CHAPTER 1

PART 1 - CLIMATE SYSTEM AND COMBATING GLOBAL WARMING AND AIR POLLUTION

1.1 Summary

The rapid global industrialisation including the shipping industries in last few decades, has led to drastic increase in the use of fossil fuels which are primarily composed on Hydrocarbons. The fossil fuel consists of Hydrogen, Carbon and Sulphur which, when burnt, turned into water vapour, CO_2 and CO, various kinds of Sulphur Oxides (SO_x) and also during the burning process with air it produces Nitrogen Oxides (NO_x). As shown in Figure 1 below, the atmospheric concentrations of important long-lived greenhouse gases over the last 2,000 years only saw minor changes until about 1750 when the first industrial revolution began. To this end, the rapid increase in the level of pollutants shown therefore can be attributed to the human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion air molecules, respectively, in an atmospheric sample.(Ziarati el al, 2018, MariEMS Project, the evolution of atmospheric concentration of a number of GHG emissions extracted from IPCC (2007a).

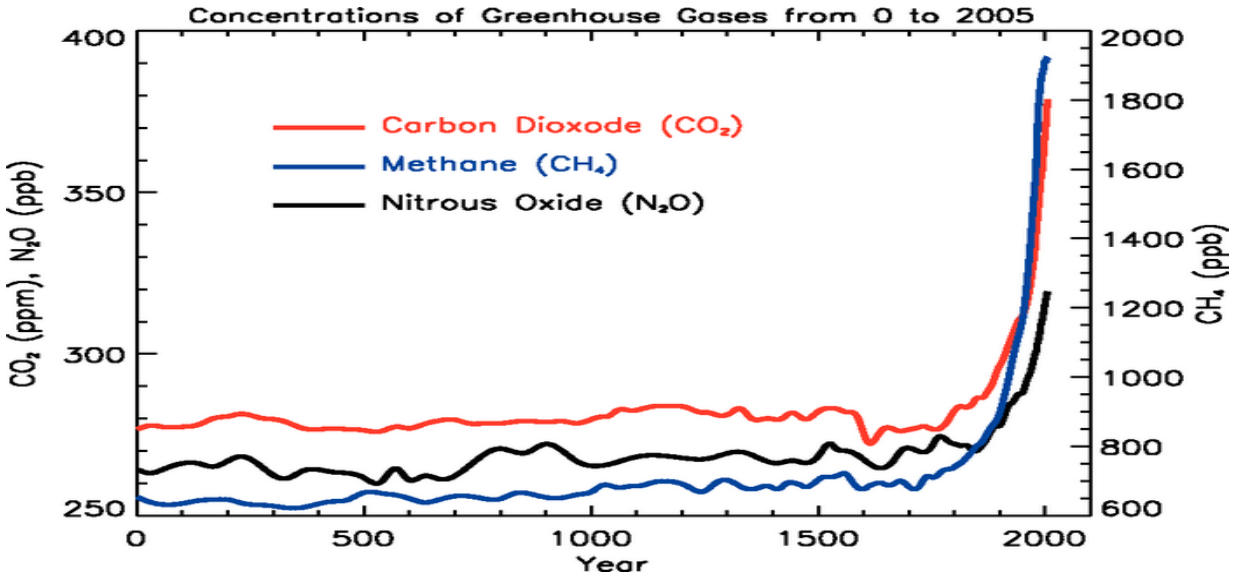


Figure 1. The atmospheric concentrations of important long-lived greenhouse gases over the last 2,000 years. Source IPCC (2007a).

Except the water vapour, the other flue products are mainly toxic and some of them contribute to reduce the Oxygen level in the air. These emissions have severe impact on human health and natural eco systems including sea and shore. Air emissions affected the public health; the environment, sea, land, agriculture, etc. which has been deeply notified and observed by the international authorities and scientific community (Ziarati et al, MariEMS, 2020)[1]. Clean air is of utmost requirement for breathing by human and other creatures. The human lungs breathe in about 13,000 litres of air a day on a normal pace. Therefore, air quality is a very important factor for human body as the lungs have a direct access to it and Oxygen in the air is mixed with blood in the lungs.

