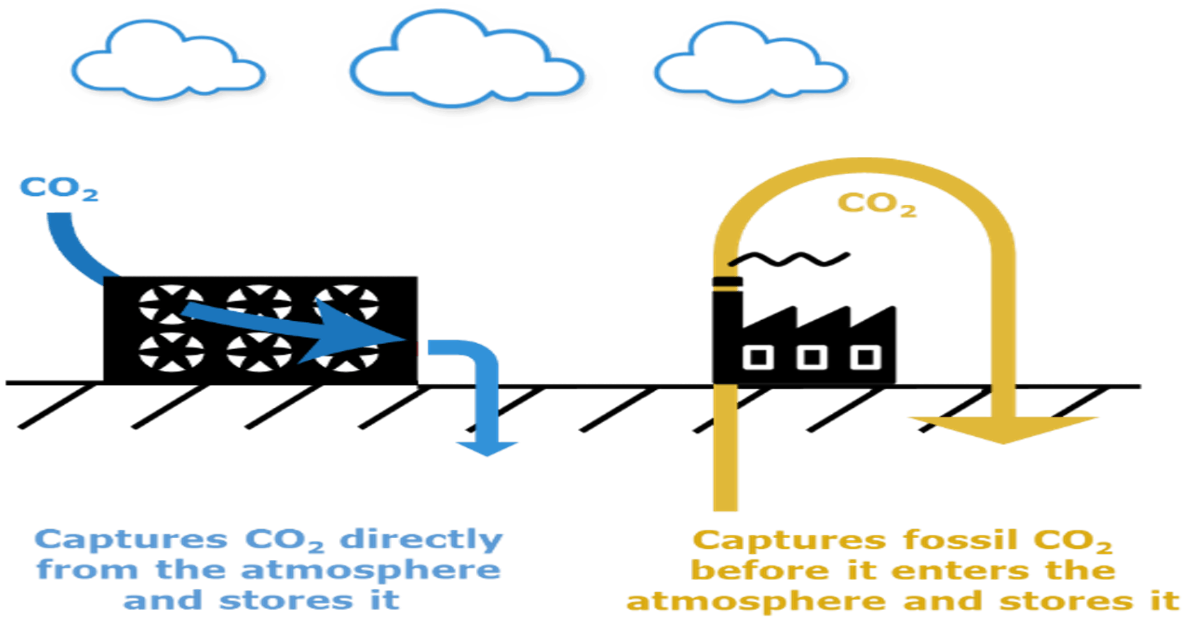



*Figure 17 The deference between carbon capture and direct air capture [74]*

**VI.13 Trees and carbon capture**

Trees are definitely our allies in the crusade against global warming and climate change. Photosynthesis allows them to absorb and store carbon dioxide, so the plants act a bit like all-natural CCS devices. Unfortunately, scientists say there's no way to plant enough trees to counteract all the excess CO2 we've pumped into our atmosphere by burning fossil fuels. Besides, older forests populated by a variety of tree species are better at locking CO2 away than younger, more homogeneous ones.

Other Solutions

**VI.14 Other Solutions**

Wild fires and coral bleaching are caused by us overstepping the climate boundary. In addition, we were destroying nature, our ecosystems; we have been doing very aggressive agricultural practices. we were doing an incredible, very aggressive deforestation. If we add to that the fact that we live in very polluted cities with a very high population density, all these elements were contributing to create the perfect scenario for any virus to spread.

Zoonotic diseases emerge. and spread into the human population when nature's resilience is weakened. It's not healthy nature that causes pandemics. In terms of transmission of diseases. It's only with certain species under certain circumstances and when we invade their environment in a very aggressive way.

So, for the human health, animal health, and environmental health, the three are much linked.

Now, it's not a question anymore of doing economic growth here and then does some environmental impacts reduction over here. Now, it's rather a question of framing the entire growth model around sustainability, and let's has the planet guide everything we do.

An immediate priority is to reduce carbon emissions to zero and stable global temperature as low as we possibly can. Of course, we cannot shut down all energy utilities worldwide overnight, so the only orderly way to do this is to bend the global curve of emission now, because that's all-science shows. Now is the last chance we have to bend the global curve.

And the most rapid pace of emission reduction that we can accomplish per year is of 6 to 7%, because that is cutting by half in a decade, which would mean we would be fossil fuel-free in one generation in 30 years' time, a company can do it, a country can do it , or the world can and must do it at this point .

Phasing out fossil fuels will, of course, begin our journey back towards the safe space within the climate boundary. And it will also substantially reduce air pollution and slow down ocean acidification as well as reduce pressure on biodiversity.

We must also consider planting more trees. A global effort to plant billions of trees could be one of the most cost-effective and achievable solutions to the climate crisis, and growing more trees is vital to offset the carbon we continue to emit, as we strive to reach 0 emissions as fast as we can. Planting trees and restoring our natural world will, of course, have huge benefits for our planet's biodiversity, but it will also help to stabilize our climate, fresh water, and have enormous benefits for our food production.

We should also eat healthier to lower out carbon footprint. Furthermore, we should aim for a world without waste in which we turn that linear system into a circular one , designing products so that the raw materials can all be recovered, our use of resources could be infinite

So, more and more evidence show that circular economies are to stand a chance of providing good lives for all citizens in the world.

**CONCLUSION**

The planetary boundaries have given us a clear path ahead. Simple things like choosing renewable energy, eating healthy food, planting trees, saying no to waste, using new technologies such as CCUS for greenhouse gas reduction. Together, these could transform our future on Earth

And the transformation could also improve our lives right now. Even if you don't care at all about the planet and even if you don't care too much about equity in the world, but rather are selfish, just focusing on yourself and your own family and life, which is a very respectful position to have as a human being struggling with everyday life, still you want to come back to a safe operating space.

So, all in all, you would want to be in a a safe place rather than being in a danger zone where everything is just in flex.

# GENERAL CONCLUSION

The world as we know it is changing at an alarming rate. A cascade of rapid and catastrophic environmental changes is witnessed all over planet Earth.

It's now or never. If we are to save our planet or rather save what s left of it and help it recover, we must act now.

An immediate priority is to reduce carbon emissions and other greenhouse gases to half by 2030 and to zero by 2050 and stable global temperature as low as we possibly can because we just cannot allow ourselves to go beyond 1.5°C. of course, we cannot shut down all energy utilities worldwide overnight, so the only orderly way to do this is to bend the global curve of emission now, because that's all-science shows. Now is the last chance we have to bend the global curve.

Now. It's not a question anymore of doing economic growth here and then do some environmental impacts reduction over here. Now, it's rather a question of framing the entire growth model around Sustainability, and have the planet guide everything we do.

The aim of this memoire was to better understand the grand impact of greenhouse gases in creating rapid and catastrophic environmental changes and destabilizing whole planetary boundaries and thus Earth itself. Furthermore, the phenomena was to be assessed and compared to regulatory thresholds, and we wondered about the new methods, solutions that are to be established to mitigate this emissions in what's called a circular and future industry .

In order to achieve our work object, we divide this thesis into three parts:

The first part is a bibliographic study, which includes an overview of earth's boundaries, their tipping points. Then the environment and the changes in the natural parameters and their grand impact on our future lives, as well as the definitions and basic concepts related to the industrial safety and the danger, risk and hazardous phenomena management. In addition to defining some important regulations, both national and international , related to our subject of study, and finally the tools and software used for assessing the environmental impact.

The second part consists of our assessment of the environmental impact study, which includes GP1Z complex presentation, where we had our internship, followed by a demonstration of the AERMOD, Our work consisted of assessing both the impact of CO2 and NOX emissions for three months in 1hour and 24 hours time of dispersion. This dispersion modeling shows that Shows that the nearer the industries are the to the cities, the greater the impact is, and the greater the impact on people by these pollutant gases. Moreover, by overlaying the output maps, we got to know the cumulative impacts resulting from different gases emission sources as well as synergetic impacts.

In the last part we proposed some of the new processes of mitigation of greenhouse gases as part of a new circular and new industry.

These new techniques and technologies are our way out of this crisis. and humanity would once again step back from overshooting another planetary boundary and preserve the world for the future generations.

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**Annex A**

# *Appendices*


IHI
(35-T-0512) RESERVOIR D'EAU D'ALIMENTATION DE CHAUDIERE
BASE DE CALCUL
API 650
FLUIDE
L'EAU
VOLUME
450000 Liter
POIDS A VIDE
23900 kg
PRESS. DE CALCUL
PLEIN D'EAU
TEMP. DE CALCUL
100.0 ℃
PRESS. DE SERVICE
ATM
TEMP. DE SERVICE
50 ~ 90 ℃
PRESS. D'EPREUVE HYDRO.
PLEIN D'EAU
SUREPAISSEUR DE CORR.
1.0 mm
RELAX. DE CONTRAINTE
NON
RADIOGRAPHITE
PONCTUEL
NO. DE SERIE DE MFR
35-T-0512
DATE DE FABRICATION
APPROUVEPAR / DATE
POSS
SONATRACH
CONTR
I H I Corporation
MFR
IKATAN ENGINEERING SDN. BHD

( 3 / )

# FLARE STACK DATA SHEET

| | | |
|---|---|---|
| FILE NO. | | |
| SHEET NO. | 1 of 1 | |
| **CLIENT** | SONATRACH | |
| **LOCATION** | ARZEW, ALGERIA | ITEM NO. 34-F-0701 |
| **SERVICE** | HIGH PRESSURE FLARE STACK | |

I . GENERAL SPECIFICATION

| | |
|---|---|
| TYPE OF STACK | : VERTICAL |
| NO. REQUIRED | : 1 (one) |
| TYPE OF FLARE TIP | : SMOKELESS |
| | SMOKELESS FLARING IS ACHIEVED FROM ZERO TO 5% OF DESIGN CAPACITY BY MEANS OF STEAM INJECTION. |
| TYPE OF SEAL | : Molecular Seal |

II. PROCESS SPECIFICATIONS

| | |
|---|---|
| FLUID | : ETHANE, PROPANE, BUTANE, PENTANE |
| | PROPANE (100%) OR BUTANE (100%) FOR DESIGN |
| DESIGN CAPACITY | : 340 TON / HR PER STACK |
| MOLECULAR WEIGHT | : 44.1 (PROPANE), 58.1 (BUTANE) |
| OPERATING PRESSURE | : MAX. 0.57, MIN. 0.005 MPaG (Refer to B0100-6101-05) |
| TEMPERATURE | : MAX. 131 , MIN. -41.8 °C |
| ALLOWABLE PRESSURE DROP | : 0.031 MPa (From Inlet Nozzle to Flare Tip) · NOTE 1) |
| TEMPERATURE OF MAXIMUM FLOW (DESIGN CAPACITY) | : 68 °C (PROPANE), 125 °C (BUTANE) |

III. MECHANICAL SPECIFICATIONS

| | |
|---|---|
| DESIGN PRESSURE | : Riser 0.75 MPaG |
| | Molecular Seal 0.35 MPaG |
| DESIGN TEMPERATURE | : -48 / 150 °C |
| SIZE OF GAS INLET NOZZLE | : TO BE DECIDED BY DETAIL ENGINEERING GROUP |
| CORROSION ALLOWANCE | : 3.0 mm |
| MATERIAL | : C.S FOR LOW TEMPERATURE |

IV. UTILITY CONDITIONS : REFER TO page5

V. EXTENT OF SUPPLY

1) IGNITER : 34-M-0705

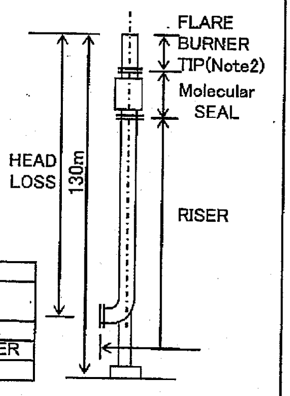



FIG-1

DISTRIBUTION

NOTE:

1. INCLUDING FLARE BURNER TIP, DRY SEAL, STACK AND HEAD LOSS AS SHOWN IN FIG.1.
   - Vendor shall inform the distance of radiation circles of 1.58 KW/m2 and 4.73 KW/m2

2. Connection for burner tip shall be below.
   To ensure interchangerbility with existing spare burner

| Size | Rating | Q'ty | Service |
|---|---|---|---|
| 36" | 150#RF ASME B 16.47 SERIESS B | 1 | INLET |
| 3/4" | ASME300# RF | 3 | GAS INLET FOR PILOT BURNER |
| 1" | ASME300# RF | 3 | GAS INLET FOR IGNITER BURNER |
| 6" | ASME150# RF | 1 | STEAM INLET |

| REV.NO. | DATE | REVISIONS | BY | CHK'D | APPVD |
|---|---|---|---|---|---|

| | | | |
|---|---|---|---|
| Issued by | IHI | PROJECT NAME Réalisation de Trois Nouveaux Trains de Séparation de GPL à Intégrer au Complexe GP1.Z - Arzew | JOB NO. 5011-117 |
| | | | DRAWING NO. B0100-3126 REV. 4A |

**IHI Corporation**

(4/ )

# FLARE STACK DATA SHEET

FILE NO.

