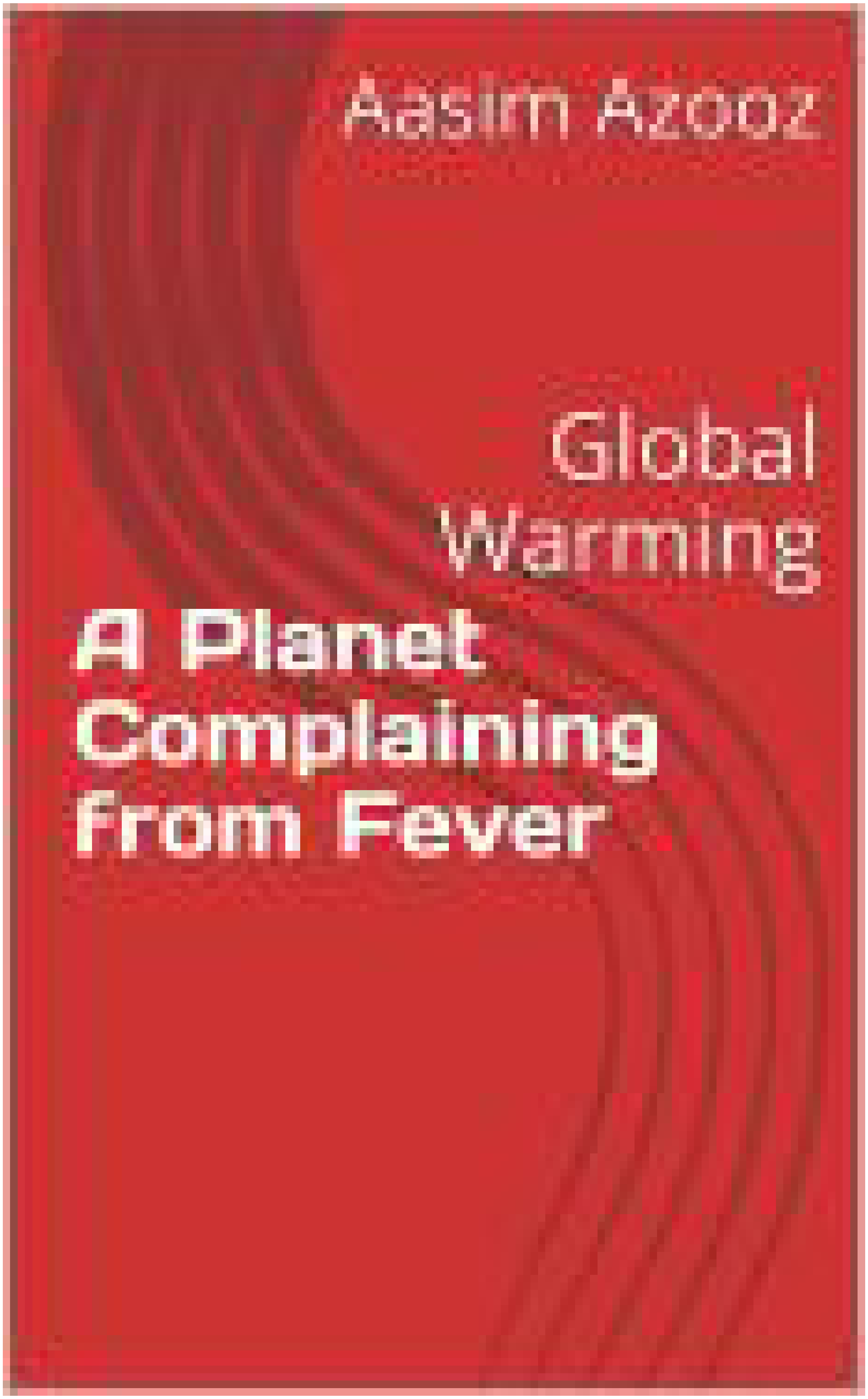
Aasim Azooz
Global
Warming
A Planet
Complaining
from Fever

A Planet Complaining from Fever (Global Warming)

Aasim Azooz

The Author

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Dr Azooz had to leave Mosul in 2014, after it was taken over by ISIS, and is currently living as a refuge in Lebanon waiting for reallocation.

Preface

Humanity faces many huge problems. These include hunger, poverty, illiteracy, epidemic illnesses, wars, terrorism, mass displacements, water shortages and others. Even so, man has somehow learnt to adapt to these problems, and live with them. They have become an integral part of his history on this planet. As if these problems were not enough, somewhere over the horizon, appears a strange new one, which man is unfamiliar with, and does know how to either solve, or live with. Ironically, and much similar to man's other problems; this one again is his own doing. It is the danger of earth climate change, or global warming as it is called. The purpose of this book is to throw some light on the historical, scientific, environmental, economical and political aspects of the subject.

The book is addressed to the general reader, and it does not require any prior knowledge apart from simple arithmetic. I have tried my best to exclude any mathematical equations from the text.

This book is not a scientific research review, or an academic thesis work. Consequently, I did not prefer to add reference citations, or footnotes relating to statements made, as those may cause only distraction for the general reader. Instead, the book contains an appendix, which lists most of the important websites needed by a reader who is interested in further information about a particular subject

Information in the book are obtained from well credited public domain publications such as the those of the united nations, International Energy Agency, the World Bank, and those of official Governments websites.

Chapter One

Alive Planet

Earth and Life

Scientists say that earth was formed 4.56 billion years ago, and it became supportive to some kinds of life during last 500 million years only. We are not interested here with presenting different theories concerning the creation of the universe in general or the earth in particular. It neither our interest, nor our specialization, to get involved in any discussion related to the teachings of different religions about the creation of universe. Our interest in earth springs out of simple basic fact. This fact is that we humans have found ourselves living on this planet, with water covering three quarters of its surface. One of the very few things, which scientists and all religions agree about, is the fact that this water is the basic ingredient for life on earth. Uncountable numbers of living species of plants, animals, and what is between them, come to life, reproduce, and die, or even become extinct. Each species has its own role to play on this earth. This is true from both purely theological religious and evolutionary scientific points of views. As far as the religious way of thinking is concerned, the Divine Creator who put life on this earth is surly interested in its continuity until he decides otherwise. The evolutionary theory, which is based on natural selection from probalisticaly random events, has the inherited assumption that life is to continue. Even with these two completely different scenarios, it is only spectacular to note that so many very simple things can determine if lives can exist or not. To demonstrate this fact, let us just assume that the charge of electron was 1.4×10^{-19} Coulomb instead of its well-known value of 1.6×10^{-19} Coulomb. This hypothetical assumption only reduces the electric charge of the electron by about 0.12%, which should not be a big deal in any case. Even so, this reduction will cause all life to seize to exist all together in one go. This fact becomes less surprising if we remember that this hypothetical reduction in electronic charge will result in 41% weaker bonding between Hydrogen and Oxygen atoms within water molecules because binding energy is proportional to the fourth power of electronic charge. This weaker bonding can make water molecules susceptible to dissociation by ordinary blue sunlight of 400-nanometer wavelength instead of the need for 280-nanometer ultraviolet wavelength. The ultimate trivial consequence under such circumstance is the dissociation and disappearance of water altogether. This will consequently end all kinds of life, as we know it. Fortunately, the bonding of water molecules can only be broken down by ultra violet radiation and not ordinary sunlight. Another fortunate fact is that earth has it natural protection against ultraviolet radiation coming from the sun. This point will be further discussed at some later stage. This simple example may demonstrate the very sensitive and susceptible balance between interacting nature's constituents, and how any disruption of this balance, can result in catastrophic consequences on life.

Some people will consider it a form of exaggerated arrogance to say that the human specie is the most important specie on this earth. Even so, such a statement may seem reasonable in the current time at least. To justify such statement, we have to admit that every creature has an important role to play in the process of maintaining the biological equilibrium on this planet. Having admitted so, one might reach the conclusion that man's role in this process is far grater than even what man himself thinks.

. To explain this super role further, let us get back to the constituents of this planet, which we found ourselves living on in order to define man's role and responsibility in the continuation of life, as we know it. We must admit here that in spite of the fact that man played no role in the creation of life, he may have a decisive one in its destiny.

Characteristics of Earth

Earth is a planet that spins about its axis, and revolves round the sun. The latter provides all the energy needed for life to continue. The core of the earth is a huge mass of melting metals (mainly iron). This core generates the earth magnetic field. This magnetic field plays an important role in the continuation of life on earth. This importance will be further discussed later. The earth core is surrounded by the solid earth crust, which consists of calcium and silica compounds, forming rocks, soil and sand. Oceans and seas, which cover three quarters of the earth surface, are contained within this crust. Earth has a mass of 5.972×10^{24} kilograms (about six thousands million million million Tons). The mean radius of earth 6371 kilometers measured from its center to the surface. This gives the value of its circumference as 40075 kilometers. It is interesting to note that history records show that it was the Greek scholar, astrologist, and mathematician ***Eratosthenes*** has made the first experimental measurement of the earth circumference in 240 BC. His measurement is considered accurate to within 0.5%. Eratosthenes used a very genius method to carry out this task without any need to leave the land of Egypt. In short, Eratosthenes used the time difference for the sun to be directly overhead at noon in two locations in Egypt on the day of the Summer Solstice. These two locations were

Alexandria and Aswan. The distance between these two locations was reasonably known to be equivalent to about 800 nowadays kilometers. His measurements showed that this time is 1/50 of the 24-hour day. Using his knowledge in mathematics and trigonometry, Eratosthenes concluded that the earth circumference is $800 \times 50 = 40000$ kilometers.

Earth's Atmosphere

Earth is surrounded by a gaseous mixture, which extends to a height of about 480 kilometers above its surface. The bulk of gaseous atmosphere is concentrated within the first 16 kilometers above the earth surface. The atmosphere exerts atmospheric pressure on everything existing on the earth surface including our bodies. Without this pressure, our bodied will simply explode outward like rubber balloons. This is the reason why astronauts wear specially designed thick, perfectly sealed space suits containing atmospheric pressured air, which balances their internal body pressure. Any tiny puncher in these space suits will definitely be fatal to the astronaut's life.

The volume ratios of the main constituents of earth atmosphere are Nitrogen 78.09%, Oxygen 20.95%, Argon 0.93% and Carbon dioxide currently at about 0.04%. Water vapor ratio over the whole atmosphere is about 0.4%, and reaches up to 1% at sea level. In spite of the fact that these ratios are well known to most people, some contemplation on them may be essential in reaching the goal behind writing this book.

Considering one of these atmospheric constituents, which is Oxygen as an example, may expose few surprising facts about the delicate balance of this planet. The natural atmospheric concentration of oxygen is 20.95%.