Therefore, contaminated air with harmful substance has a direct effect to damage the respiratory systems and eventually, the whole body. The negative impact on human body was first observed in the highly dense industrialised cities where the first effort to manage the air quality was initiated.

Air pollution, in the long run, is responsible for destroying the eco system and eventually it is responsible for several diseases to biological environment. There are other kinds of emissions which are known as Greenhouse Gas (GHG) and Ozone Depleting Substances (ODS). The GHG increases the earth's temperature resulting in climate change and the ODS raptures the Ozone layers which is very important factor to filter out the cancer causing Ultra Violet rays from the Sun. The GHG and ODS are considered to have global impacts while the other pollutants are mostly but not entirely responsible for the local or regional impacts.

The global industrialisation and subsequent marine transportation system growth has been solely based on the energy sources from fossil fuels. The huge increment of exploration and combustion of fossil fuels due to global trade demand is causing increment in contaminant addition to air, which in turn is causing global warming and climate change.

The amount of pollutant emitted to air is so large that it cannot be ignored any further.
Warming of the climate system is now evident from the observation of increases in global ocean and air temperatures, widespread melting of ice and rising global average sea level.

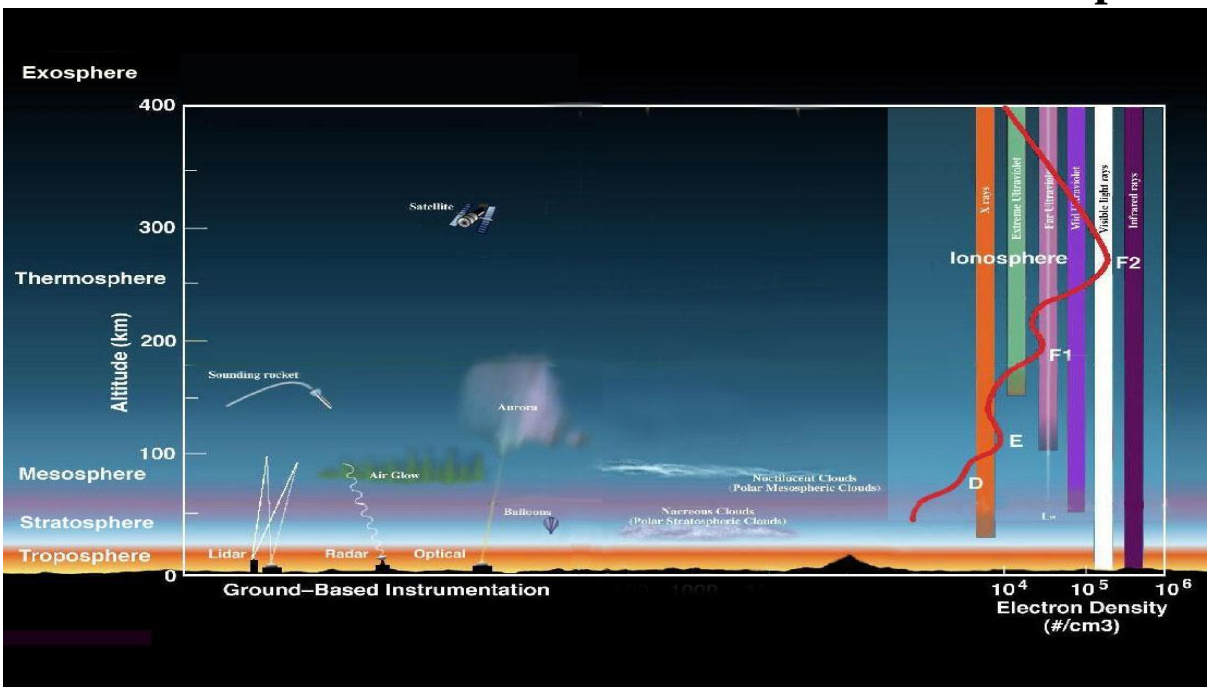
[1] MariEMS Train the Trainee (MariTTT) Courses on Energy Efficient Ship Operation - https://www.marifuture.org/Reports/Development-Papers/ADP_06_2020_MARIFUTURE.pdf

Taking the impact into account, it would be prudent to keep the rate of increment of air pollution under control by utilising the available energy resources in a very efficient manner and to minimise the emission of ODS.