SHEET NO. 1 of 1

**CLIENT** SONATRACH

**LOCATION** ARZEW, ALGERIA

**SERVICE** LOW PRESSURE FLARE STACK

ITEM NO. 34-F-0702

## I. GENERAL SPECIFICATION

| | | |
|---|---|---|
| TYPE OF STACK | : | VERTICAL |
| NO. REQUIRED | : | 1 (one) |
| TYPE OF FLARE TIP | : | SMOKELESS<br>SMOKELESS FLARING IS ACHIEVED FROM ZERO TO 5% OF DESIGN CAPACITY BY MEANS OF STEAM INJECTION. |
| TYPE OF SEAL | : | Molecular Seal |

## II. PROCESS SPECIFICATIONS

| | | |
|---|---|---|
| FLUID | : | ETHANE, PROPANE, BUTANE, PENTANE<br>PROPANE (100%) OR BUTANE (100%) FOR DESIGN |
| DESIGN CAPACITY | : | 90 TON / HR PER STACK |
| MOLECULAR WEIGHT | : | 44.1 (PROPANE), 58.1 (BUTANE) |
| OPERATING PRESSURE | : | MAX. 0.005 , MIN. 0.0005 MPaG |
| TEMPERATURE | : | MAX. 55 , MIN. -41.8 ℃ |
| ALLOWABLE PRESSURE DROP | : | 0.002 MPa (From Inlet Nozzle to Flare Tip) NOTE 1) |
| TEMPERATURE OF MAXIMUM FLOW (DESIGN CAPACITY) | : | 45 ℃ |

## III. MECHANICAL SPECIFICATIONS

| | | |
|---|---|---|
| DESIGN PRESSURE | : | Riser 0.35MPaG<br>Molecular Seal 0.35MPaG |
| DESIGN TEMPERATURE | : | -48 / 150 ℃ |
| SIZE OF INLET NOZZLE | : | TO BE DECIDED BY DETAIL ENGINEERING |
| CORROSION ALLOWANCE | : | 3.0 mm |
| MATERIAL | : | C.S FOR LOW TEMPERATURE |

## IV. UTILITY CONDITIONS : REFER TO page5

## V. EXTENT OF SUPPLY

1) IGNITER : 34-M-0706

NOTE:

1. INCLUDING FLARE BURNER TIP, DRY SEAL, STACK AND HEAD LOSS AS SHOWN IN FIG.1.
   - Vendor shall inform the distance of radiation circles of 1.58 KW/m2 and 4.73 KW/m2
2. Connection for burner tip shall be below. To ensure Interchangerbility with existing spare burner

| Size | Rating | Q'ty | Service |
|---|---|---|---|
| 42" | 150#RF ASME B 16.47 SERIESS B | 1 | INLET |
| 3/4" | ASME300# RF | 3 | GAS INLET FOR PILOT BURNER |
| 1" | ASME300# RF | 3 | GAS INLET FOR IGNITER BURNER |
| * | ASME150# RF | 1 | STEAM INLET |

(*) SPECIFIED BY VENDER

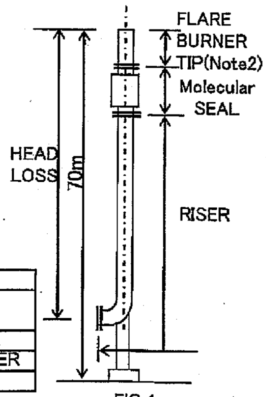



FIG-1

DISTRIBUTION

| REV.NO. | DATE | REVISIONS | BY | CHK'D | APPVD |
|---|---|---|---|---|---|

Issued by

**IHI**

| | | |
|---|---|---|
| PROJECT NAME<br>Réalisation de Trois Nouveaux Trains de Séparation de GPL à Intégrer au Complexe GP1.Z - Arzew | JOB NO.<br>5011-117 | |
| | DRAWING NO.<br>B0100-3126 | REV.<br>4A |

(5/5)

| | | |
|---|---|---|
| **FLARE STACK DATA SHEET** | FILE NO. | |
| | SHEET NO. | 1 of 1 |
| CLIENT | SONATRACH | |
| LOCATION | ARZEW, ALGERIA | |
| SERVICE | | |

UTILITY CONDITIONS

1. FUEL GAS AND SEAL GAS (NG)

PRESSURE : 0.1 MPaG (DESIGN FOR PILOT : 0.2MPaG, FOR IGNITER : 2.5MPaG)
TEMPERATURE : NOR. 14 °C, MAX. 55 °C , MIN 2 °C (DESIGN -29/65 °C)

COMPOSITION : ( mol %)

$N_2$ = 5.8
He = 0.19
$CO_2$ = 0.21
C1 = 83.00
C2 = 7.10
C3 = 2.25
i-C4 = 0.40
n-C4 = 0.60
i-C5 = 0.12
n-C5 = 0.15
C6 = 0.18
$H_2O$ = 50 VOL PPM

MOLECULAR WEIGHT : 19.06
LOW HEATING VALUE : 44,807 KJ/Kg

2. INSTRUMENT AIR (IA)

PRESSURE : 0.10 ~ 0.15 MPaG (DESIGN 0.75MPaG)
TEMPERATURE : MAX. 50 °C(DESIGN : 70°C)
DEW POINT : -30 °C (AT 1ATM)

3. STEAM (SL)

PRESSURE : Max. 1.0 MPaG, Min 0.76 MPaG (DESIGN : 1.2 MPaG)
TEMPERATURE : MAX. 183 °C MIN. 173 °C (DESIGN : 200°C)

4. INDUSTRIAL WATER (IW)

PRESSURE : 0.5 MPaG (DESIGN : 0.73MPaG)
TEMPERATURE : 41.8°C (DESIGN : 45°C)

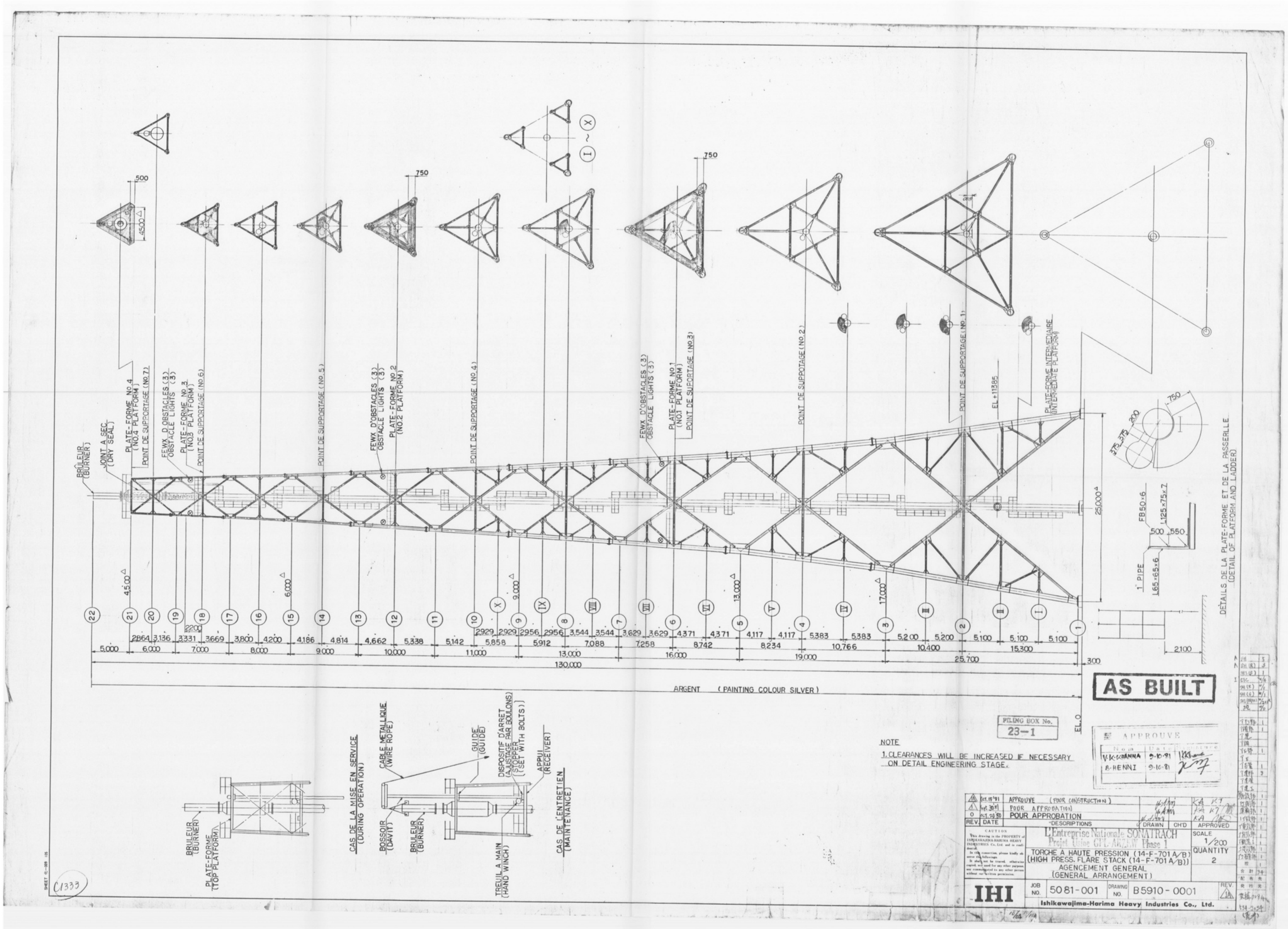
5. ELECTRICITY : AC110V 1PHASE 50Hz
: ~~AC380V 3PHASE 50Hz~~

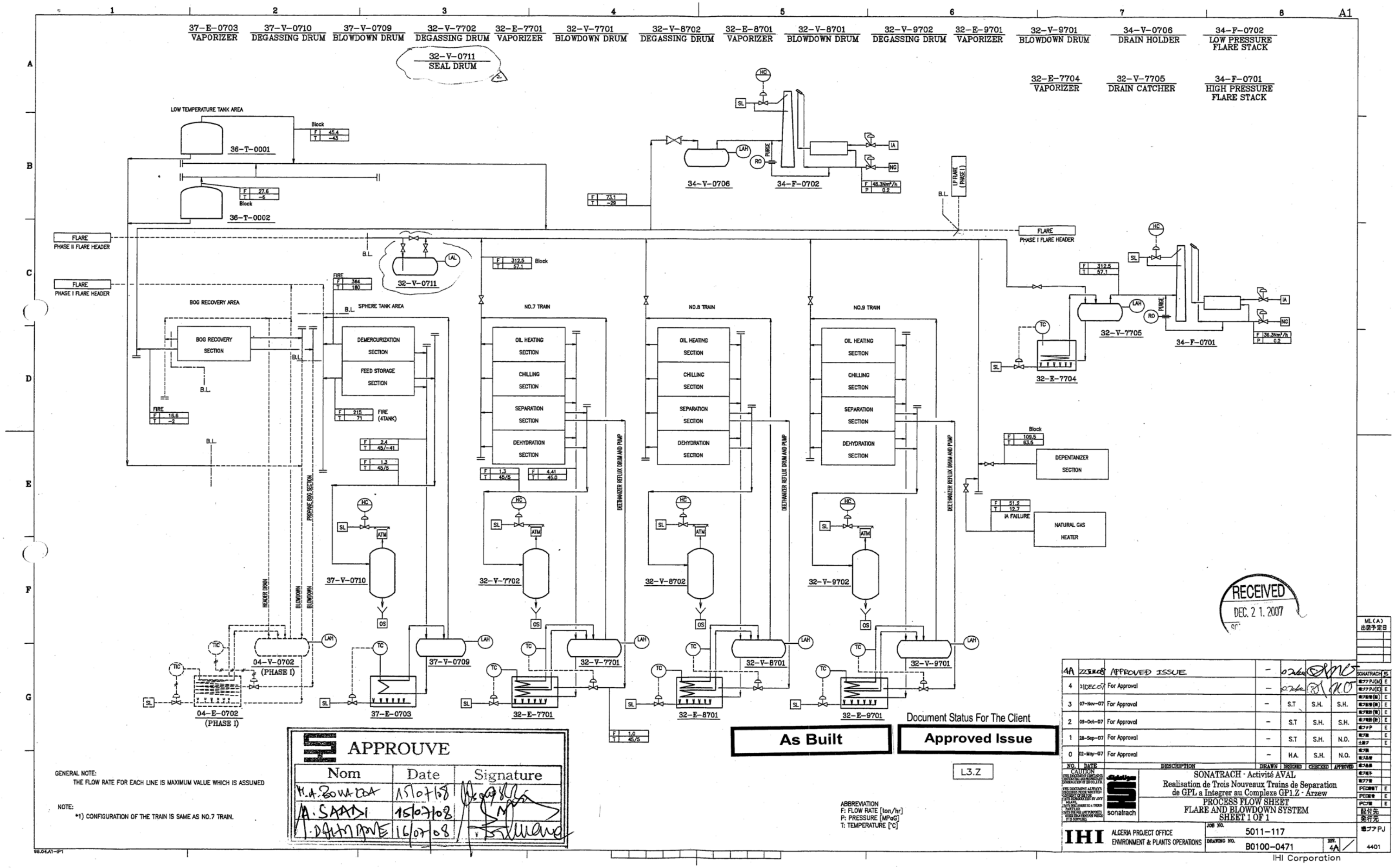
NOTE) Stack shall be designed to keep the following limit value of atmospheric discharge parameters. Vendor shall confirm and reply that vendor can achieve the alternative values.