Decreasing this amount by only 1% can result in a dangerous atmosphere. The United States 1970 Industrial Safety Code defines the minimum Oxygen concentration in industrial areas at 19.5%. Oxygen levels below this limit are considered highly dangerous or even fatal. There have been cases of people suffering suffocation at Oxygen levels of 20%. On the opposite side, a person can suffer Oxygen poisoning at atmospheric Oxygen level of 23%. This is happens to sea divers unless they take complicated measures during ascends, in order to avoid such poisoning. Furthermore, atmospheric Oxygen levels above 21% will catalyze fire ignitions of forests all over the world. This will ultimately result in the end of life on this planet. Similar, but may not be identical consequences related to disturbances in atmospheric Nitrogen levels. These consequences do not represent our major concern here because we are more interested in Carbon dioxide in the first place. Some discussion related to Ozone also will be given at some coming stage.

Sun's Energy

The relation between earth and the sun is that of a locked common destiny type. This relation is governed by the energy received by earth from the sun. This energy is affected by factors like the distance between earth and the sun, nature of earth atmosphere, earth surface properties …etc. These factors beside many others have made planet earth uniquely distinguishable from other solar planets. This distinction stems from the fact that earth accommodates life, as we know it.

Energy from the sun reaches earth in three main forms. One of these forms is the visible white light, which is a mixture of colors ranging between violet and red. The other two forms are the ultraviolet, and the infrared radiations. Both these latter forms are invisible to the human eye. These three forms of radiation represent a very narrow band in a much wider radiation spectrum called the electromagnetic spectrum. All radiations within this spectrum are vibrations of electric and associated magnetic fields in space. These vibrations share the universal property of traveling with the same speed of light. This speed is 300000 kilometers per second. However, and in spite of the fact that all types of electromagnet radiation are parts of the same family, they differ from one another in their wavelengths. This wavelength represents the decisive factor in the effect of each type of radiation on both living and nonliving materials. Table (1) presents a list of these electromagnetic radiations together with some of their properties and uses.

Table (1) Type, wavelengths and uses of electromagnetic radiations

$$Millimeter = \frac{1}{1000} meter \text{ . } nanometer = \frac{1}{1000000000} meter$$

Uses	Wavelength	Type of wave
Long, medium and short wave radio	10 – 1000 meters	Radio waves
TV and radio transmissions	0.2 – 10 meters	TV an FM radio waves
Radar, satellite TV, internet and microwave ovens	0.001 – 0.2 meters	Microwaves
Heat radiation	1 millimeter – 700 nanometer	Infrared radiation
Vision	390 – 700 nanometer	Visible light
Sterilization	10 – 390 nanometer	Ultraviolet radiation
X- ray diagnosis	0.01 – 10 nanometer	X- ray
	Less than 0.01 nanometer	Nuclear Gamma radiation

Ultraviolet Radiation

The sun emits all above types of electromagnetic radiations. Even so, the important ones, which reach earth, are only three. These are the infrared, which are heat waves, white visible light, which ultimately transforms to heat, and ultraviolet (UV) radiations. The latter is of some very special importance because of its energy, which enables it to breakdown molecular bonds connecting elements, which form chemical molecules. Ultraviolet radiation can simply cause water molecules H_2O to dissociate to Hydrogen and Oxygen. Ultraviolet can also alter, or even destroy complicated molecular structures, which form living tissues. Such destructions are life threatening. Typical major disease induced by exposure to ultraviolet radiation, is skin cancer. This is why most weather forecasts give predictions about the UV index beside their usual rain, wind and temperature forecasts. It is reasonable to say that most types of known life will ultimately disappear if all ultraviolet coming from the sun can make it through to the earth surface. Luckily enough, this is not the situation. Ultraviolet cannot pass earth atmosphere and reach earth surface due to the presence of Ozone. Ozone is a special form of Oxygen formed from bonding of three Oxygen atoms O_3, instead of two, as it is the case with ordinary Oxygen O_2. Ozone has very interesting property of being able to absorb most ultraviolet radiation coming from the sun, preventing it from reaching earth surface. More discussion on this subject will come in a future chapter.

Solar Wind

In addition to electromagnetic waves mentioned above, the sun ejects streams of electrically charged particles into space. These particles are ions of atoms belonging to elements that have lost electrons because of the sun high temperature. Some of these streams of ions have enough energy to reach earth and they are called ***Solar Wind***. The earth magnetic field acts to deflect these charged particles toward the north and south poles where they become neutralized, emitting bright colorful lights known as the ***Aurora,*** which can be seen in courtiers close to the poles such as north Canada, Sweden, and Norway.

Cosmic Radiations

Earth receives other types of radiations that do not originate from the sun. The sources of these radiations are far away galaxies deep in the universe. These radiations are very highly energetic charge particles that can strongly react with materials, representing a danger to all kinds of life on earth. The earth atmosphere acts as a shield to prevent these radiations from reaching earth surface. Cosmic radiation particles interact strongly with upper atmosphere producing another type of weakly reacting particles called μ particles or meons. Meons are members of the same family of the electrons, but with much larger mass of about 207 times that for the electron. It is estimated that the human body is struck by about one meon every second. Even though, these represent no danger to life due to their very weak tendency to react with any matter.

Meteorites

Earth atmosphere play another important role of acting as a shield, protecting earth from Meteorites. These are masses of rocks or ice swimming through space with very high speeds. Some of these Meteorites come close enough to earth and fall into its field of gravity, leading them to strike earth surface with very high speeds, resulting in widespread damages. However, upon entering earth atmosphere, these meteorites are subjected to huge friction force, causing them to heat up and ultimately evaporate before reaching earth surface. It is a nice sightseeing experience to observe the glowing vapors of these meteorites on a clear summer night sky. Taking a close look at a magnified picture of our poor moon surface, which does not have an atmosphere helps understand the silent guard - duty earth atmosphere is doing. Seldom enough, can remains of such meteorites complete their journey through to the earth surface on very rare occasions if they are large enough. Such events can result in large damages in a way similar to what happened when a meteorite resulted in the extinction of dinosaurs millions of years ago.

Nature's Equilibrium

Although very brief, the above presentation of some earth constituents, and the nature of the relation between earth and sun demonstrates that earth has a rare, if not also unique characteristics. Earth is unique at least among its other sister's solar planets. This uniqueness covers earth structure, position, constituents, and the interactions between these constituents. Earth is an extremely complicated system that appears to be specially designed to support the continuity of life in its known forms. This system looks like a vastly huge machine with endless number of gears and wheels acting together in an unbelievingly highly tuned way to perform the simple task of supporting life on earth. The above presentation mentioned only very few parts of this huge system. Relation between earth atmosphere and world oceans, wind, rain, snow and other weather manifestations are not discussed. Furthermore, we only used the simple word "Life" to summarize an almost endless number of types of life ranging between submicroscopic creatures on the lower scale and the man of reason at the other end of the scale. It is reasonable to say that every living cell is a world or even many worlds in its right. These worlds interact, give to and take from each other. In a much similar way, planet earth constituents do the same. Oceans produce clouds that move by wind to form rain. The latter is the basic ingredient of life on this planet. Earth position and its axis inclination angle result in the four seasons of the year. Earth has been repeating this behavior for millions of years. Earth has its sometimes violent ups and down unpredictable changing modes. We see angry volcanoes erupting violently sending lavas and ashes high into the sky, then come to settle quietly for hundreds or thousands of years. The clear blue sea that provide calm of the soul, and inspire poetry, can suddenly change to become all wild and scary. Light little breezes that give us comfort and hope can transform to dark clouded storms carrying rain, snow or even sand. Rivers and streams that revive green fields can get wild, flooding and destroying all those same green fields without warning. Shady green forests may only become fuels for a senseless huge fire on a hot summer day. Lovely looking nice green fields can transform to bare arid land by a wave of hungry locusts. White pieces of clouds decorating the clear blue sky can suddenly become dark heavy storms down pouring heavy rains and thunders, just to calm down again for the blue sky to show up again. We are used to describing all these changes and many others by the one word, "**Nature**". We talk about the charm and beauty of nature, about the cruelty of nature, about nature's anger …etc. Even though, it remains nature. The very use of this word implicitly expresses our familiarity with it. This means that we are very much familiar with all its change of modes, which are also very much expected and anticipated. There is nothing in all this that needs to raise our concerns. We know this nature, we have examined it, dealt with it, and used to it the same way our predecessors have done for millions of years. Every living creature has developed ways to adapt to nature the same way humankind did. Nature has not noticeably changed much during the past millions of years at least, and it is unlikely to change for the next few millions at least, unless it suffers from some accident, or being tampered with by some ignorant or idiot. Nature oscillates back and forth like a pendulum about an equilibrium position. This oscillation may take nature at times to some extreme situations, but it had remained strictly bounded to this equilibrium for millions of years. It is true that there had been some major changes of this equilibrium, but those changes took millions of years to happen, and they were never sudden on natures time scale. Even though, life has done a good job in adapting to those changes. This is due to the long time spans those changed needed to happen. Such adaptation will not be possible if any change in nature's behavior happens suddenly due to some severe accident or because of someone's ignorant actions.

Perturbation of Equilibrium

The probability that nature can become the subject of a severe accident can never be ruled our. This is true if we believe in an Almighty Creator, who made this earth and what is above and underneath its surface, who has well planned its orbit and motion, and he who knows its destiny. This is equally true if we are inclined to believe that the universe had materialized because of a large sequence of random events. This is because randomness by itself involves the probability that anything can happen any time. In both cases, humanity has neither the power, nor the means to prevent such accident that might even destroy our planet partially or completely.

The situation becomes completely different when some vandal tampers with nature. This will be similar to some idiot who knows nothing about electricity or electronics opening a TV back cover, cutting a wire here or there, or removing some part just because he thinks it is good enough to be a nice key holder medal. This will certainly result in an unavoidable catastrophe. This vandal must be a living creature of some kind. It can be plant, or animal, or microscopic or submicroscopic creature. It can be alien creatures coming from the depth of the universe. It can also be humanity it self.