It is well established that the air contains a large variety of gas and vaporous components. Despite the overwhelming presence of oxygen and nitrogen, the atmosphere contains various gases, vapours and aerosols. Such substances originate from natural processes or as a result of human activities.

- Naturogenic Emissions: Natural chemical and biochemical processes release and particulates matters and gaseous substances into the atmosphere e.g. volcanoes gas eruptions, forest fires, decaying dead animals, humans or plants, etc. These are referred to as Naturogenic Emissions.
- Anthropogenic Emissions: Marine and industrial activities, produce a large amount of gases and chemicals which are released into the atmosphere. These emissions are increasing day by day as the industrialisation and shipping trade increase. These emissions are normally known as anthropogenic emissions.

The atmosphere contains all the air in Earth's system. It extends from less than 1 m below the planet's surface to more than 10,000 km above the planet's surface. The upper portion of the atmosphere protects the organisms of the biosphere from the sun's ultraviolet radiation by means of the protecting layer of Ozone gas. It also absorbs and emits heat. When air temperature in the lower portion of this sphere changes, weather changes occur. As air in the lower atmosphere is heated or cooled, it moves around the planet as a result of density change. The result can be as simple as a breeze or as complex as a tornado. The diagram below (Figure 2) is a good representation of the layers within Earth's atmosphere.



Firgure 2. The layers within Earth's atmosphere. Source Ziarati el al, 2018, MariEMS Project, the evolution of atmospheric concentration of a number of GHG emissions extracted from IPCC (2007a).

The troposphere is the first main layer in the atmosphere and it is often referred to the Earth's blanket; it reflects infrared radiation and warms the earth; unfortunately it also contains Ozone depleting substances such as man-made pollutants (Fluorocarbons, CFCs, HFCs and other cooling agents, some of them radioactive). Almost all of weather changes happens within this layer. The troposphere forms the lowest level of the Earth's atmosphere, extending down to the surface of the Earth.

The layer just above the troposphere is the stratosphere. It is the second main layer in the atmosphere and contains the ozone layer which filters the UV light coming from the sun's radiation; unfortunately, the man-made pollutants in the troposphere deplete the ozone in the stratosphere which are the main reason for the hole in the ozone layer. No weather changes happens within this layer. The Green House Gas (GHG) is a very important part of the stratosphere because it reflects the energy of the infrared emitted by the earth's surface. What this means is that it keeps earth warm, without it the earth would be too cold for life to be sustained. The presence of the GHG in The stratosphere is not a problem in itself, in fact as mentioned above, it is vital in keeping the earth warm. (Ziarati et al, MariEMS Project 2018).

The global warming and the air substances absorbed by the oceans deeply affect their health. Ecosystems and habitats are disturbed by the changes to the ocean properties as a result of global warming. Another consequence of the warming is the ocean dilatation and sea level rise which endangers the coastal ecosystems and accelerates erosion.

In addition, the carbon dioxide combined with other atmospheric compounds possesses another important impact: oceans acidification. As part of the natural carbon cycle, oceans absorb the CO_2. While the CO_2 increases in the air, its amount dissolved in the oceans increases. In the sea water, the CO_2 reacts with H_2O and forms carbonic acid and the overall acidification process of the ocean begins.

$CO_2 + H_2O = H_2CO_3$

As pointed out by *Hunter et al. (2011),* "the acidification of the surface ocean by anthropogenic carbon dioxide (CO_2) absorbed from the atmosphere is now well-recognized and is considered to have lowered surface ocean pH by 0.1 units" (corresponding to an approximately 25% increase in the acidity of the surface of the oceans) since the mid-18th century." (GESAMP, 2012). The present rate of increase in ocean acidification has no precedent for the last 30 million years. The high speed acidification may impair the ability of many organisms to cope with changing oceanic properties.

Ocean acidification is known to have significant impacts on ocean areas, including reduced ability of many key marine organisms, including calcareous phytoplankton, the base of much of the marine food chain, to build their shell and skeletal structures; increased physiological stress, reduced growth and survival of early life stages of some species. (IOC/UNESCO, 2011).

In global risks context, the local and national regulations could be deemed ineffective and insufficient as this needs a global response. The progressive recognition of this context offers opportunities to the United Nations bodies to drive adequate international governance.