| Parameters | Unit | Limit values | Alternative Value |
|---|---|---|---|
| Sulfer oxide | mg/Nm3 | 800 | 35 |
| Nitrogen oxide | mg/Nm3 | 200 | |
| Carbon oxide | mg/Nm3 | 150 | 50 |
| Volatile organic compounds | mg/Nm3 | 150 | |
| Sulfuric acid | mg/Nm3 | 5 | |
| Particles | mg/Nm3 | 50 | 5 |

| REV.NO. | DATE | REVISIONS | BY | CHK'D | APPVD |
|---|---|---|---|---|---|
| | | | | | |

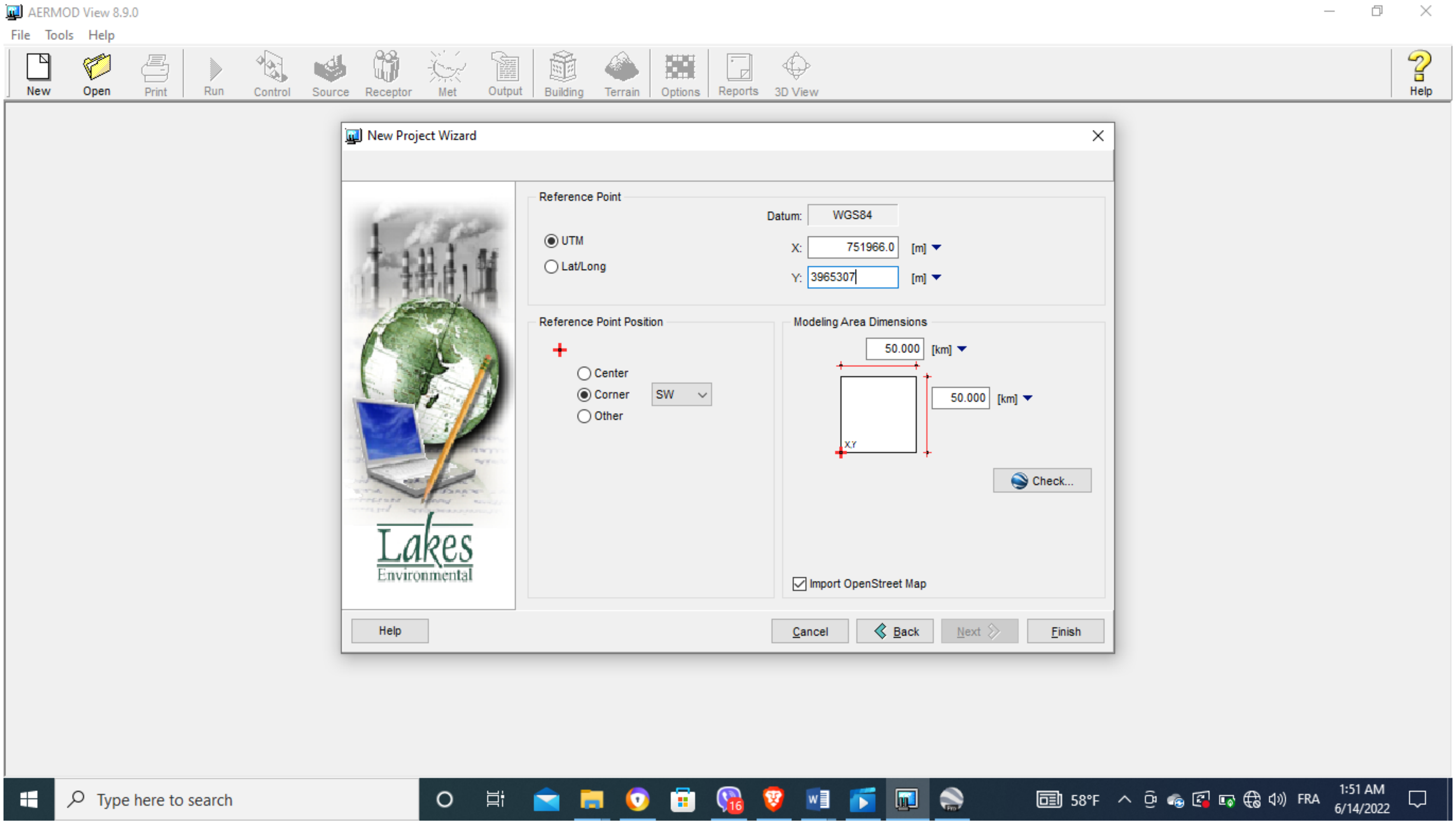
| | | | |
|---|---|---|---|
| IHI | PROJECT NAME<br>Réalisation de Trois Nouveaux Trains de Séparation de GPL à Intégrer au Complexe GP1.Z - Arzew | JOB NO. 5011-117<br>DRAWING NO. B0100-3126 | REV. 4A |

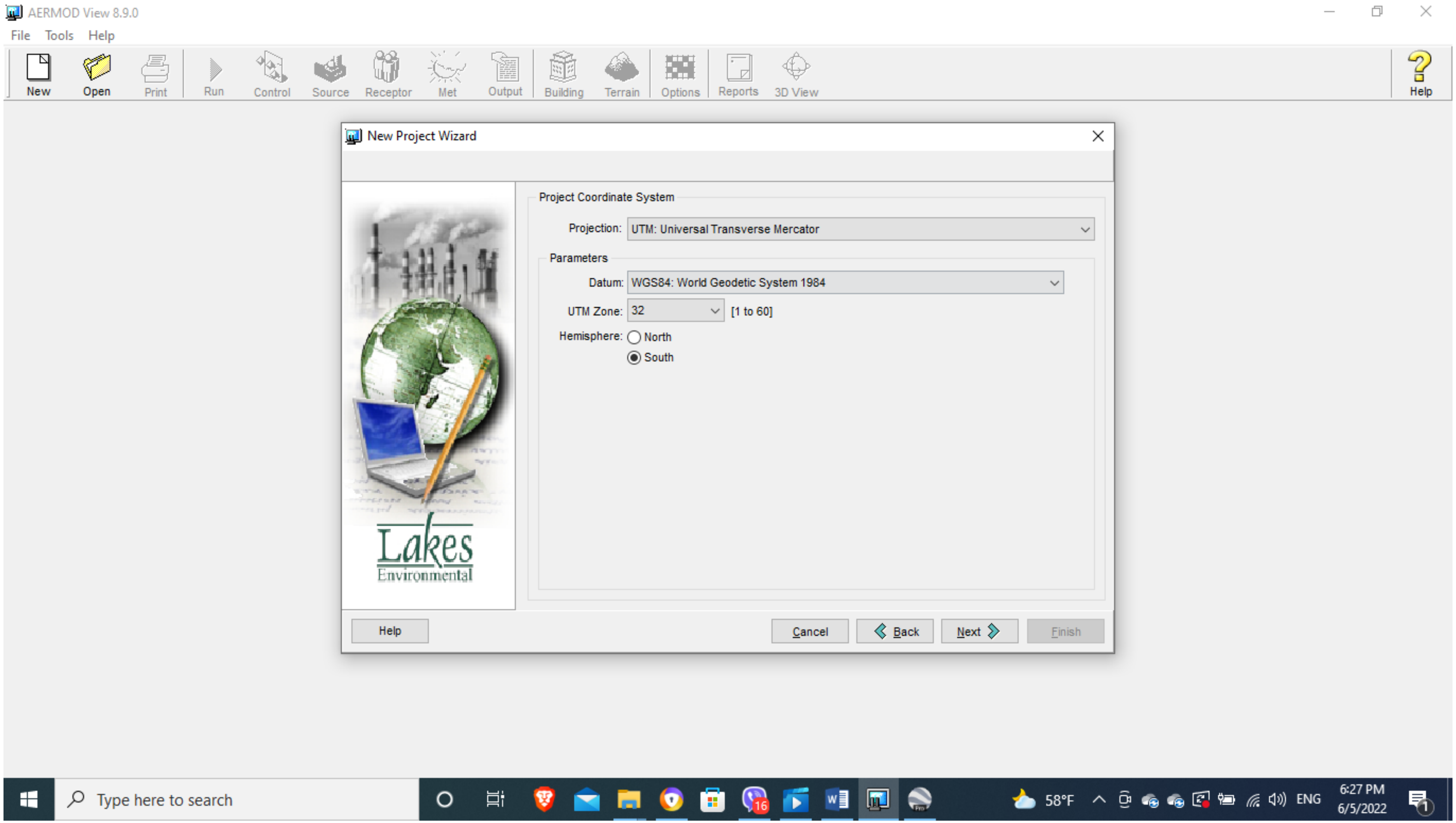

AS BUILT
ARGENT (PAINTING COLOUR SILVER)
NOTE
1. CLEARANCES WILL BE INCREASED IF NECESSARY ON DETAIL ENGINEERING STAGE.
POUR APPROBATION
TORCHE A HAUTE PRESSION (14-F-701A/B)
(HIGH PRESS. FLARE STACK (14-F-701A/B))
AGENCEMENT GENERAL
(GENERAL ARRANGEMENT)
IHI
5081-001
B5910-0001
Ishikawajima-Harima Heavy Industries Co., Ltd.