Plants, animals and microorganisms are an integral part of the earth, the basic component of the nature of life on it, without which the life we know does not exist. The basis of life on earth is carbon. That is why it is called carbon life. Apart from some rare bacteria, whose life is based on other elements such as iron, carbon is the main element of all life on earth. Plants, in their various varieties and forms, represent the only natural way in which the earth can store energy from sunlight to transform it into food for other organisms. This occurs through the process of photosynthesis. Animals, plants, microorganisms, and sub microorganisms have formed the basis of the carbon life we know. It is true that some of these creatures were more proliferating and spread, while others were extinct, across different periods of life, but the balance that was sustaining life has remained in one form or another, although some aspects of this balance have changed. It is therefore possible to say that the kingdoms of animals and plants, as well as the kingdoms of microorganisms, are incapable to produce a rapid imbalance in nature. For example, if the number of carnivores on the surface of the earth increases, suddenly, for some reason, it will quickly eliminate the herbivores, so that the first will not have more food, and then will not have the hand or the trick to maintain its increased population. Any excess population beyond some equilibrium limit must thus face its ultimate fate being wiped out because of simple hunger. This equilibrium limit is set by nature itself. This is simply because these animals lack the power to produce their own food and they are restricted by what nature has to give. History of the animal world suggests that changes in the equilibrium of earth animals diversity has required tens or even hundreds of millions of year to take place rather than just few tens or hundreds of years. It is true that there had been some rare cases when plants and animals balanced population was disturbed when earth experienced a cosmic catastrophe like when it was struck by some large enough meteor. This is what is believed to have had happened when dinosaurs became extinct. However, even under those rare situations, plants and animals were the victims and not the cause of the change on this planet

Although the idea that there are beings coming from other worlds that are capable of disturbing the balance of nature on our planet seems very unlikely, if not nondescript, discussion of this subject may be useful. True, there are solid institutions, and even governments, including the US space agency NASA, have devoted their money and efforts to searching for a form of life outside our planet, but these efforts has not produced anything that confirms any kind of life, and even primitive ones, within the space around us, for distances of hundreds of light years. A Light year is the distance traveled by light within a year and equal to 9.561 million million km. If we assume that rational beings have access to technology, which enables them to travel cosmic distances measured by hundreds of millions of light years, or that they have created means of travel faster than that of light, they must also have already come to the manufacture of deadly weapons such as nuclear weapons, or something superior to them. No scientific facts available on the history of the earth showed that it was subjected to any invasion, attack or destruction with weapons of this kind, which caused a change in its climate or a disruption of the balance of its nature. From here, it can be said that the idea of virtual space creatures, tampering with the nature of our planet, is not based on logic or any sound basis.

Human through the Centuries

We have one creature that is capable of disrupting nature's balance on earth in one way or another. This creature has a mind, by which he can plan and manage. He has two hands with fingers, which can work with a unique precision. With his mind and hands, he managed to design and manufacture tools, enabling him to change some of the characteristics of the earth's face. Tools, that served him in cutting forests, diverting rivers, drying parts of the sea, and moving rapidly from one place to another. These tools developed into machines that enabled him invade parts of the space. Other machines and materials helped him build homes that protect him from summer heat, winter cold and other weather ever-changing modes. This creature is only human himself. However, has man throughout the ages caused any tampering with nature, since his presence on earth? To answer this question, it is enough to take a quick look at the history of man on this planet.

No more than 200,000 years ago, man found himself on this planet. He, a carnivore and an herbivore, had to live safely, cut and hunt to eat and save his living, but he did not have sharp claws, or strong teeth. Most animals around him have stronger bodies and their muscles are thicker. The trees are high, and he watches them, but they are not easily accessible. The dangers of monsters stare at him and his children from every side. His nails, teeth and muscles are no match for theirs. However, he had something that is for more severe than the claws, and superior to teeth, and much stronger than the muscles. He had the mind. This mind is distinct from the minds of the rest of the creatures, which also have minds to help them learn, and to gain experience only. There are two commonalities between man and animal, instinct and ability to learn from nature. Nevertheless, man has a unique ability that surpasses animals. This is the ability to innovate and invent to adapt his surroundings to his own advantage. This was the secret of his survival and the continuation of his race. He knew how to use the stone to hunt with it, and how to sharpen a tree branch to become more effective than a clap or claw. This gave him both strength and security that made him well adapt to this situation for more than 190 thousand thousand years. It was only 6000 years ago when his mind tapped about the idea of farming, and invented the plow and the sickle, and became familiar with farming seasons... Farming forced him to leave the high mountain caves down to the open landscape. This forced him to build what were better than caves. These huts soon became cities and kingdoms. Here again, one common instinct between man and animal played its active role. This is the instinct of love for domination and control. Wars were caused by the desire for domination of land, water, property, women, creed, race, color, or even for a camel. These wars required more innovation, weapons developed, stone tools replaced with copper and iron ones, and spears and swords were made. Yes, man, although he has a mind to create and build, can not get rid of his instinct, which he shares with other mammals in his desire to go into conflicts and fighting's with his own race from time to time, for reasons that seem logical sometimes, and out of logic on more occasions. This is not the fault of man in all cases. Man is simply the breed of this nature, and one of the laws of this nature is the need for competitions leading to armed conflicts and wars between different races or between individuals of communities of the same race. This desire for wars may be one of nature's means to maintain its equilibrium. This should not be thought as too worrisome as far as the universal issue of planet earth equilibrium is concerned.

The Pre-Industrial Era

Since ancient times, until the middle of the eighteenth century, humans lived a simple life, relying mainly on agriculture and grazing, using simple hand tools. The human needs of energy were also simple. They did not exceed some of the wood from the trees, the remains of the plants and the waste of the animals. These were used for heating the house and cooking the food. This was all the fuel that a family needed in its daily life. This situation was true for the urban people, faming villages and nomadic shepherds.

Nature was generous with this fuel, and there was never a shortage of it. This fuel was replenished each year. This fuel in was too much excess for human needs, and ended up submerging underground, turning into coal, oil and gas, deep below earth surface, over millions of years. Water was drawn from rivers and wells, and the earth plowed, sowed and reaped using human or animal muscles power. Here, too, nature balanced itself precisely, between what sprouts, what burns, and what is stored beneath its surface. There was a balance between what was on the surface of the land, what was dissolved in the sea, what was stored under its surface, and what was burnt up and turned into gases in the atmosphere. This balance has existed for thousands of years, since the presence of humans on Earth at least up to Mid-eighteenth century AD.

The Industrial Revolution

The use of steam power in the operation of machinery, and driving of transport, was the starting point that completely changed human life. History tells us that the Greeks were the first to make a simple steam-driven machine. This machine was made by ***Hero*** in the first century BC. It was named ***Aeolipile***, meaning the god of ***Aeolus***, the god of air and wind. The machine consisted of a metal sphere that can revolve about an axis. Water inside the sphere is heated and two tubes at a right angle release the steam. Steam coming out of the two tubes cause the sphere to revolve about the axis However, there is no historical evidence that this machine was subsequently used for any practical purpose.

The British inventor ***James Watt*** was the first to make an engine that is driven by the power of steam. James Watt first built a steam-powered machine that pumps out water from coalmines. He then further developed this engine to another, which can produce rotary motion that can be conveyed to other associated driven machines, such as textile machines and wagon wheels. The invention of James Watt for the first rotary steam operated engine in 1781 represented the real starting point for the beginning of the industrial revolution in the world. For the first time in human history, energy derived from burning fuel, is used in driving machinery, towing vehicles and trains, raising loads in ports, dragging plows of agriculture …etc.

Figure (1) Sketch of the first known steam machine designed by Hero during the first century BC.

James Watt's invention of the steam engine changed man's way of living for once and for all in one stroke. For thousands of years, muscle strength of humans and animals were the only sources of mechanical power used for driving everything. However, steam machines replaced these muscles very quickly. Steam machines are called external combustion engines because they burn fuel to heat a steam boiler. These have played a major role putting the wheel of industries and transport into motion for half a century. Another type of more efficient engines, called internal combustion engines followed steam engines. The inventor ***Nikolaus Otto*** was the first to make a machine of this kind in 1876. Otto's machine is considered the legitimate mother of all current automotive engines that use liquid fuel in operation to these days.

It is very justified to say that the use of coal to generate steam and the subsequent use of liquid fuel to run internal combustion engines represented the beginning of the industrial revolution and the subsequent, scientific, technological and medical ones. These revolutions, gave the 20th century a face that is different from that of to every other century past in human history. The invention of the steam engine soon resulted in the beginning of large-scale electricity generation. The first legitimate electricity power station was established in 1879 in Cleveland Ohio. This was followed by invention of electronic valve at beginning of the 20th century. This formed the cornerstone of radio science and radio communications. The first broadcast of television pictures took place in 1927, and the first electronic digital computer appeared in the 1940s to meet the requirements for decoding of World War II encrypted communications. On the other hand, and although horse-drawn trains that rolled on wooden bars were known since the sixteenth century in Europe, the first steam trains, only began to work in Britain in 1804, and it was about 100 years later, when the first mass production of Ford motor cars started in 1903. The same year saw the first successful flying machine built by ***Orville Wright and Wilbur Wright*** brothers.

Gluttony for fuel

Institutions and States quickly realized that all the industrial achievements that had developed since the beginning of the Industrial Revolution required increasing amounts of fuel. It was obvious that cutting off what would grow on the ground would not be sufficient to sustain the running of machinery, rolling of transport and operation of factories. It was necessary to resort to what nature had in store within its interior such as coal, and oil. In short, one of the most important real causes of the post industrial revolution battles and wars, which took place between the countries, was somehow induced by the desire to control areas of the land where thought to contain coal or oil underneath their surface. It may be true that the First World War was triggered by the assassination of Austria's Crown prince in the Serbia. Even so, Britain desires for Middle East oil and Austria's eyes on the coal in Balkan were thought to be worth the effort. World War II started because Germany invaded Poland and North Africa, hoping for the Polish coalmines and North African oil. Britain and Germany invoked their armies, not for the love of the blue eyes of the Poles or the dark eyes of the Middle Eastern people, but for an important reason, that those places were thought to contain the largest coal and oil reserves at the time.

The need for oil and coal has increased beyond imagination. World consumption of coal doubled eightfold between 1900 and 2000, rising from 682 million tons in 1900 to 5.5 trillion tons in 2000. Oil consumption also increased from negligible amounts before 1900 to about 100 million barrels per day at current time. It is worth mentioning that coal consumption has shrunk slightly in recent years, due to its replacement with oil and natural gas.

The price of revolution

The extracting and burning of these enormous amounts of fossil fuels over a relatively short period of about 150 years did not go without a price. These fuels needed millions of years to form. The price of burning them over such a short period goes far beyond the human lives lost in wars that took place in adventures for fuel reserves. These include the First and Second World Wars, and other international and civil wars that erupted in every location where oil exists. All of this can be considered a cheap price from consumer's point of view at least. The price here is much heavier because it is related to earth climate, and the effects of burning these quantities of fuel on the nature of the equilibrium of the climate of the planet, and the extent of disruption of this balance, and its consequences on the future of life on Earth

Coal, oil, and gas are hydrocarbon compounds, mainly made up of carbon and hydrogen. When burnt, they generate water vapor, and carbon dioxide. Water vapor does not have a significant impact on the atmosphere because it enters the water cycle in the atmosphere from evaporation, condensation, rain or snow, and fresh water, ending up in the sea, to restore the cycle again. Carbon dioxide on the other hand is different. This difference needs some explanation here.