In 1972 the United Nations Conference on the Human Environment (UNCHE) adopted a body of principles which transformed into international instruments.

The early 80s discovered the global consequences of the air emission through the development of the Ozone holes above poles. This global threat was directly addressed at an international level that lead to Montreal Protocol on Ozone Depletion issues. Adopted in 1985, the Vienna Convention for the M1 Climate Change and the Shipping Response module.

Efforts during the 1970 and 1980 produced multiple international regulatory instruments to protect air quality. These instruments aimed to control identified substances but did not intend to holistically address the issue of climate change. In parallel to the creation of such instruments, several international conferences were organized on climate change, but no internationally binding instrument was adopted (Ziarati et al, MariFuture, Development Papers, 2016-2019)[2].

Another important outcome of the UNCHE was the creation of the United Nations Environment Programme (UNEP), whose mandate is to coordinate the global response to established and emerging environmental challenges. UNEP activities cover the atmosphere, marine and terrestrial ecosystems, environment governance and green economy.

In the field of climate change the UNEP supports countries and, in particular, developing nations with integrating the climate problem in their domestic development process. Four elements foster the achievement of this objective

-Adapting to climate change. The purpose is to reduce vulnerability and improve resilience.
-Mitigating climate change. The UNEP supports technologies, policies and investments designed to reduce GHG emissions as well as energy efficiency and conservation programs
-Reducing emissions from deforestation and forest degradation. The purpose is to valorize forests and sinks as well as promoting sustainable management of forest ecosystems.
-Enhancing knowledge and communication. The UNEP support education and awareness programs (Ziarati et al, MariFuture, Development Papers, 2016-2019).

Created under the auspices of the UNEP and the WMO, the Intergovernmental Panel on Climate Change (IPCC) was endorsed by the UN in 1988. The objective was to build an

[2] See the 36th Development paper published in August 2019 - https://www.marifuture.org/Reports/Development-Papers/ADP_08_2019_MARIFUTURE.pdf

internationally recognised structure capable to monitor and diagnose the evolution on the climate system and its consequences regularly.

Purpose of the IPCC is to provide a clear scientific view on climate change and its potential environmental and socio-economic consequences as well as propose control measures and solutions. IPCC is thus the ultimate expert authority on environmental issues those related to climate change. The IPCC gathers the data published worldwide and produces assessments reports about climate change. Thousands of scientists participate in the IPCC in order to provide accurate, rigorous and reliable data to policy makers (Ziarati et al, MariFuture, Development Papers, 2016-2019).

After years of intensive negotiation through the Intergovernmental Negotiating Committee on Climate Change, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted and opened for signature in 1992 in the Rio summit. The UNFCCC entered into force in March 1994. This Convention was drafted in accordance with the format designed for the Vienna Convention for the Protection of the Ozone Layer. The UNFCCC is another framework Convention which focuses on promoting cooperation by means of systematic observations, research and information exchange on the effects of human activities on climate and adopting legislative or administrative measures against activities likely to have adverse effects (Ziarati et al, MariFuture, Development Papers, 2016-2019).

The Kyoto Protocol is an international agreement linked to the United Nations Framework convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005. Its first commitment period started in 2008 and ended in 2012.

Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of “common but differentiated responsibilities”. During the first commitment period, 37 industrialized countries and the European Community committed to reduce GHG emissions to an average of five percent against 1990-levels.

The Kyoto Protocol is seen as an important first step towards a truly global emission reduction regime that will stabilize GHG emissions and can provide the architecture for future international agreement on climate change (Ziarati et al, MariFuture, Development Papers, 2018-2019). The Kyoto Protocol set binding emission targets for the developed countries in Annex 1 in order to pursue the ultimate objective of the UNFCCC*: " with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012".* (UNFCCC www-pages 2019). In addition, the Annex B of the Kyoto Protocol under the "quantified emission limitation or reduction commitment" contains the targets to be reached by individual countries. The GHG emissions are categorized as six main item including CO_2, CH_4, N_2O, HFCs, PFCs, and SFs. (UNFCCC www-pages 2019). A good account of air pollution is given in the Ziarati et al Development Papers, December 2016 - February 2019).