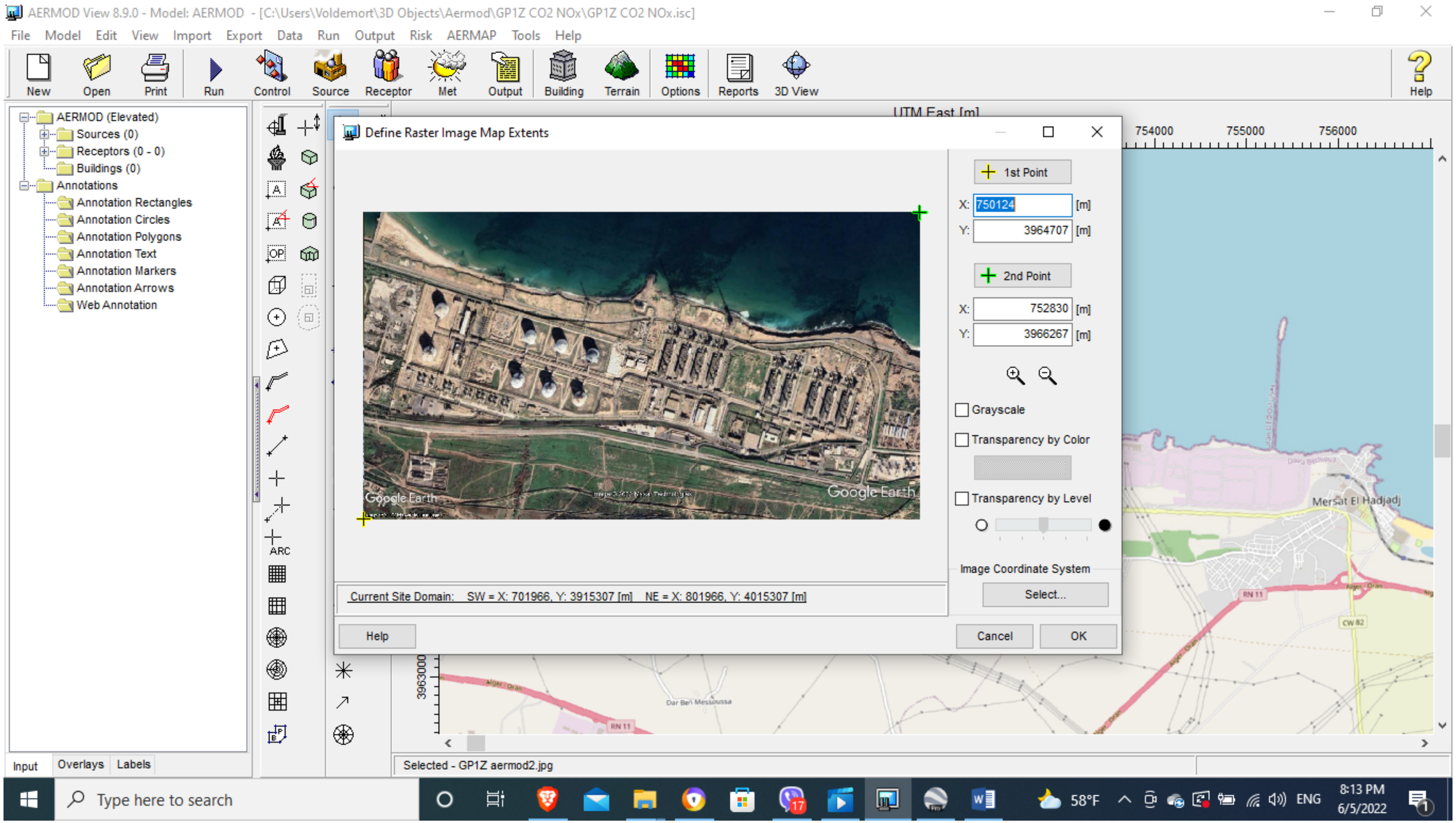


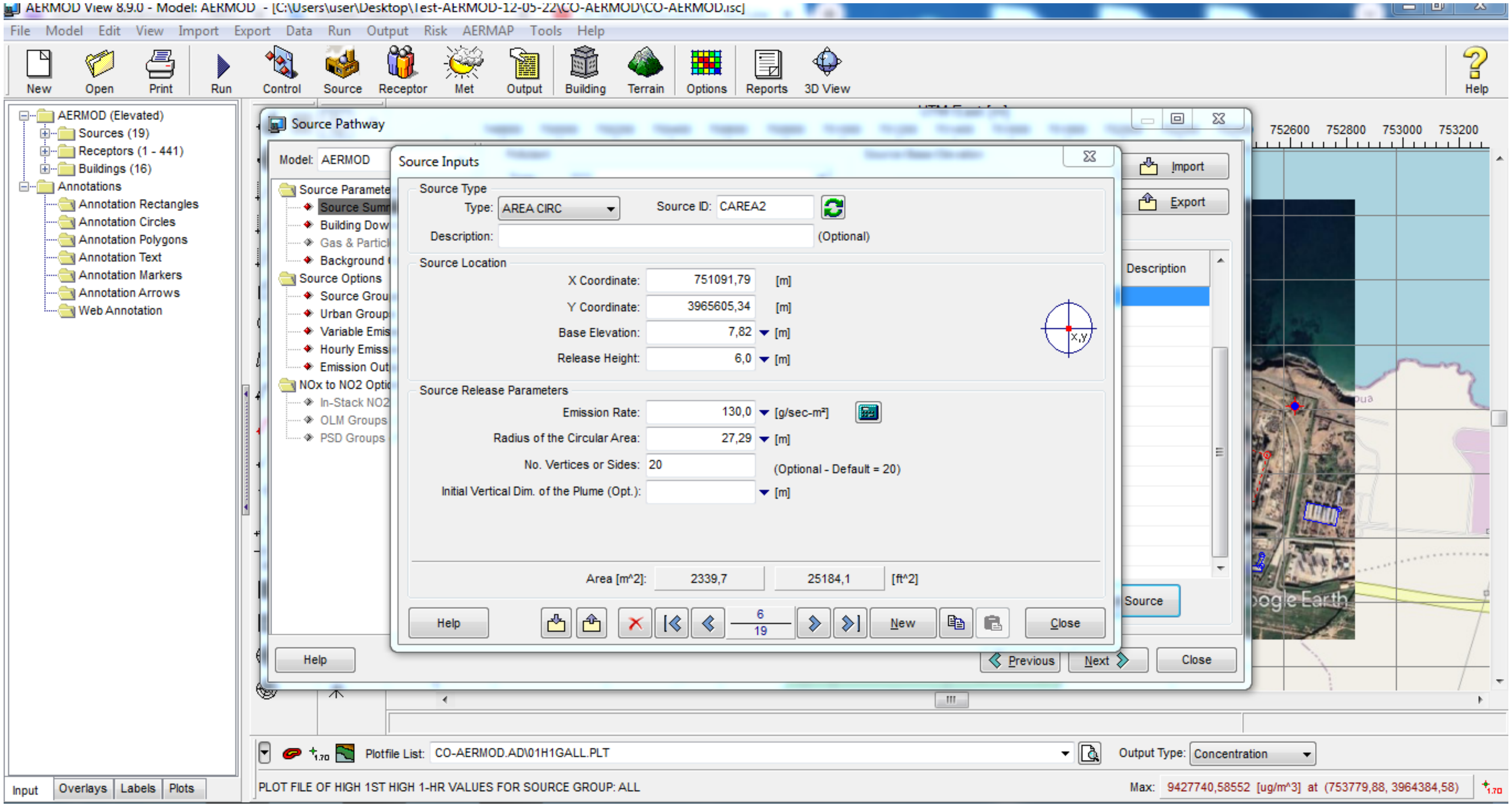
37-E-0703 VAPORIZER
37-V-0710 DEGASSING DRUM
37-V-0709 BLOWDOWN DRUM
32-V-7702 DEGASSING DRUM
32-E-7701 VAPORIZER
32-V-7701 BLOWDOWN DRUM
32-V-8702 DEGASSING DRUM
32-E-8701 VAPORIZER
32-V-8701 BLOWDOWN DRUM
32-V-9702 DEGASSING DRUM
32-E-9701 VAPORIZER
32-V-9701 BLOWDOWN DRUM
34-V-0706 DRAIN HOLDER
34-F-0702 LOW PRESSURE FLARE STACK
32-V-0711 SEAL DRUM
32-E-7704 VAPORIZER
32-V-7705 DRAIN CATCHER
34-F-0701 HIGH PRESSURE FLARE STACK
LOW TEMPERATURE TANK AREA
36-T-0001
36-T-0002
BOG RECOVERY AREA
BOG RECOVERY SECTION
SPHERE TANK AREA
DEMERCURIZATION SECTION
FEED STORAGE SECTION
NO.7 TRAIN
NO.8 TRAIN
NO.9 TRAIN
OIL HEATING SECTION
CHILLING SECTION
SEPARATION SECTION
DEHYDRATION SECTION
DEETHANIZER REFLUX DRUM AND PUMP
PROPANE BOG SECTION
FLARE PHASE II FLARE HEADER
FLARE PHASE I FLARE HEADER
DEPENTANIZER SECTION
NATURAL GAS HEATER
04-V-0702 (PHASE I)
04-E-0702 (PHASE I)
RECEIVED DEC. 21. 2007
APPROUVE
Nom | Date | Signature
M.A. BOUAZZA | 15/07/08
A. SAADI | 15/07/08
DAHMANE | 16/07/08
Document Status For The Client
As Built
Approved Issue
L3.Z
GENERAL NOTE:
THE FLOW RATE FOR EACH LINE IS MAXIMUM VALUE WHICH IS ASSUMED
NOTE:
*1) CONFIGURATION OF THE TRAIN IS SAME AS NO.7 TRAIN.
ABBREVIATION
F: FLOW RATE [ton/hr]
P: PRESSURE [MPaG]
T: TEMPERATURE [°C]
4A APPROVED ISSUE
4 For Approval
3 07-Nov-07 For Approval
2 08-Oct-07 For Approval
1 28-Sep-07 For Approval
0 02-May-07 For Approval
SONATRACH - Activité AVAL
Realisation de Trois Nouveaux Trains de Separation de GPL a Integrer au Complexe GP1.Z - Arzew
PROCESS FLOW SHEET
FLARE AND BLOWDOWN SYSTEM
SHEET 1 OF 1
IHI ALGERIA PROJECT OFFICE ENVIRONMENT & PLANTS OPERATIONS
5011-117
B0100-0471
IHI Corporation