The Suffocating Gas

We studied in schools, that CO_2 is a gas that neither ignite, nor assist ignition. For this reason, it is used to extinguish fires. Any amount of this gas released into the atmosphere will end up in one of three destinies. The first is its absorption by green plants, and its re-conversion into oxygen and carbon (wood in plants). The second is its partial dissolution into the waters of the seas and oceans. The remaining part, which plants cannot absorb, and the sea does not dissolve, can only remain suspended in the atmosphere with the other components of the atmosphere. The burning of huge amounts of fossil fuels over the past 150 years, in quantities that could not be processed by plants and ocean waters, has led to cumulative increases in the proportion of this gas relative to other atmospheric constituents. Measurements and studies conducted by several global agencies, including NASA and the US Department of the Ocean and Atmospheric Administration (NOAA) of the US Department of Commerce, have shown that carbon dioxide levels in the earth's atmosphere rose in 2017 and 2018 to record levels of Both 409 and 411 parts per million respectively. Such levels did not occur during the last two million years of the earth's lifetime. These figures are much larger than the 280-part-per-million that prevailed for periods of thousands of years before the Industrial Revolution. Current levels represent an increase of about 50% from those before the industrial revolution, as shown in Figure (2). These Unprecedented levels will result in significant consequences related to climatic changes in the earth's atmosphere. We will examine these consequences and discuss their vital, geographical, economic and political aspects in the coming chapters in more detail.

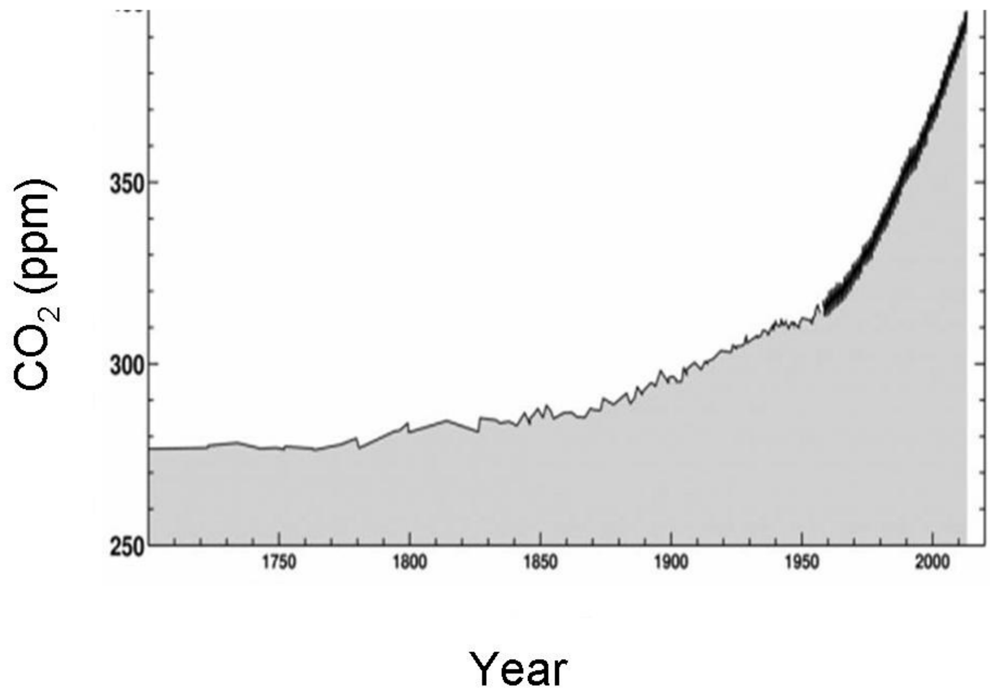

Figure (2) Historical carbon dioxide atmospheric concentrations (NOAA publications)

Chapter Two

Climate Change or Global Warming?

Names and Positions

Difference of opinions, and points of view, are inherent characteristic of individuals and societies, peoples and nations. Differences led to arguments and discussions, resulting in agreements and positive results that benefited humanity. Other disagreements and discussions resulted in a break between brothers, and even devastating wars between countries. Leaders, states, scientists, philosophers, families, and members of one family disagree. Man is subject to controversy, even within himself. This is the nature of life. However, it can be said that it has not happened in the history of mankind and civilization, for a controversial issue to cause a divide within the ranks of scientists and politicians alike, as happened with the theme of (global warming), or as some call it (climate change). The mere use of one of the two names is in fact, an expression of scientific opinion and a political position at the same time.

Quite simply, the advocates of global warming are convinced that the manifestations of climate change are due to human activity, which followed the industrial revolution post the mid-nineteenth century to the present. The skeptics think that all the observed climatic changes are just natural, that the Earth has passed through the like, and therefore there is no need to worry. Skeptics believe that human's activities are neither the cause of this the observed climate change nor can anything be done about it.

Review of the Subject History

Study of the earth's climate and its variations, is a very complex scientific issue. This is because it involves a countless number of complexly interacting and overlapping parameters. Some of these parameters are fairly known. Others are more ambiguous to human knowledge so far. One of the most famous comments on the subject is, "*How can scientists dare, to predict: how will the climate be 50 or 100 years from now, while they do not know exactly how the weather will be next week ??, or when they even fail to make correct forecast for tomorrow!"* Tens of thousands of research papers have been published in literature in recent years. These, if combined, they can form huge volumes. Research results related to climate charge are divided into two sections. The two sections are those of the advocates and the skeptics. Results of members of each section tend to agree among each other, contradicting or critical of those produced by members of the other section. On many occasions, the research results seem to reflect the interests of the parties providing support for the particular research project. Even so, there are some important waypoints along the history of climate change research, which one needs to stop by.

The Greeks were the first to think that human activity could have effects on the climate of a particular geographical area. ***Theophrastus***, a disciple of ***Aristotle***, speculated that drying the marshes in a region could lead to increased freezing in that spot. He also stated that deforestation could make the earth warmer, due to exposure to direct sunlight.

French mathematician ***Joseph Fourier*** was an engineer in ***Napoleon's*** army. Post to Napoleon defeat at the famous Battle of Waterloo, Fourier devoted himself to the study of thermo-physics. His calculations related to earth's climate, published in 1820 suggested that a planet of the same size as earth must be at a much lower temperature than what it is. This led him to conclude that there is an additional factor, which works alongside the sun's radiation. This factor tends to act in keeping the earth's temperature warm at what it is. Fourier suggested that this effect is related the atmosphere of the earth, which somehow works to allow light and ultraviolet radiation to reach the surface of the earth, while acting at the same time as a blanket that prevents the leakage of heat from the earth into outer space again.

In 1860, the British natural history professor ***John Tyndall*** found evidence that the continent of Europe was in historical periods completely covered with snow. He tried to explain why its climate changed to near moderate, because of changing atmospheric composition. Tyndall tried to prove this theory, through a series of practical experiments, and proved that the presence of water vapor in the atmosphere, works as a barrier that prevents leakage of heat to outer space. More importantly, he also proved that carbon dioxide acts as a very efficient heat blanket, and has shown that this gas has an important impact on the climate, despite its low proportion of the atmosphere, which does not exceed 300 ppm. His argument was that some gases had important effects, even if they were present in small proportions. For example, hydrogen sulfide gas H_2S, is lethal if its atmospheric concentration reaches 500 ppm only. Although Tyndell's theory did not fully explain the ice age, it laid the scientific basis for subsequent studies on climate change, which may be caused by changes in concentrations of atmospheric constituents.

Other studies on the same subject followed. The most important of which was that carried out by Swedish scientist ***Svante Arrhenius*** in 1903. Arrhenius pointed out that as the water vapor circulates between the atmosphere and the sea, so it is thus balanced, and cannot lead to climate changes in the atmosphere of the earth. He therefore focused on studying the effects of carbon dioxide. The concentration of this gas during that period was almost constant, and only changed because of sudden ego events, such as volcanic eruptions, or rapid and sudden growth of species of green plants. Arrhenius has developed a theory stating that the effect of carbon dioxide is a compound one. This means that any particular rise in atmospheric temperature due to the increase in the proportion of this gas in the atmosphere will necessarily increase the proportion of water vapor also. As water vapor has also a property of heat containment, the final effect will be stronger. Arrhenius calculations showed that if carbon dioxide levels were halved, temperatures in Europe would fall by 4-5 degrees Celsius. He also calculated that doubling the proportion of this gas in the atmosphere, would lead to higher temperatures by 4-5 degrees Celsius also. However, at that time, these studies were merely theoretical calculations, which could not be ascertained in practice because the amounts of fuel burned by factories were almost negligible, so that doubling the amounts of carbon dioxide by burning fuel at rates that period, would have taken thousands of years. For this reason, Arrhenius calculations did not meet much interest, and the whole subject was more like an intellectual exercise serving purposes of purely academic discussions.

The subject received some interest again in 1931 when the American scientist ***Edward Olson Hulburt*** repeated Arrhenius calculations, taking into account the compounding effect of increasing water vapor in the atmosphere. ***Hurlburt*** concluded that doubling carbon dioxide would raise the temperature by 4 ° C. In 1938, English engineer ***Guy Stewart Callendar*** compiled data on temperature and carbon dioxide concentrations since the beginning of the 20th century and presented evidence that gas concentrations had increased by 10% since the beginning of the century. He suggested that there would be a future change in temperature. However, Callendar studies and research did not receive significant attention by most scientists during that period. Some scientist even criticized these results for several reasons, the most important of which were the inaccuracies in the historic carbon dioxide concentration measurements, as well as questioning the validity of Arrhenius theory to start with.

The Cold War between the eastern and western camps - in the post-World War II era - has positively influenced the studies of atmospheric components. This was a result of the need for studies related to the trajectories of intercontinental ballistic missiles in this atmosphere, and the need to know the details of the components and densities of upper atmospheric layers. This helped turning the subject of the study of the concentration of carbon dioxide from being limited to individual efforts of some scientists, to research being carried out by large research centers, supported by huge financial allocations. Dozens of gas monitoring stations were established in various locations, most notably those built near the North Pole and on the island of Hawaii. Scientists were able to determine the proportion of gas with great precision in 1958, and that value was considered a basis for comparison with subsequent years. Measurements conducted in 1959 and 1960 showed that gas concentrations are increasing compared to 1958. These measurements were accurate enough to show clear seasonal variations. These variations showed an increase in atmospheric CO_2 concentration before spring, and their decrease in autumn. This is because the growth of green plants is completed in the summer, which leads to the absorption of quantities of this gas, while the relative decrease of green leaves in winter leads to the accumulation of additional quantities of gas in the atmosphere, as shown in Figure (3) below.