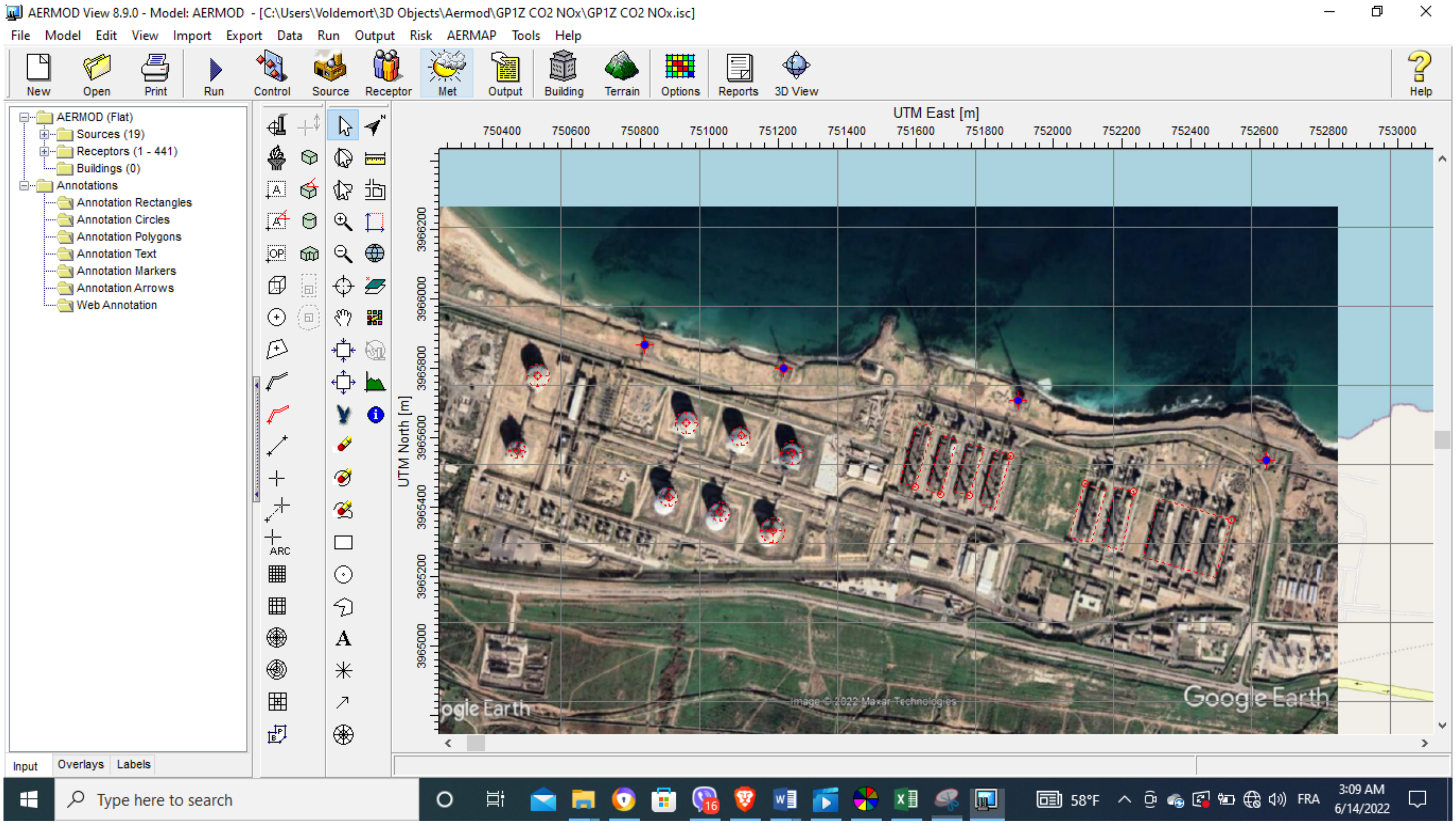
## Annex B

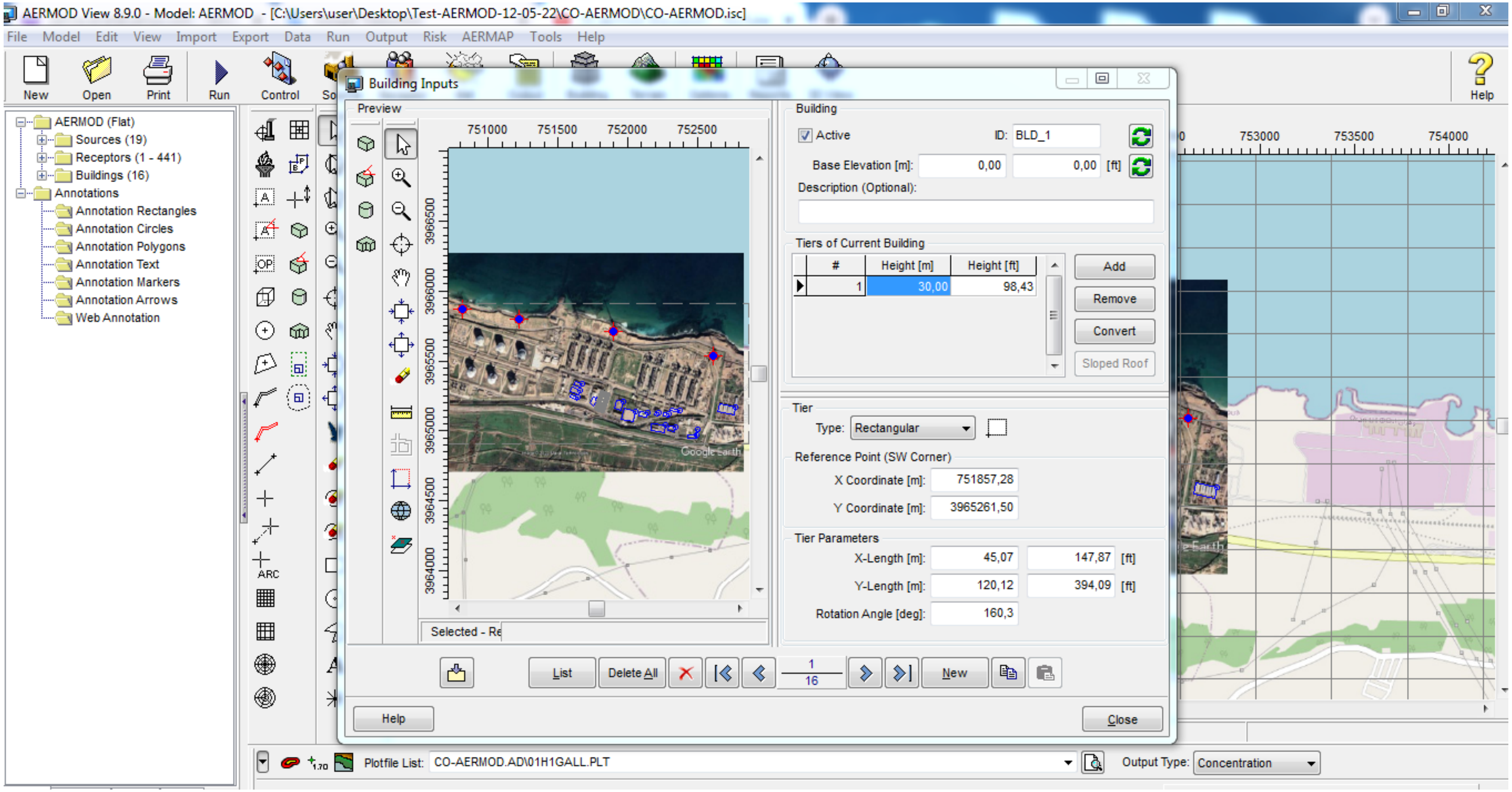

AERMOD View 8.9.0
File Tools Help
New Open Print Run Control Source Receptor Met Output Building Terrain Options Reports 3D View Help
New Project Wizard
Reference Point
Datum: WGS84
UTM
Lat/Long
X: 751966.0 [m]
Y: 3965307 [m]
Reference Point Position
Center
Corner SW
Other
Modeling Area Dimensions
50.000 [km]
50.000 [km]
X,Y
Check...
Import OpenStreet Map
Lakes Environmental
Help
Cancel
Back
Next
Finish
Type here to search
58°F
FRA
1:51 AM
6/14/2022

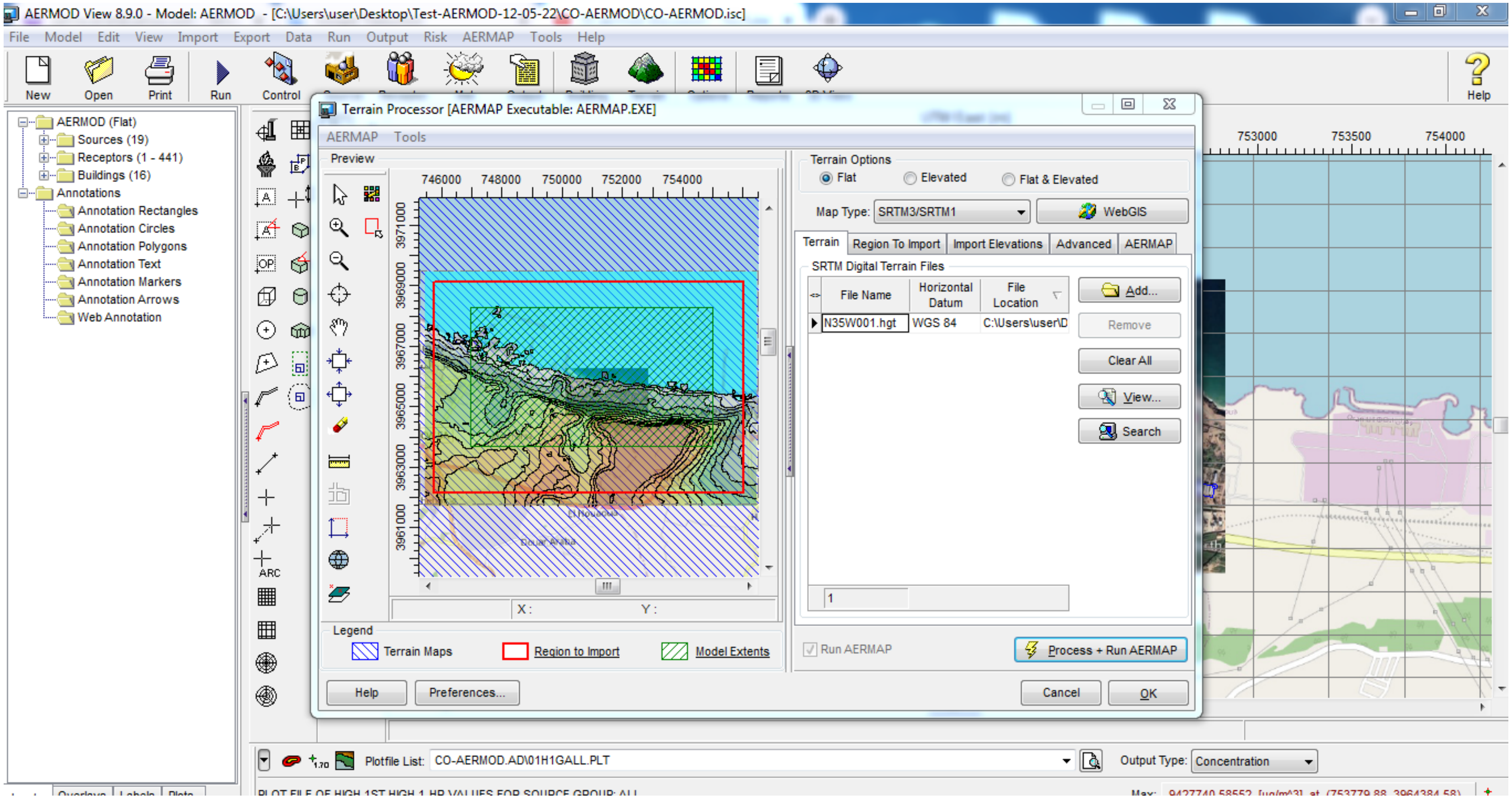

AERMOD View 8.9.0
File Tools Help
New
Open
Print
Run
Control
Source
Receptor
Met
Output
Building
Terrain
Options
Reports
3D View
Help
New Project Wizard
Project Coordinate System
Projection: UTM: Universal Transverse Mercator
Parameters
Datum: WGS84: World Geodetic System 1984
UTM Zone: 32
[1 to 60]
Hemisphere:
North
South
Lakes
Environmental
Help
Cancel
Back
Next
Finish
Type here to search
58°F
ENG
6:27 PM
6/5/2022

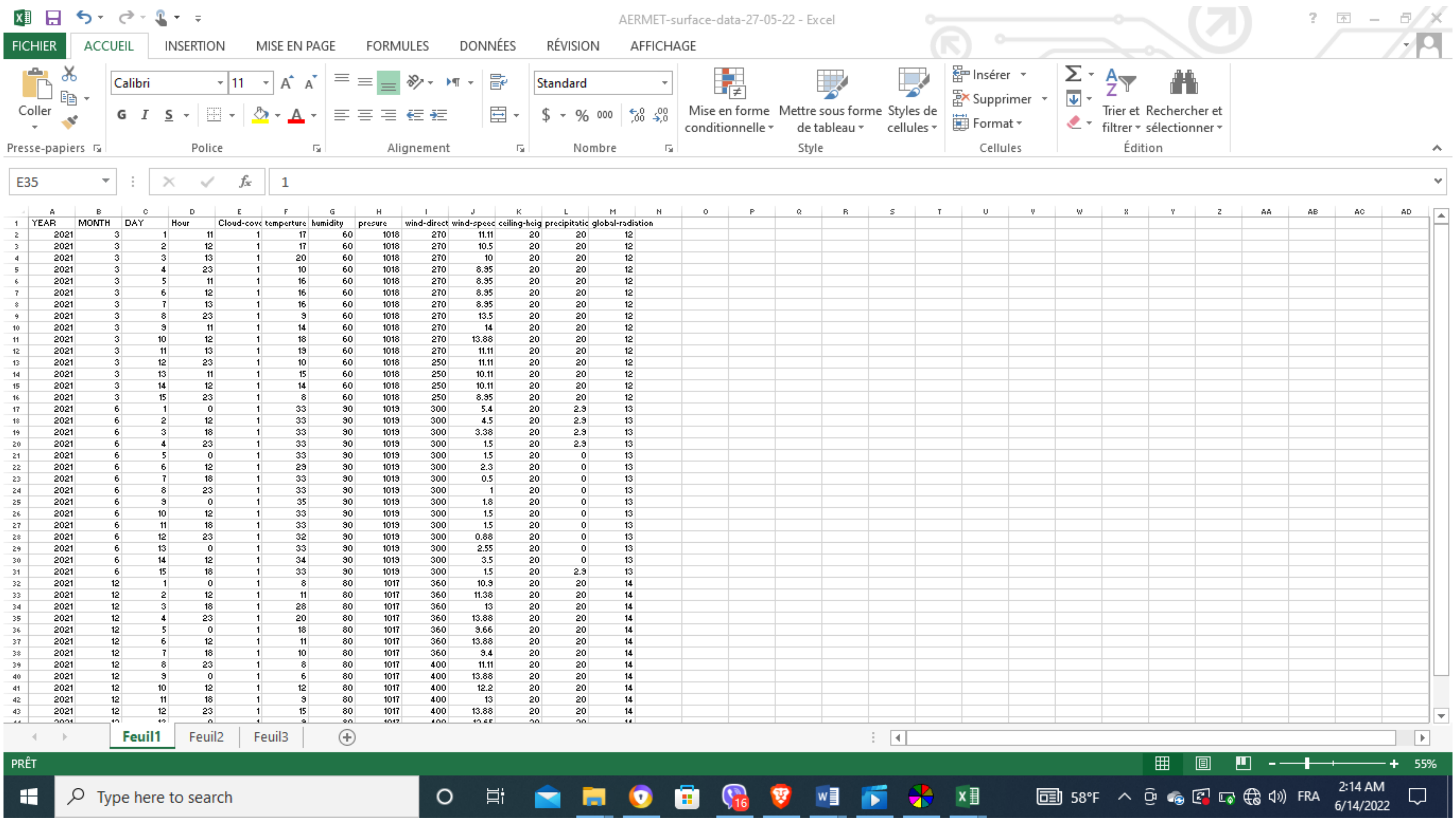

AERMOD View 8.9.0 - Model: AERMOD - [C:\Users\Voldemort\3D Objects\Aermod\GP1Z CO2 NOx\GP1Z CO2 NOx.isc]
File Model Edit View Import Export Data Run Output Risk AERMAP Tools Help
New Open Print Run Control Source Receptor Met Output Building Terrain Options Reports 3D View Help
AERMOD (Elevated)
Sources (0)
Receptors (0 - 0)
Buildings (0)
Annotations
Annotation Rectangles
Annotation Circles
Annotation Polygons
Annotation Text
Annotation Markers
Annotation Arrows
Web Annotation
Define Raster Image Map Extents
1st Point
X: 750124 [m]
Y: 3964707 [m]
2nd Point
X: 752830 [m]
Y: 3966267 [m]
Grayscale
Transparency by Color
Transparency by Level
Image Coordinate System
Select...
Current Site Domain: SW = X: 701966, Y: 3915307 [m] NE = X: 801966, Y: 4015307 [m]
Help
Cancel
OK
UTM East [m]
754000
755000
756000
Mersat El Hadjadj
3963000
Input Overlays Labels
Selected - GP1Z aermod2.jpg
Type here to search
58°F
ENG
8:13 PM
6/5/2022


AERMOD View 8.9.0 - Model: AERMOD - [C:\Users\user\Desktop\Test-AERMOD-12-05-22\CO-AERMOD\CO-AERMOD.isc]
File Model Edit View Import Export Data Run Output Risk AERMAP Tools Help
New Open Print Run Control Source Receptor Met Output Building Terrain Options Reports 3D View Help
AERMOD (Elevated)
Sources (19)
Receptors (1 - 441)
Buildings (16)
Annotations
Annotation Rectangles
Annotation Circles
Annotation Polygons
Annotation Text
Annotation Markers
Annotation Arrows
Web Annotation
Source Pathway
Model: AERMOD
Source Inputs
Source Type
Type: AREA CIRC
Source ID: CAREA2
Description:
(Optional)
Source Location
X Coordinate: 751091,79 [m]
Y Coordinate: 3965605,34 [m]
Base Elevation: 7,82 [m]
Release Height: 6,0 [m]
Source Release Parameters
Emission Rate: 130,0 [g/sec-m²]
Radius of the Circular Area: 27,29 [m]
No. Vertices or Sides: 20 (Optional - Default = 20)
Initial Vertical Dim. of the Plume (Opt.): [m]
Area [m^2]: 2339,7 25184,1 [ft^2]
Help New Close
6
19
Import
Export
Description
Source
Previous Next Close
752600 752800 753000 753200
Plotfile List: CO-AERMOD.AD\01H1GALL.PLT
Output Type: Concentration
Input Overlays Labels Plots
PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL
Max: 9427740,58552 [ug/m^3] at (753779,88, 3964384,58)

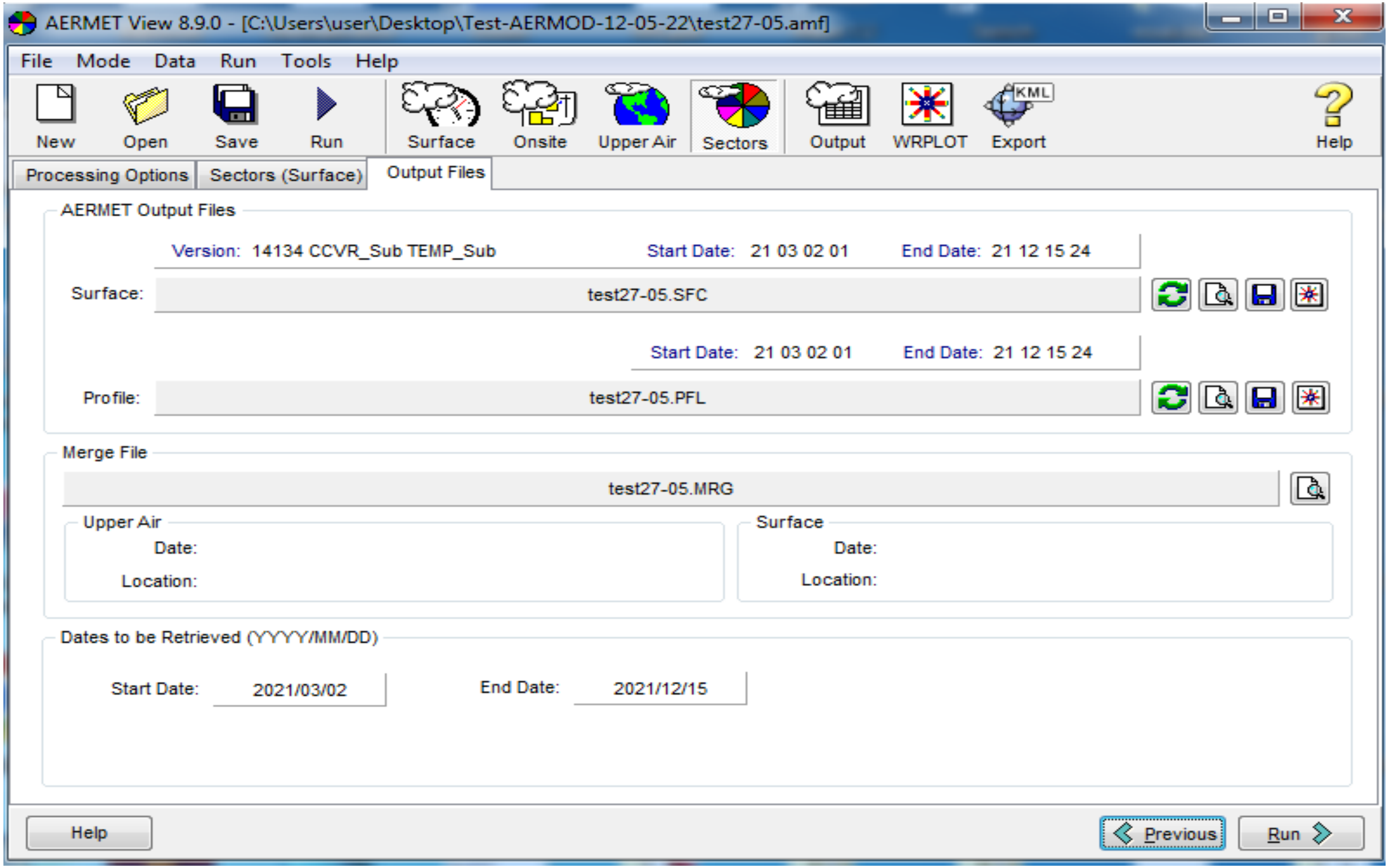

AERMOD View 8.9.0 - Model: AERMOD - [C:\Users\Voldemort\3D Objects\Aermod\GP1Z CO2 NOx\GP1Z CO2 NOx.isc]
File Model Edit View Import Export Data Run Output Risk AERMAP Tools Help
New Open Print Run Control Source Receptor Met Output Building Terrain Options Reports 3D View Help
AERMOD (Flat)
Sources (19)
Receptors (1 - 441)
Buildings (0)
Annotations
Annotation Rectangles
Annotation Circles
Annotation Polygons
Annotation Text
Annotation Markers
Annotation Arrows
Web Annotation
Input Overlays Labels
UTM East [m]
750400 750600 750800 751000 751200 751400 751600 751800 752000 752200 752400 752600 752800 753000
UTM North [m]
3966200 3966000 3965800 3965600 3965400 3965200 3965000
Google Earth
Type here to search
58°F FRA 3:09 AM 6/14/2022

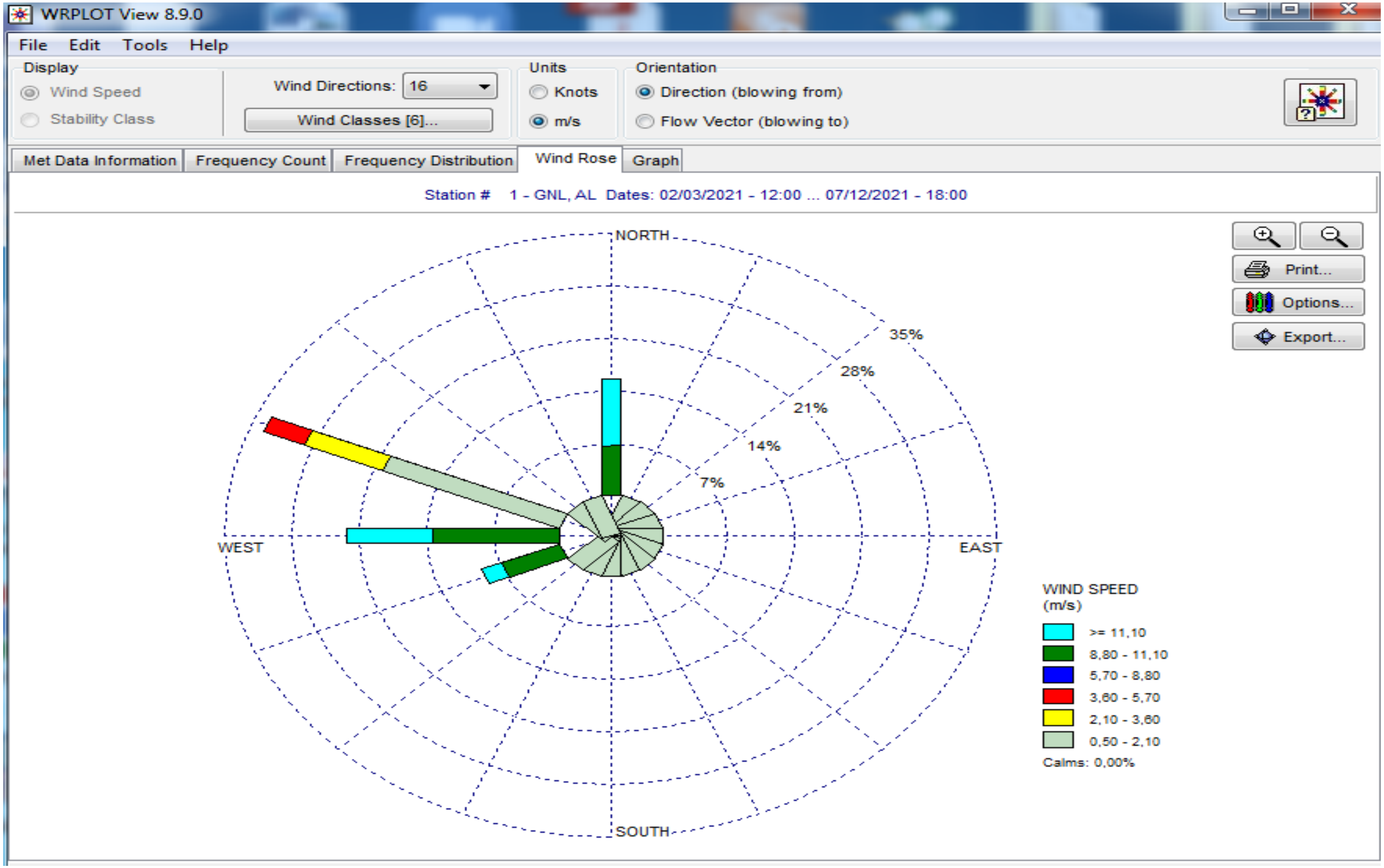

AERMOD View 8.9.0 - Model: AERMOD - [C:\Users\user\Desktop\Test-AERMOD-12-05-22\CO-AERMOD\CO-AERMOD.isc]
File Model Edit View Import Export Data Run Output Risk AERMAP Tools Help
New Open Print Run Control Help
AERMOD (Flat)
Sources (19)
Receptors (1 - 441)
Buildings (16)
Annotations
Annotation Rectangles
Annotation Circles
Annotation Polygons
Annotation Text
Annotation Markers
Annotation Arrows
Web Annotation
Building Inputs
Preview
751000 751500 752000 752500
3966500 3966000 3965500 3965000 3964500 3964000
Selected - Re
Building
Active
ID: BLD_1
Base Elevation [m]: 0,00 0,00 [ft]
Description (Optional):
Tiers of Current Building
# Height [m] Height [ft]
1 30,00 98,43
Add
Remove
Convert
Sloped Roof
Tier
Type: Rectangular
Reference Point (SW Corner)
X Coordinate [m]: 751857,28
Y Coordinate [m]: 3965261,50
Tier Parameters
X-Length [m]: 45,07 147,87 [ft]
Y-Length [m]: 120,12 394,09 [ft]
Rotation Angle [deg]: 160,3
List Delete All 1 16 New
Help Close
753000 753500 754000
Plotfile List: CO-AERMOD.AD\01H1GALL.PLT
Output Type: Concentration