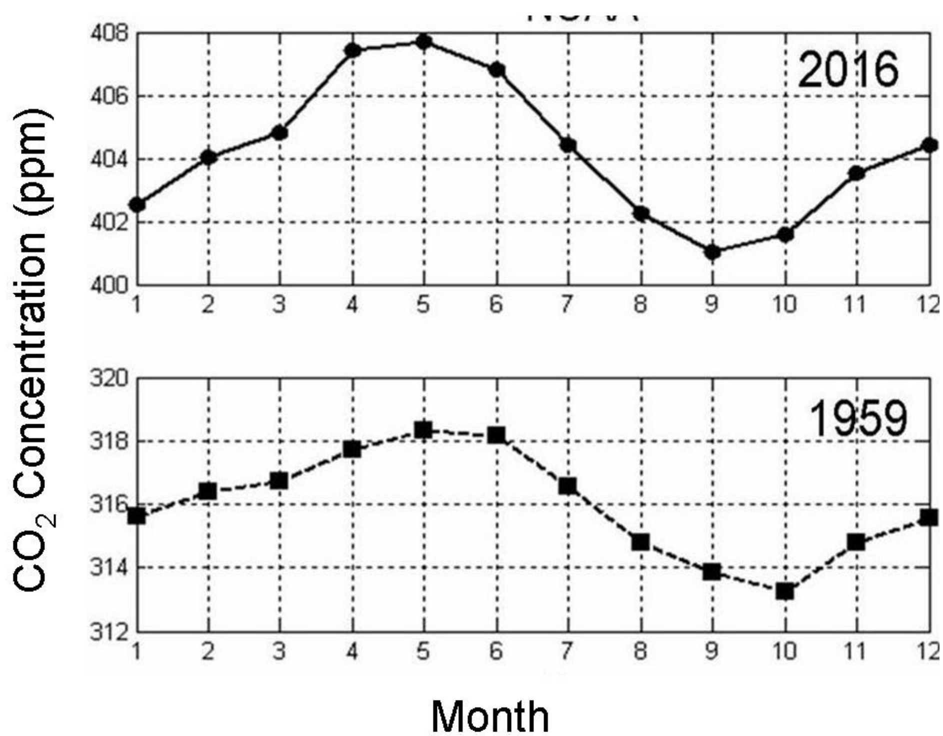

Figure (3) Seasonal variations of atmospheric carbon dioxide for the years 1958 and 2016 (NOAA publications)

Figure (3) above does not only show the seasonal variations of atmospheric gas concentrations, but in addition, the comparison between the top part of 2016 and the bottom part 1959 demonstrates an increase of about 90 ppm. This represents an increase of about 30% over the past 60 years, due to increased use of fossil fuels from oil, coal and gas.

The evolution of electronic computers in the 1970s and beyond enabled scientists to perform calculations that are more complex related to earth climate. These calculations took into account a greater number of parameters that are thought to play a role in the earth's climate. New mathematical models included atmospheric gases, green vegetation density on the surface of the earth reflection of sunlight from snow covered areas, oceans and their ability to dissolve gases, ocean and wind currents, and everything that is believed to have a potential impact on the earth's climate.

Rise of Anxiety

In 1981, two worlds leading climate scientists named***, Tom Wigley*** and ***Phil Jones***, published the results of an in-depth study in the prestigious scientific journal "***Nature***". The study concluded that although the effect of carbon dioxide on the earth's climate is still uncertain by the beginning of the 21st century, these effects would be more important than they were during the 20th century. This work was followed by extensive studies on the subject, which is still gaining increasing international attention. This attention is especially paid by environmental groups and organizations, and the green parties formed in Europe and succeeded in gaining increasing political pressure. All this prompted governments to make an important decision to set up the ***Intergovernmental Panel on Climate Change*** (IPCC) under the umbrella of the United Nations, through the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). The main task of this panel, established in 1988, is to follow up evaluation on all research and studies on climate change, and make necessary recommendations, through reports issued every 5 to 7 years, called ***assessment reports***. These reports are submitted to decision-makers in all countries of the world as guides in decisions making.

The IPCC issued its first assessment report in 1990. This report was supplemented by a 1992 report. Both reports recommended periodic summits of heads of state within the United Nations framework for climate change. These summits are called **Earth Summits**.

The first of these summits was held in 1992 in Rio de Janeiro, Brazil. The United States was one of the signatory states. Its decisions included the development of some mechanisms to address climate change. This Conference also laid the groundwork for another World Conference in Berlin in 1995, which produced an important document called the ***Berlin Mandate***. This paved the way for subsequent negotiations with a view to making binding commitments by industrialized countries to reduce their greenhouse gas emissions by the year 2000.

The IPCC issued its second assessment report in 1996. The report included studies on the potential risks of emission types and their geographical distribution, with arguments that subsequently convinced the world to adopt the **Kyoto Protocol** in 1997. The latter protocol set binding targets aiming to limit emissions by developed countries.

The third IPCC assessment report drew a more pessimistic picture, emphasizing the conclusion that the expected increase in global temperatures in the 21st century may be higher than previously thought. This was followed by the fourth report in 2007, which confirmed that the rise in temperature of the planet is unambiguous, and that it has already begun to affect the life systems around the world.

The IPCC's fifth assessment report, 2013-2014, is considered one of its most important issued reports ever. It stressed that human activity is the main cause of climate change due to the emission of combustion gases, the failure of green plants to process these emissions, and that the levels of these emissions, especially carbon dioxide, have reached record highs, which the earth has not reached in its history for millions of years. The results of this report were the basis for the subsequent adoption of the **Paris Climate agreement**. But as we shall see later, This agreement has not come easily because of some criticism of this report and other previous reports by the skeptics who argue that climate change is only natural and that human activity is not its cause. These criticisms are to be discussed in a coming chapter.

Chapter Three

The Advocates and the Skeptics

Who are the Advocates?

These are individuals, groups, and a large community of scientists and political parties that place environmental concern among their most priorities. Their arrow spear activists are the Green parties, which have unequivocal convictions that observed climate changes are strongly linked to human activity, which has occurred since the beginning of the industrial revolution because of the continued increase in the burning of fossil fuels from coal, oil and gas. This, in turn, led to a confirmed catabolism in the proportion of greenhouse gases, particularly carbon dioxide. They strongly demand that states take swift and decisive actions and develop effective programs to reduce emission rates as a first stage, and eliminate them out altogether at a second stage. IPCC recommendations, especially those in the fourth and fifth reports, have given the advocates very strong of cause in their efforts towards achieving their goals.

Who are the Skeptics?

These are also individuals and groups, supported by another community of scientists, and sections of conservative political parties in the West. The international oil, coal and gas companies support many of their climate research and studies in order to refute the findings of research and studies that support the idea that human activity has led to climate change. They consider that all observed climatic phenomena are mainly a natural part of the climate action of the earth's atmosphere rather than being due to man's activities. They furthermore argue that no one can do anything about these phenomena. On this basis, they do not see any need or feasibility of any action, especially with regard to reducing emissions to the atmosphere. Skeptics do not deny that carbon dioxide levels in the atmosphere have increased and they do not deny that climate change has occurred in the atmosphere of the earth, but they strongly object to the idea of the interconnectivity of these two events, and that increased emissions are the reason for the increase in temperature. Their arguments in this objection can be summarized in two main points. The first is that the earth's atmosphere is balanced, but it suffers long-term changes between extreme. These are the naturally cold, and the naturally hot conditions, and we now live in a warm period following the last ice age. Therefore, the recorded climate changes are natural and do not cause any concern. Their second argument is that, though carbon dioxide concentrations have increased since the industrial revolution, but linking this climate change to this increase is not justified. This argument was further especially supported after the publication of important scientific papers, by a number of scientists, which indicate that the proportion of carbon dioxide in the atmosphere at certain historical periods was many folds higher than what it is at present. Atmospheric CO_2 concentrations were between 3000 and 6000 ppm, while there was a prevailing ice age. This represents a complete contradiction to the theory that global warming is resulting from increased atmospheric concentrations of this gas.

Carbon Dioxide Measurements

Direct measurements, using latest state the art techniques currently available, for carbon dioxide concentrations in the atmosphere cover the period from 1958 to the present day. These are very accurate and highly reliable. IPCC reports has required knowledge of the concentrations of this gas for thousands and even millions of years to asses how these concentrations correlate to the climate changes that have hit the earth throughout its history. Measurements of this kind cannot be obtained directly, and intelligent ways of obtaining such information had to be devised. Such indirect methods are called ***proxy methods***. Fortunately enough, our planet has somehow kept good records of both its prevailing temperatures and its atmospheric CO_2 concentrations. These proxy records are encrypted within fossils, polar ice cores, minerals, old tree trunks … etc. This helped contemporary man to be able to read those records after some efforts in decrypting them.

Ice Core Records

The glaciers that have accumulated through the ages in the North and South Poles are rich records of the earth's atmosphere and the important historical natural events that took place. Although the ice layers look similar to the naked eye, they are in fact distinct layers for each year, because of the different properties of snow falling in the spring and that in autumn. Therefore, careful study of these layers can provide important information about the age of the ice sheet. This age is determined in several ways. After drilling for specific depths within the ice accumulated over the years, and obtaining a solid cylindrical core, the study of the ice cylindrical core can provide valuable information. A method used to determine the age is through manual counting in a way similar to that of determining the age of trees by enumerating wood rings. This method is accurate, but it becomes difficult, when the number of these layers is large, or when dealing with ice taken from very deep layers, where the layers are very close because of the compression on each other. This method is generally suitable for the dating of layers up to 10,000 years old. Several other methods are used to determine the age of the layers. These include the study of the volcanic ash contained within a particular layer. The presence of ash in the atmosphere during volcanic eruptions can lead to trapping some of that ash in the snow falling in that period. Volcanic ash is characterized by its chemical composition. It would be thus possible to identify and distinguish ash from a particular volcano. If the date of the volcano eruption is known, it will be possible to know the age of the ice sheet, which contains the ashes of that particular volcano.

Other methods used study the age of glaciers rely on the study of concentrations of some radioisotopes of certain elements, such as radioactive oxygen 18, radioactive carbon 14, and radioactive boron 11. Ice acidity is also used for this purpose as well. These are all too complex methods that are not detailed here, but they are generally adopted to determine the age of glaciers aged millions of years.

After determining the age of a particular glacial layer, carbon dioxide concentrations in the air during each particular year corresponding to a particular layer are studied using trapped air bubbles in that layer. Ice contains bubbles of trapped air inside it. Thus, we have a clear log, which represents a table that contains the age of each ice layer, Carbon dioxide in the snow-capped era of ice that year. It is really an impressive record.

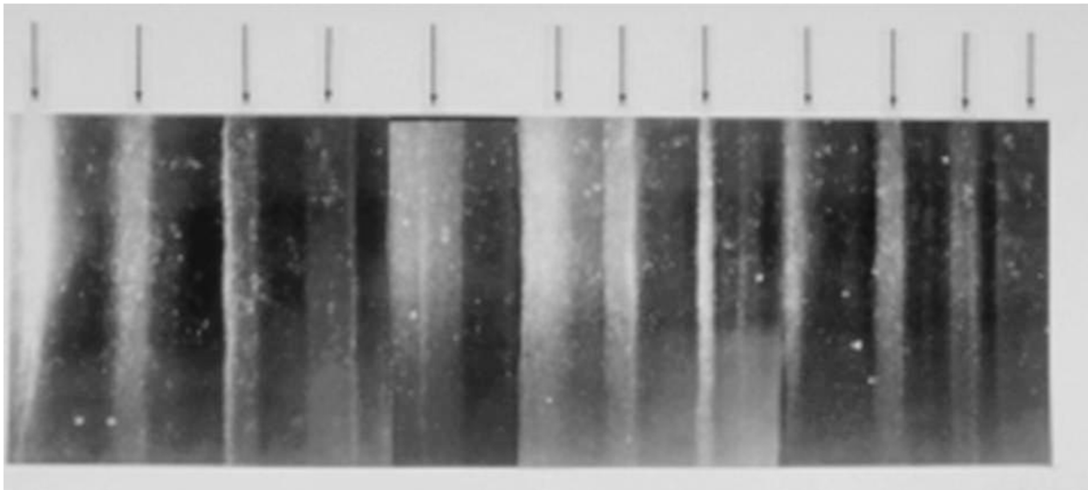

Figure (4) Photo of 19 cm ice core from 1855 meter depth. The core contains 11 annual layers (NOAA publications).

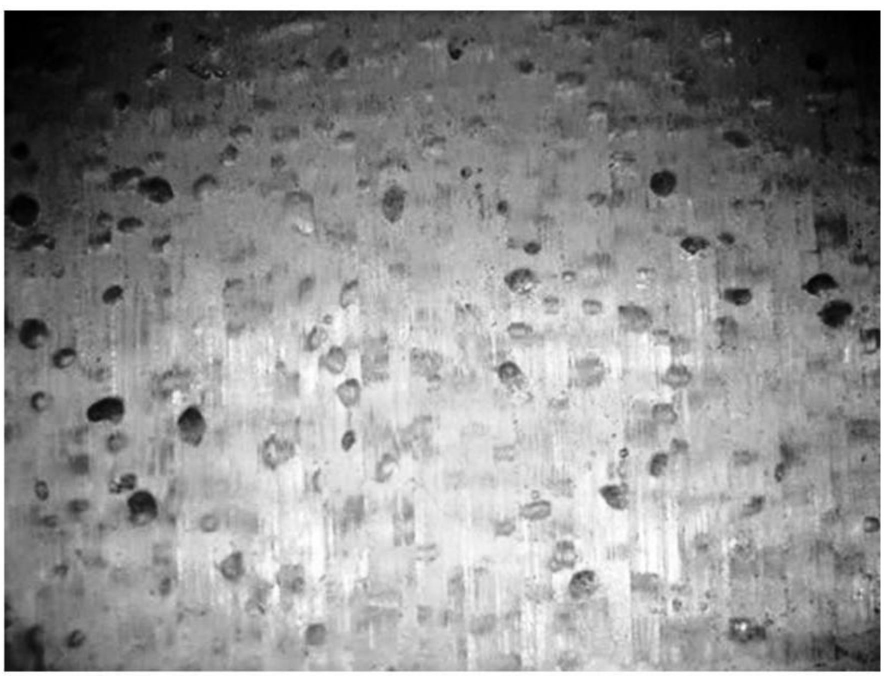

Figure (5) Magnified section in the ice core showing trapped air bubbles (NOAA publications)

Extraction of Historic Temperatures

Once the age and the carbon dioxide concentration in a particular ice layer is known, there remains another important issue needs to be addressed in order to complete the record of the gas concentration relationship with the earth's climate. This issue is the determination of the temperature of the earth's atmosphere for that particular deep in history period.

Man began measuring and recording atmospheric temperatures since the seventeenth century AD. The oldest thermometers measurements were carried out in 1659 in England, though by individuals, not institutions, as is the case at present. Formal temperature measurements carried out by institutions did not start until 1914, so we do not have direct temperature information or figures prior to that date. Nevertheless, here, too, nature has provided us with proxy records, which contain a tremendous amount of information, about past temperatures in different regions of the world.

The first of these records is historical documents and personal diaries, in which the people wrote their own personal observations. These documents include the notes of some farmers and ship captains, who described the weather at certain dates. These, in many cases, have been of the utmost benefit, in giving qualitative or sometimes even quantitative information, about the overall weather, especially temperatures. For example, contemporary scientists used dates for the beginning of the grape harvest season in the Paris region to derive the temperatures that prevailed between the months of April and September 1870-1879.

Another spectacular record, in which the earth has recorded its temperature, is that contained is coral reefs. Coral reefs belong to the animal kingdom. They extract calcium from seawater and convert it into the water insoluble calcium carbonate to build its structures and corals. Fortunately, the density of the corals formed depends on the temperature, light, and nutrients available. Therefore, the layers formed in the summer will differ in intensity from those generated by the animal in winter, thus forming the coral rocks in the form of annual layers similar to the rings of wood trees, or layers of polar ice. Analysis of the ratios of oxygen isotopes trapped in these rocks can provide information on ocean temperatures when each layer of rock is formed because the degree of trapping of these isotopes depends on the surrounding temperature.

Plant pollinators provide another valuable record of temperature over the ages. Sands, rocks and mud in lakes sediments contain pollen of various plants that grow in a particular area. The identification of pollen plant species has enabled scientists to identify plants that thrived during a given period in each region of the world. Each plant has a particular climate at which its growth and proliferation are at its best. This has helped scientists know the properties of climate in each region over the years.

The ice cores obtained by drilling at the poles are the most important sources of temperature records in addition to what we have reported as being a record of carbon dioxide concentrations. Some of the oxygen isotopes increase in snow when temperatures increase. By analyzing the ratios of these isotopes in a particular ice layer, an idea of the temperature during the year at which the ice layer formed is obtained. In addition, the thickness of each annual ice layer is a measure of the amount of snowfall during that year. Therefore, the temperature for that year can be determined by comparing the thickness of the glaciers with others formed at known years with known temperatures.

Tree logs rings offer another precious record in which nature registered weather through days, years and even centuries. It is known to botanists that annual rings grow thicker during warm or rainy years, while they are thinner in colder or less rainy years. In addition, the growth gradient of individual cells, within the particular annual layer is temperature dependent. Thus, careful microscopic examination of the sizes of these cells provides another record of the temperature gradients within that year. Wood rings from years of known temperatures provide calibration for rings with unknown temperatures, and their associated temperatures are retrieved from timber trees grown hundreds, or even thousands of years ago before the invention of the thermometer.

Conclusions of IPCC reports

Since its establishment, the IPCC has issued five extensive and comprehensive reports. The third and fourth reports are the most significant. These two reports took into account the results of thousands of research and strenuous studies conducted by thousands of scientists around the world. Their works involved trips to the Arctic, drilling in the ice, diving at sea, taking samples of coral rocks, lake sediments and wandering around the world's forests. Samples of rocks, sediments, ice cores and wood from trees were dispatched to highly sophisticate, specialized laboratories, housing high-precision devices that represent the latest invented techniques and equipments for chemical, radiological, physical, electron microscopy and all other scientific analysis technologies in various disciplines. The results of all these findings were made available to the IPCC. Thousands of scientists working with this committee around the world have conducted reviews, comparisons, classifications, and scientific conclusions. All this led to the drawing of a famous relationship in Figure (6). This relationship describes the deviation in temperatures of the northern hemisphere over the past 1,000 years. The increase or decrease deviation from the horizontal baseline defined as the average temperatures for the years 1961-1990 are drawn on the vertical axis. The horizontal axis shows the years since Year 1000 to 2000. The red line in the drawing represents the directly measured temperatures, while the blue line represents the indirectly proxy derived temperatures. The gray lines in this diagram represent the estimated errors in proxy temperature extraction processes. This graph clearly shows that temperatures before 1940 were below the baseline average, while temperatures after 1940 were higher than the general average (zero baseline). This curve is called the ***hockey stick curve*** because of its similarity to a hockey stick.

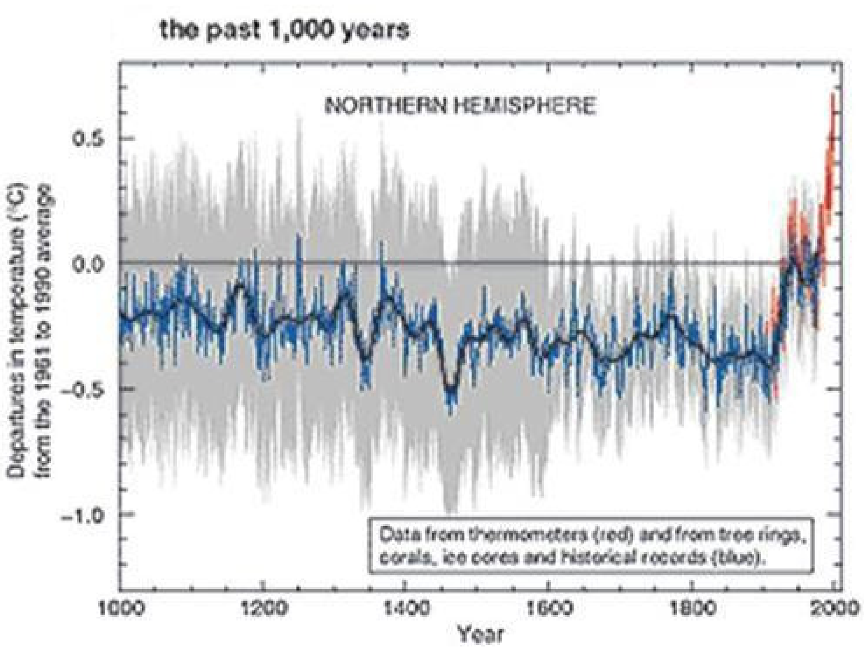

Figure (6) The Hokey stick curve, which shows changes in Earth's temperatures for the last 1000 years (IPCC report)

In addition to the above temperature rise, between 1-1.5 ° C over the last 150 years, these reports confirmed other changes in the globe. The most important of which is the rise in the sea level, by 3 millimeters per year from 1961 to the current time. This means a total rise of about 150-200 millimeters, and the shrinking of the snow-covered areas in the northern hemisphere, since 1978, at a rate of not less than 2.7% per decade, which translates to a total reduction of about 10%, as shown in Figure (7) below.

In summary, the IPCC's findings from all of its studies and reports is that the rise in temperature and the resulting melting of snow in the North and South Poles, leading to sea level rise, are solid indications of climate change, necessarily, from large increases in carbon dioxide emissions from the beginning of the industrial revolution to the present. On this basis, the Committee recommended, decision makers, in countries around the world, particularly developed one, to take swift and decisive action, to reduce and then stop emissions from burning fossil fuels.