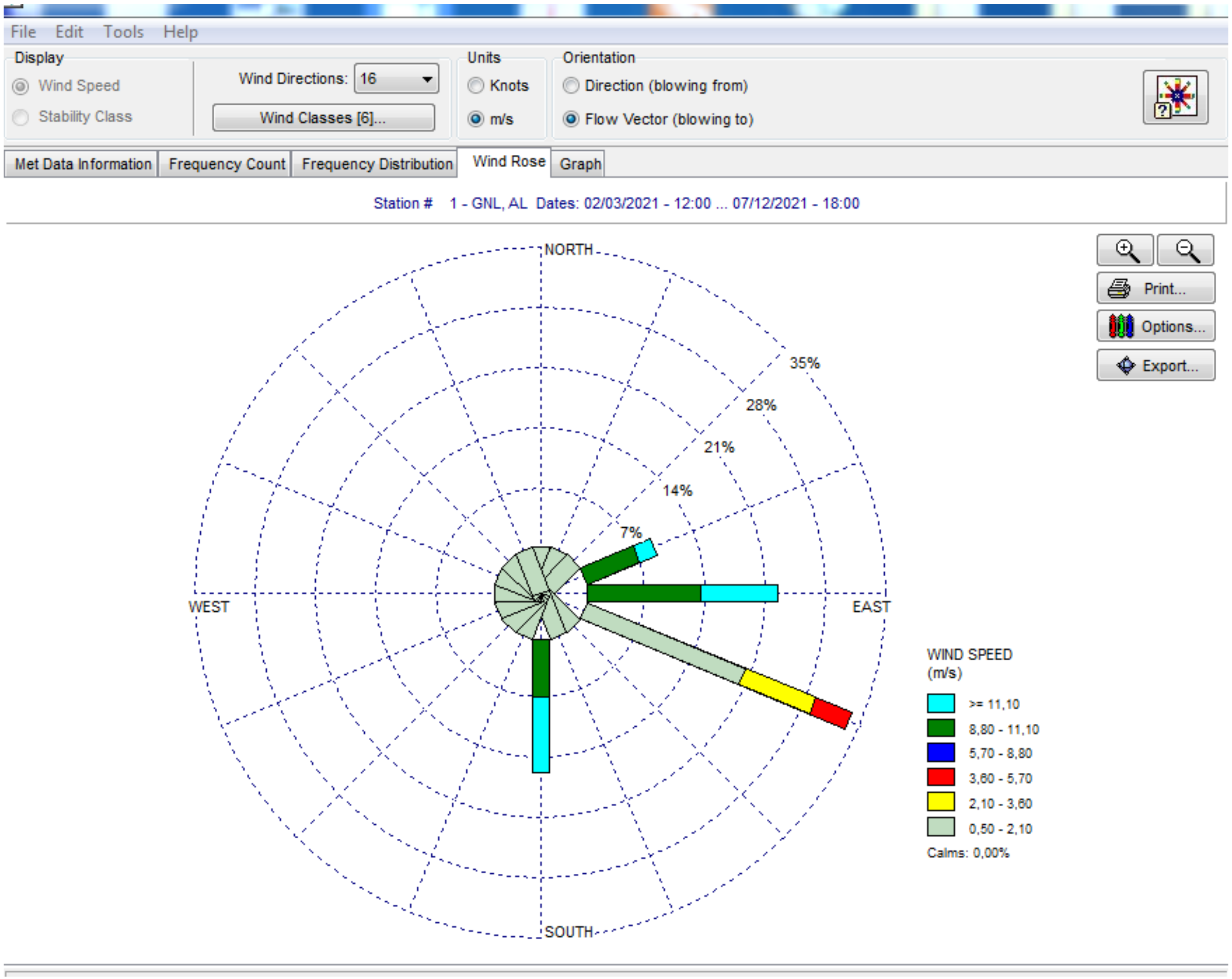

AERMOD View 8.9.0 - Model: AERMOD - [C:\Users\user\Desktop\Test-AERMOD-12-05-22\CO-AERMOD\CO-AERMOD.isc]
File Model Edit View Import Export Data Run Output Risk AERMAP Tools Help
New Open Print Run Control Help
AERMOD (Flat)
Sources (19)
Receptors (1 - 441)
Buildings (16)
Annotations
Annotation Rectangles
Annotation Circles
Annotation Polygons
Annotation Text
Annotation Markers
Annotation Arrows
Web Annotation
Terrain Processor [AERMAP Executable: AERMAP.EXE]
AERMAP Tools
Preview
Terrain Options
Flat
Elevated
Flat & Elevated
Map Type: SRTM3/SRTM1
WebGIS
Terrain
Region To Import
Import Elevations
Advanced
AERMAP
SRTM Digital Terrain Files
File Name
Horizontal Datum
File Location
N35W001.hgt
WGS 84
C:\Users\user\D
Add...
Remove
Clear All
View...
Search
Run AERMAP
Process + Run AERMAP
Legend
Terrain Maps
Region to Import
Model Extents
Help
Preferences...
Cancel
OK
Plotfile List: CO-AERMOD.AD\01H1GALL.PLT
Output Type: Concentration