The fourth assessment report, IPCC2007, raised alarm bells about future threats to the earth's atmosphere and predicted that global temperatures would rise between 2 and 2.5 degrees Celsius by 2050. The earth would have exceeded the so-called "***climate balance limit***". That is, any treatments that may be taken later will be of little or no benefit because the earth's climate will have reached the "***The point of no return***" towards a rapid rise in temperature, to hit between 5 and 6 degrees by the end of the 21st century. The report warned that this change in temperature is to be accompanied by an increase in sea level, due to the massive melting of snow from the poles. This will result in seawater covering large areas of coastal cities. In addition, there will be large-scale desertification of vast agricultural areas, with life-threatening consequences. In short, the report painted a very pessimistic, gloomy, or even catastrophic picture of the earth's climate, unless the world acts to take strong and quick actions to save the situation

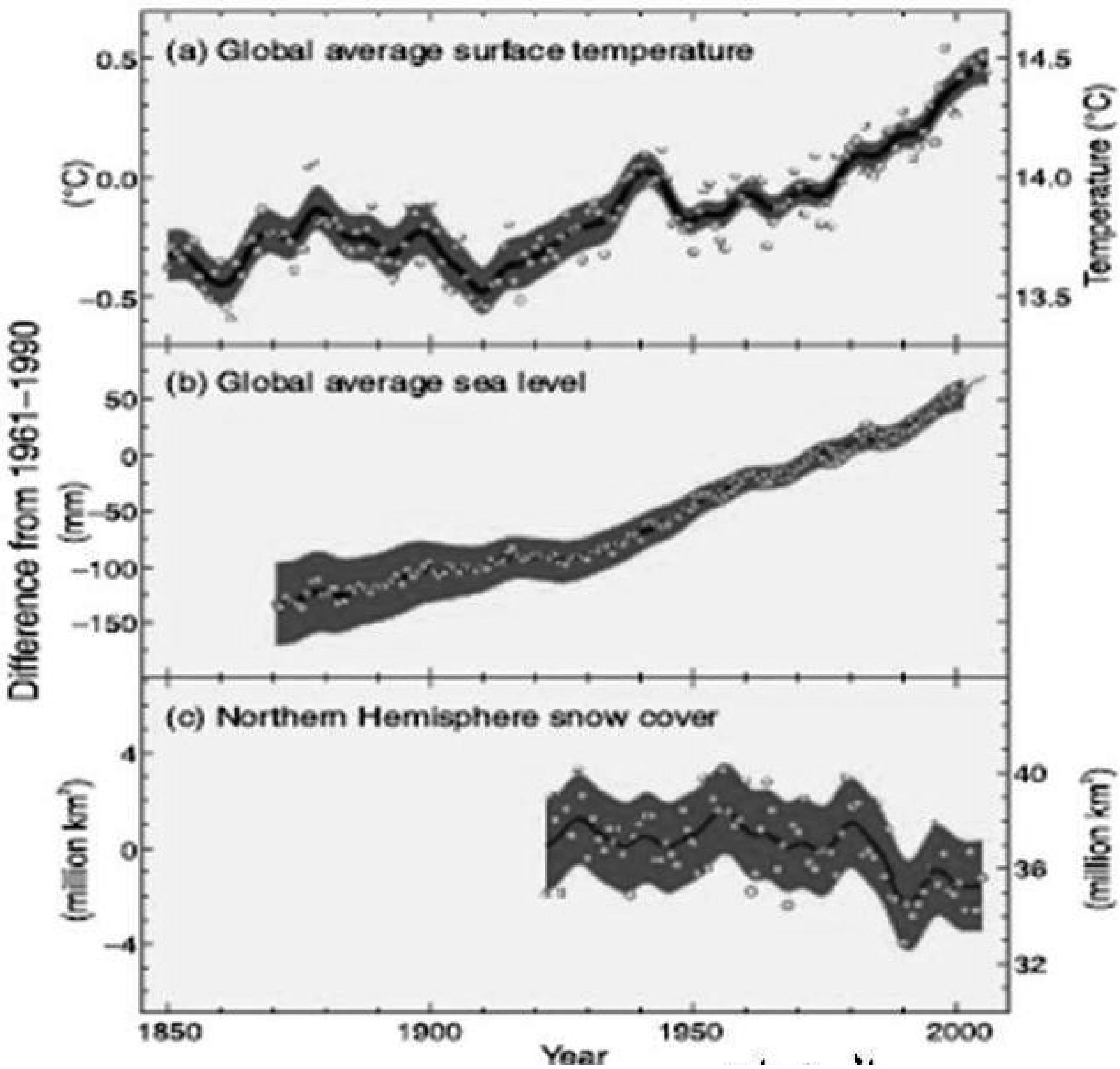

Figure (7) Temperatures deviations, sea level and ice cover areas since the start of the industrial revolution (IPCC reports)

Chapter Four
Conflict between Advocates and Skeptics

The beginning of the conflict

Although arguments and counter arguments between the two sides have existed in one way or another since the beginning of the subject's history, the evolution of the discussions into a quasi-scientific conflict emerged more clearly after the fourth IPCC2007 assessment report, which confirmed the theory of interconnection between combustion emissions, and climate change. Despite broad acceptance of the report's findings within the majority of the scientific community, but other scientific, economic, and political groups with contrary believes have emerged to criticize much of report findings. The arguments of some of these critics came to the extent that they expressed their conviction that the so-called "global warming" promoted by the report is a great global blunder, directed against energy companies, and an attempt to change the path of industry, in a way that serves the interests of other industrial companies, institutions, or countries.

The most important of these objections centered on the hockey stick curve mentioned above. However, before proceeding into the details of the subject, it is necessary to recall that indirect proxy temperature measurements contain large margins of inaccuracy. Temperature measurements from ice core analysis, coral reefs, and tree rings are never expected be as accurate as thermometers. The report included ranges of inaccuracy bar lines on the curve, as indicated by the gray lines. As we can see, some of these lines can give historical temperatures similar to what they are now. It is worth mentioning here that each temperature value, on the hockey curve, was calculated by taking the mean of the results of a number of independent measurements, giving the blue line on the curve. Uncertainty bars represented by the gray lines are calculated using dispersions and differences between corresponding independent measurements and their standard deviation around the mean value, which is a statistical gauge usually used for such purposes.

The skeptic's second objection to the idea of increasing carbon dioxide in the atmosphere is increasing global temperature is that historical measurements have shown that the proportion of gas in the atmosphere during the Ordovician glaciations ice age 440 million to 500 million years ago was more than twice as high as it is today. It even reached between 3000 - 6000 parts per million at times when there was an ice age.

These skeptics also used the argument based on the results of rigorous scientific studies, of historic temperatures in the northern hemisphere. These clearly showed that the medieval period (800-1400 AD) was a warm period in this part of the world. The temperature measurements for this period, obtained from studies of tree rings and ice cores, proved to be more or less the same, or even larger than what they are now. Historical evidence also supports this rise in temperature, as relatively high temperatures have enabled the Viking tribes of Europe to penetrate northward to areas close to the North Pole, such as Greenland. This is a scientific fact, which the IPCC report clearly avoided to emphasize. This epoch followed the period of the so-called little ice age. This was a period of time, which extended from the end of the middle Ages until 1850, (although there is some controversy among scholars on determining the history of the beginning of this age). Skeptics conclude from all this: that the earth's climate is constantly changing, according to their belief. One of the founders of the American Geological Association, ***François Matthes***, was the first to use the term " little ice age" in 1939, and suggested that earth was currently undergoing a naturally warm phase, which followed the little ice age. Numerous studies have been published putting the IPCC report conclusions and the hockey stick curve under scrutiny. The most important of these results are the extensive compilation of historic temperature values for the last two thousand years, carried out by different research groups, shown in a different color for each set of data in figure (8). This figure shows a pattern of significant discrepancies between these results, as well as the clear appearance of the little ice age and the warmth of the middle Ages. It should be noted here that these temperature differences are based on the value of a baseline average for a number of years which is different from that 1961-1990 adopted by the IPCC report.

Another important objection by the skeptics was that IPCC reports did not pay enough importance to the effects of solar activity on the earth's climate. It is known that the activity of the sun is not constant, but rather harmonious, on time cycles of 11 years and 22 years, in addition to other cycles for long periods. These changes are characterized by increasing the sunspots to a maximum number and then falling to a few during each solar cycle. Sunspots are regions of the outer layers of the sun that have very strong magnetic fields, resulting in the retention of particles with high temperatures in that region. This warming results in very strong releases of those particles from the vicinity of the solar spot towards space. These are called solar flare, some of which reaches Earth, and lead to the occurrence of disturbances in the upper atmosphere that can disrupt radio communications and satellites. The amount of energy that reaches earth from the sun increases by up to 0.1% during periods of peak sunspot increase. Some scientists associate the increasing number of sunspots that change with solar activity, with global warming, and vice versa. There is evidence that the period 1645-1715, the coldest period in the small ice age, coincided with occurrence the lowest number of sunspots, which is about 50 spot only. The skeptics link the current observed increases in global temperature to the increase in the number of sunspots.

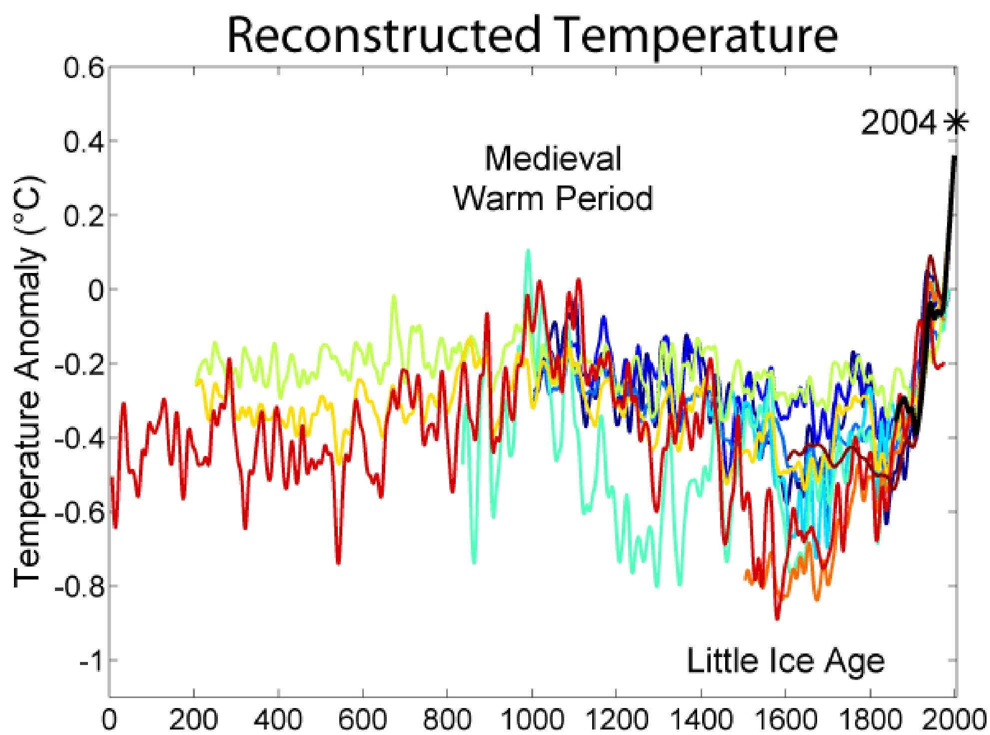

Figure (8) the results of a number of independent temperature studies measured in several methods covering past 2000 years. Results show significant discrepancies and illustrate the occurrence of the small ice age (Publications of the US Environmental Protection Agency AEPA)