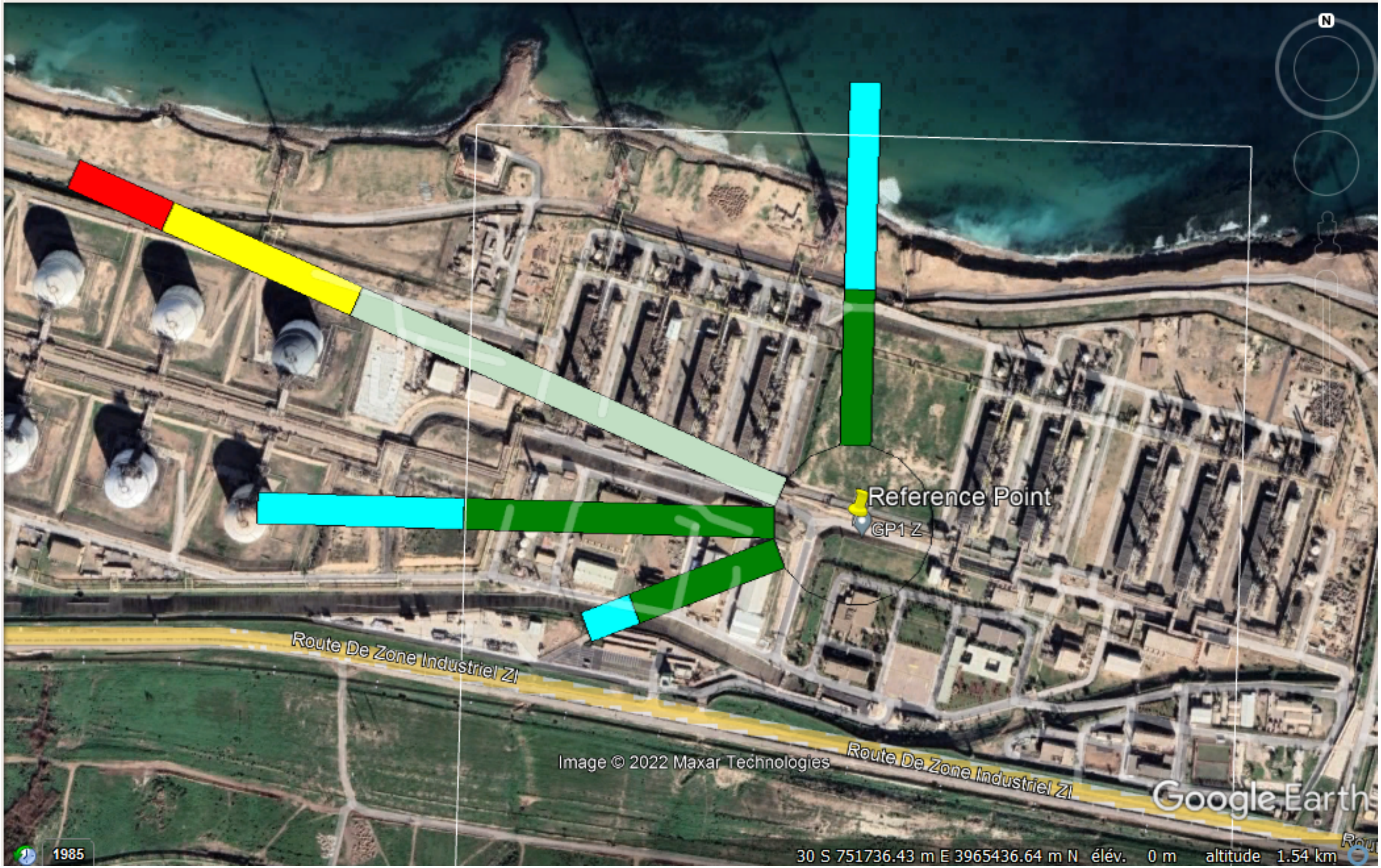

| YEAR | MONTH | DAY | Hour | Cloud-cove | temperture | humidity | presure | wind-direct | wind-speec | ceiling-heig | precipitatic | global-radiation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2021 | 3 | 1 | 11 | 1 | 17 | 60 | 1018 | 270 | 11.11 | 20 | 20 | 12 |
| 2021 | 3 | 2 | 12 | 1 | 17 | 60 | 1018 | 270 | 10.5 | 20 | 20 | 12 |
| 2021 | 3 | 3 | 13 | 1 | 20 | 60 | 1018 | 270 | 10 | 20 | 20 | 12 |
| 2021 | 3 | 4 | 23 | 1 | 10 | 60 | 1018 | 270 | 8.95 | 20 | 20 | 12 |
| 2021 | 3 | 5 | 11 | 1 | 16 | 60 | 1018 | 270 | 8.95 | 20 | 20 | 12 |
| 2021 | 3 | 6 | 12 | 1 | 16 | 60 | 1018 | 270 | 8.95 | 20 | 20 | 12 |
| 2021 | 3 | 7 | 13 | 1 | 16 | 60 | 1018 | 270 | 8.95 | 20 | 20 | 12 |
| 2021 | 3 | 8 | 23 | 1 | 9 | 60 | 1018 | 270 | 13.5 | 20 | 20 | 12 |
| 2021 | 3 | 9 | 11 | 1 | 14 | 60 | 1018 | 270 | 14 | 20 | 20 | 12 |
| 2021 | 3 | 10 | 12 | 1 | 18 | 60 | 1018 | 270 | 13.88 | 20 | 20 | 12 |
| 2021 | 3 | 11 | 13 | 1 | 19 | 60 | 1018 | 270 | 11.11 | 20 | 20 | 12 |
| 2021 | 3 | 12 | 23 | 1 | 10 | 60 | 1018 | 250 | 11.11 | 20 | 20 | 12 |
| 2021 | 3 | 13 | 11 | 1 | 15 | 60 | 1018 | 250 | 10.11 | 20 | 20 | 12 |
| 2021 | 3 | 14 | 12 | 1 | 14 | 60 | 1018 | 250 | 10.11 | 20 | 20 | 12 |
| 2021 | 3 | 15 | 23 | 1 | 8 | 60 | 1018 | 250 | 8.95 | 20 | 20 | 12 |
| 2021 | 6 | 1 | 0 | 1 | 33 | 90 | 1019 | 300 | 5.4 | 20 | 2.9 | 13 |
| 2021 | 6 | 2 | 12 | 1 | 33 | 90 | 1019 | 300 | 4.5 | 20 | 2.9 | 13 |
| 2021 | 6 | 3 | 18 | 1 | 33 | 90 | 1019 | 300 | 3.38 | 20 | 2.9 | 13 |
| 2021 | 6 | 4 | 23 | 1 | 33 | 90 | 1019 | 300 | 1.5 | 20 | 2.9 | 13 |
| 2021 | 6 | 5 | 0 | 1 | 33 | 90 | 1019 | 300 | 1.5 | 20 | 0 | 13 |
| 2021 | 6 | 6 | 12 | 1 | 29 | 90 | 1019 | 300 | 2.3 | 20 | 0 | 13 |
| 2021 | 6 | 7 | 18 | 1 | 33 | 90 | 1019 | 300 | 0.5 | 20 | 0 | 13 |
| 2021 | 6 | 8 | 23 | 1 | 33 | 90 | 1019 | 300 | 1 | 20 | 0 | 13 |
| 2021 | 6 | 9 | 0 | 1 | 35 | 90 | 1019 | 300 | 1.8 | 20 | 0 | 13 |
| 2021 | 6 | 10 | 12 | 1 | 33 | 90 | 1019 | 300 | 1.5 | 20 | 0 | 13 |
| 2021 | 6 | 11 | 18 | 1 | 33 | 90 | 1019 | 300 | 1.5 | 20 | 0 | 13 |
| 2021 | 6 | 12 | 23 | 1 | 32 | 90 | 1019 | 300 | 0.88 | 20 | 0 | 13 |
| 2021 | 6 | 13 | 0 | 1 | 33 | 90 | 1019 | 300 | 2.55 | 20 | 0 | 13 |
| 2021 | 6 | 14 | 12 | 1 | 34 | 90 | 1019 | 300 | 3.5 | 20 | 0 | 13 |
| 2021 | 6 | 15 | 18 | 1 | 33 | 90 | 1019 | 300 | 1.5 | 20 | 2.9 | 13 |
| 2021 | 12 | 1 | 0 | 1 | 8 | 80 | 1017 | 360 | 10.9 | 20 | 20 | 14 |
| 2021 | 12 | 2 | 12 | 1 | 11 | 80 | 1017 | 360 | 11.38 | 20 | 20 | 14 |
| 2021 | 12 | 3 | 18 | 1 | 28 | 80 | 1017 | 360 | 13 | 20 | 20 | 14 |
| 2021 | 12 | 4 | 23 | 1 | 20 | 80 | 1017 | 360 | 13.88 | 20 | 20 | 14 |
| 2021 | 12 | 5 | 0 | 1 | 18 | 80 | 1017 | 360 | 9.66 | 20 | 20 | 14 |
| 2021 | 12 | 6 | 12 | 1 | 11 | 80 | 1017 | 360 | 13.88 | 20 | 20 | 14 |
| 2021 | 12 | 7 | 18 | 1 | 10 | 80 | 1017 | 360 | 9.4 | 20 | 20 | 14 |
| 2021 | 12 | 8 | 23 | 1 | 8 | 80 | 1017 | 400 | 11.11 | 20 | 20 | 14 |
| 2021 | 12 | 9 | 0 | 1 | 6 | 80 | 1017 | 400 | 13.88 | 20 | 20 | 14 |
| 2021 | 12 | 10 | 12 | 1 | 12 | 80 | 1017 | 400 | 12.2 | 20 | 20 | 14 |
| 2021 | 12 | 11 | 18 | 1 | 9 | 80 | 1017 | 400 | 13 | 20 | 20 | 14 |
| 2021 | 12 | 12 | 23 | 1 | 15 | 80 | 1017 | 400 | 13.88 | 20 | 20 | 14 |

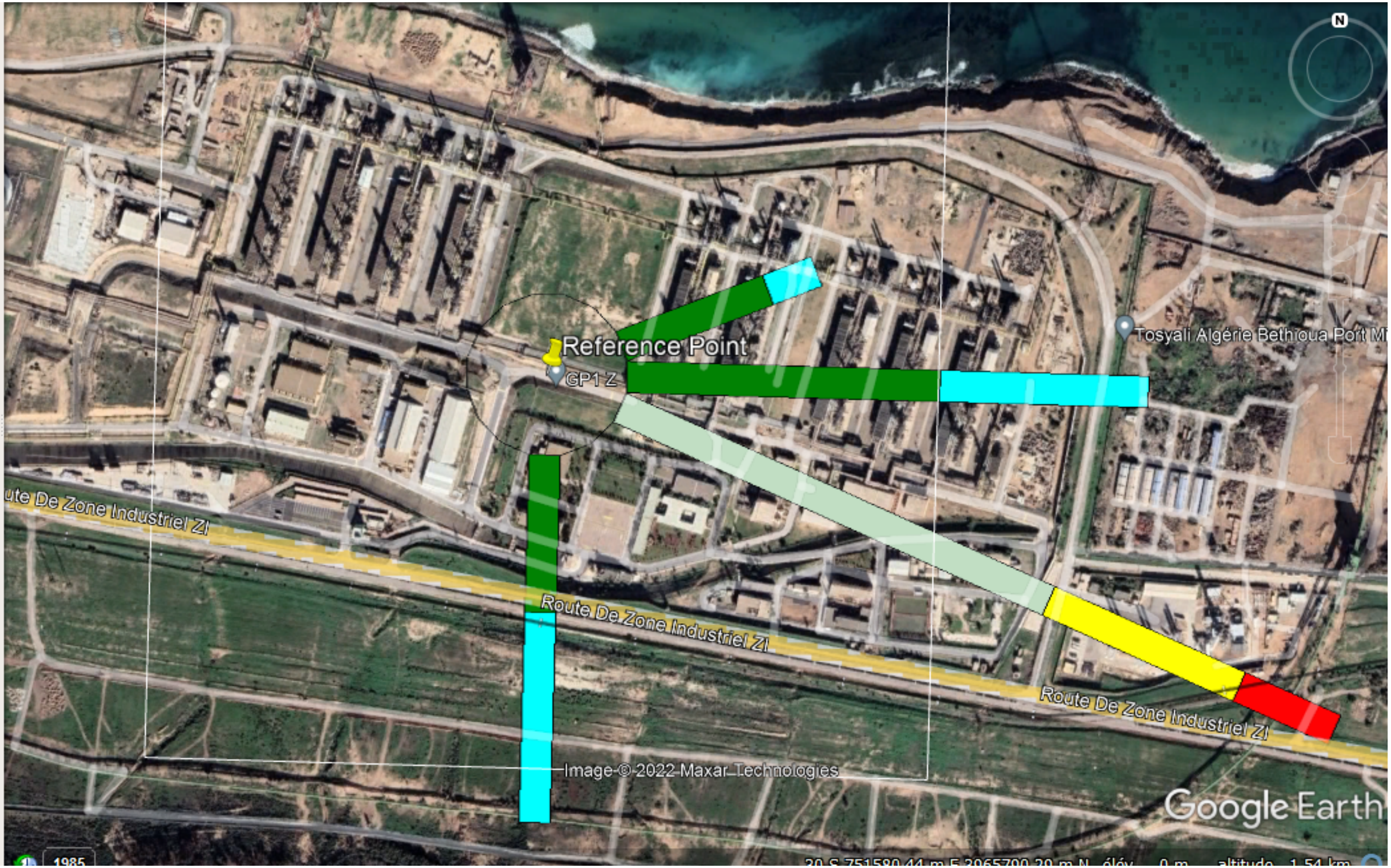

AERMET View 8.9.0 - [C:\Users\user\Desktop\Test-AERMOD-12-05-22\test27-05.amf]
File Mode Data Run Tools Help
New Open Save Run Surface Onsite Upper Air Sectors Output WRPLOT Export Help
KML
Processing Options
Sectors (Surface)
Output Files
AERMET Output Files
Version: 14134 CCVR_Sub TEMP_Sub
Start Date: 21 03 02 01
End Date: 21 12 15 24
Surface:
test27-05.SFC
Start Date: 21 03 02 01
End Date: 21 12 15 24
Profile:
test27-05.PFL
Merge File
test27-05.MRG
Upper Air
Date:
Location:
Surface
Date:
Location:
Dates to be Retrieved (YYYY/MM/DD)
Start Date:
2021/03/02
End Date:
2021/12/15
Help
Previous
Run


WRPLOT View 8.9.0
File Edit Tools Help
Display
Wind Speed
Stability Class
Wind Directions: 16
Wind Classes [6]...
Units
Knots
m/s
Orientation
Direction (blowing from)
Flow Vector (blowing to)
Met Data Information
Frequency Count
Frequency Distribution
Wind Rose
Graph
Station # 1 - GNL, AL Dates: 02/03/2021 - 12:00 ... 07/12/2021 - 18:00
Print...
Options...
Export...
NORTH
SOUTH
WEST
EAST
35%
28%
21%
14%
7%
WIND SPEED
(m/s)
>= 11,10
8,80 - 11,10
5,70 - 8,80
3,60 - 5,70
2,10 - 3,60
0,50 - 2,10
Calms: 0,00%



File Edit Tools Help
Display
Wind Speed
Stability Class
Wind Directions: 16
Wind Classes [6]...
Units
Knots
m/s
Orientation
Direction (blowing from)
Flow Vector (blowing to)
Met Data Information
Frequency Count
Frequency Distribution
Wind Rose
Graph
Station # 1 - GNL, AL Dates: 02/03/2021 - 12:00 ... 07/12/2021 - 18:00
Print...
Options...
Export...
NORTH
SOUTH
WEST
EAST
35%
28%
21%
14%
7%
WIND SPEED
(m/s)
>= 11,10
8,80 - 11,10
5,70 - 8,80
3,60 - 5,70
2,10 - 3,60
0,50 - 2,10
Calms: 0,00%


N
Reference Point
GP1 Z
Route De Zone Industriel ZI
Image © 2022 Maxar Technologies
Route De Zone Industriel ZI
Google Earth
1985
30 S 751736.43 m E 3965436.64 m N élév. 0 m altitude 1.54 km


N
Reference Point
GP1 Z
Tosyali Algérie Bethioua Port
Route De Zone Industriel ZI
Route De Zone Industriel ZI
Image © 2022 Maxar Technologies
Google Earth
1985

**Annex C**

## 6 Key Design Principles of A Industrial 4.0 ( the smart factory )

The smart factory is the name given to the new revolutionary industries And each smart factory has functional requirements that each one should include or use which emphasise what is possible today with existing technology, are based on six basic factory design principles

**Modularity**

This design capability enables system components to be assembled, disassembled, and recombined quickly and easily. On the production floor, this translates into being able to add, relocate, or rearrange components in the production line with minimal time and effort. A highly modular smart factory design enables the rapid integration of smart assets, which can be supplied by multiple vendors.

**Interoperability**

A smart factory design that emphasises interoperability ensures that technical information can be shared within [or between] system components. Such business information can then be shared between manufacturing enterprises, suppliers, and customers.

**Decentralisation**

Bringing decentralised and autonomous decision making to machines and cyber-physical systems is a core goal of Industry 4.0. The focus is on autonomous system elements, such as modules, material handling systems, and products located anywhere on the production floor. The general goal is to enable CPS to make decisions without regulation by centralised control (man or machine).

Here are two possible standards of autonomy in smart factories:

- Enable CPS to make production process decisions autonomously in real-time, if the outcome does not violate high-level business goals.
- Let embedded computers help autonomous cyber-physical systems interact with their production environment via sensors and actuators.

**Real-time capability**

Based on the modularity the smart factory should be configured / self-configured to respond to the change -both internal and external – on time. This fast response is based on the capability of collecting and analysing up-to-date data. With the capability, manufacturers will gain the insights of root-cause and predict potential risk of unplanned shutdown, as well as schedule the production line shift based on the ever changing customer demand.

**Virtualisation**

This process combines physical manufacturing systems, their digital equivalents, and process data to create a virtual factory environment. In this virtual environment, it's possible to:

- Monitor, control, and simulate physical systems and processes.
- Send data to update the virtual model in real-time.
- Make design changes to the factory by creating digital prototypes.
- Train the workforce to perform manual tasks.
- Diagnose and predict faults.
- Guide employees in maintenance tasks.

**Service orientation**

This design principle shifts the focus from selling products to selling products and services. Smart factories with a service orientation strategy will design and produce products, create related services, and sell them together. This approach encourages the innovative improvement of core processes and if necessary, the outsourcing or elimination of other processes.

- Responsiveness This essential capability reacts to changes in the status of internal production systems, customer tastes, or other changes in the market. Responsive smart factory designs:
- Use real-time data monitoring and analytics methods to identify process, equipment, or market changes.
- Include enough modularity to expedite system recovery or changes to production processes or equipment.
- Include real-time responses to internal changes, monitoring, and control.