Skeptics also argue that other factors that can affect the earth's climate have not been given sufficient importance by reports on global warming. These include volcanoes, which release fine ash particles into the atmosphere. These ash particles reflect back sun’s rays and reduce their access to the earth, leading to increased coldness. This effect has been shown to reduce the temperature by one degree Celsius

The Climategate

The early dawn hours, of June 17, 1972, witnessed the arrest of what appeared to be five ordinary burglars who infiltrated the headquarters of the Democratic Party National Committee at the Watergate complex in Washington DC. It later turned out that these were not ordinary thieves. Police investigation reveled that they were trying to wiretap telephone lines and steal presidential election campaign documents of the Democratic Party candidate. Investigations further revealed that they were linked to the reelection campaign of Republican President, ***Richard Nixon***. Nixon tried hard to deny any involvement in this affair. However, growing evidence otherwise, forced him eventually to resign from his second term presidency. He did so after appointing ***Gerald Ford*** to fill up the already vacant vice president position. On becoming president following Nixon resignation, Ford used his constitutional powers to issue a full pardon for any crime committed by Nixon. The whole scandal was given the name ***“Watergate”*** in relation to the name of the building trespassed. This scandal is considered as the biggest political scandal during the twentieth century. The name “***Gate***” has been attached to most scandals that took place ever since that time.

The skeptics' campaign received enough fuel to gain extra momentum in November 2009, shortly before the Copenhagen Climate Conference (we will mention later), when some internet hackers intruded the Climate Research Unit (CRU) Internet server of East Anglia University England. Huge piles of e-mails, thousands of research papers and documents on climate change were stolen. At the time, the University, in collaboration with the British Metrological Office (BMO), a main contractor with the IPCC, was conducting research and studies on climate change. The e-mail letters hacked somehow reached a famous journalist named ***James Delingpole***. This journalist was a skeptic who was strongly opposed to the idea of climate change being caused by human activity. He was very outspoken with his views, through his articles and columns, which he wrote on the pages of famous newspapers such as The Times, The Telegraph, The Daily Mail and the British Spectator. What the reporter saw from the contents of the e-mails exchanged between researchers at the CRU was enough to make him believe that there was a deliberate conspiracy to promote the notion of thermal retention caused by burning fuel. This triggered the skeptics to use the phrase "***Climategate***" in similarity to the Watergate scandal, in describing what they argued was another major scandal.

Soon enough, the global news media were busy publishing extracts from the pirated e-mail messages belonging to scientists of Climate Research Unit. This was timed shortly before the Copenhagen climate summit on December 7, 2009. Supporters and advocates of global warming considered the piracy operations and dissemination of such information is nothing but an attempt to influence heads of state participating in the summit to make them reluctant to make decisive decisions to reduce climate change gases emissions.

What did the pirated e-mails contain?

Parts, and sensitive extracts, of those e-mails dominated media coverage around the globe. The media were full of heated debates involving criticisms and counter criticism, and justification from both parties. A writer and editor named ***John Costella*** published controversial parts of those letters in a book edited and annotated in 2010, entitled "***The Climategate emails***". The book is freely available for download at:
https://www.lavoisier.com.au/articles/greenhouse-science/climate-change/climategate-emails.pdf

The book promotes the idea that there is almost a conspiracy by the proponents of global warming, who were involved in preparing IPCC reports. The objectives of this plot - according to the book - are to shatter public opinion, convince politicians with this theory, fight the publication of research by skeptics and prevent their scientific views from being heard. The book emphasized on the contents of about 60 important messages out of more than a thousand that were pirated. Most of these messages were communications among four key researchers in the Climate Research Unit. These researchers are ***Phil Jones***, head of the unit, ***Keith Briffa***, a climatologist who analyzes tree rings at the Climate Research Unit, and ***Mike Hulme***, director of the Tyndall Center for Climate Change Research, who was involved in climate research using various disciplines, from science, engineering, and technology. The fourth person is ***Tim Osborn,*** a climatologist. The book presents the contents of the letters, gives a summary of the background of the events and the subjects they are related to, and then gives his interpretation, impression, conclusion concerning defect or assumed scientific malpractice in each message. The unbiased reader of the book can note that while parts of the analyzes and conclusions of the author can be considered as reasonable, others do show a degree of deliberate truncations of certain texts from their general context, and presenting them in a manner that is intended to raise doubts.

The content of the controversial messages centered on trends of unacceptable practices in scientific research traditions carried out by researchers at the Climate Research Unit (CRU) and in collaboration with scientists and other researchers around the world. The alleged malpractices involve:

1. Lack of traditional scientific neutrality required with measurements, by selecting methods of data presentation that tend to hide previous historical high temperatures in order to support the argument that the post industrial revolution increase in temperatures in unique.
2. Unscientific intensive concern with building a highly polarized public opinion in support of Global Warming theory through making high profile statements and selecting particular timings for research results publications. Such practices made the whole issue looks like a public relation exercise rather that a solid scientific activity.
3. Make the utmost efforts to make the greatest impact on political leaders and participants in various climate conferences.
4. The systematic failure of the CRU to follow fair methods in the publication of scientific research, and influencing the peer review process in scientific journals. This is carried out through the

establishment of semi-Calertel, in which researchers supporting the theory of warming evaluate each other's research and attempting to block the publications of research papers that are inconsistent or contradictory to the theory of Global Warming.

5. Evidence of non-cooperation which amounts to obstructions by the CRU in making climate data and associated computer software available to other researchers in the field and hindering them from crosschecking results and conclusions made by the CRU group.

Reactions to Climategate

Soon enough, published e-mails caused a sensation in the scientific, political and even economic circles. The scientific community called on the University of East Anglia to make original measurements of historical temperatures and associated computer programs available under the provisions of the British Freedom of Information Act. These requests were for the purposes independent checking and ensuring the integrity of the findings contained in IPCC reports. However, the university rejected this categorically at the outset, considering that this information constitutes intellectual and physical properties of the university.

Supporters of both parties at the political level on both sides of the Atlantic, both in Europe and in America went into action. Calls in Britain increased for the opening formal investigations into the issues raised through the letters. For example, conservative politician ***Lord Lawson*** stated that the integrity of the scientific evidence has been called into question, the reputation of British science has been seriously tarnished and that a high-level commission of inquiry should be set up immediately. US Senator. ***Jim***

Inhofe, well known for his statement that described global warming as ***"the greatest hoax ever perpetrated on the American people***" demanded an investigation into the case. Some Republican members read extracts of from the letters during a debate in the US House of Representatives on 2 December 2009. One of representative said that these messages show a pattern of scientific repression, manipulation, and secrecy and a decline in the scientific standard, motivated by profit.

The media also had its fair share of covering the arguments of both sides. One of the Wall Street Journal writers, for example, stated that the contents of these messages exposed the IPCC's efforts to present its views while excluding those of others and that the scientists kept the results of the scientific measurements only for themselves . The Associated Press reported that the pirated letters from climate scientists show that these scientists have blocked the skeptics and discussed among themselves the concealment of measurements. On the same lines, the New York Times wrote, "*these researchers, who are some of the most prominent climate experts in Britain and America, seem so focused on winning the public-relations war; they also exaggerate their certitude and ultimately undermined their own cause*". Many commentators quoted one email in which Phil Jones said that he had used "***Mike's Nature trick***" in a 1999 graph for the World Meteorological Organization to hide the decline in proxy temperatures derived from tree-ring analyses when measured temperatures were actually rising

On the other hand, the British Daily Telegraph wrote that climate scientists had denied all accusations, saying that there was no evidence of deliberate errors in those letters that could weaken the theory that human activity had affected the climate. In another article, the Associated Press said that what came in those letters did not affect the theory that global warming was caused by man. It also said that there were attempts to give misinterpretations to the messages, in order to support baseless allegations, about erroneous scientific malpractices.

The scientific community was inclined to be supportive to the climate scientists. ***Spencer Wert*** of the American Institute of Science declared, "*There is no such precedent in the history of science, and no one has ever seen a group of people accuse a whole community of scientists of deliberate deception and professional irregularities*". The American Academy of Sciences also expressed concern, condemning a political attack on scientists in general and climate scientists in particular. In addition, the journal "Nature" published an article stating, "*A fair reading of the e-mails reveals nothing to support the skeptics' conspiracy theories. At the same time, however, it is clear that there was harassment of other scientists when they requested access to information through the Freedom of Information Act, but the release of such information was prevented, under the pretext of governmental restrictions".*

There have also been many comments in support of the researchers at the University of East Anglia by a large number of climatologists. One of the most prominent members of the IPCC, ***Perry Humber*** of the University of Chicago, said that the piracy and dissemination of these messages is a criminal act, with the goals of subversion and harassment of a group of scientists doing their work for science, trying only to reach the truth. Another senior IPCC official, ***David Carroll***, of the University of Melbourne in Australia, described the messages as an organized campaign, in order to shake confidence in certain climate scientists. In addition, 1,700 British scientists signed a document adopted by the British Metrological Office that expressed their *"utmost confidence in the observational evidence for global* *warming and the scientific basis for concluding that it is due primarily to human activities*".

There have also been claims by some scientists that they have received threats to their lives from unknown sources. These threats included Phil Jones and Michael Manns in Britain. The US Federal Bureau of Investigation has investigated threats to two other scientists in America. Other scientists in Australia also reported that they had received threats to their lives.

There were counter critical voices from the opposite side of the scientific spectrum. ***Patrick Mitchell***, a professor of environmental sciences at the University of Virginia and former president of the American Climatologists' Organization, said, "*This is not a smoking gun…, but a mushroom cloud*". He added that there is evidence of deliberately blocking the results of the measurements, in order to prevent their review and scrutiny, and that some messages referred to him personally, attacking his research results that are not consistent with the results of IPCC scientists. ***Judith Curry***, a professor of climate science at the Georgia Institute of Technology in the United States, said there are two important dimensions to the messages, which reduce public confidence in climate science. The first dimension concerns the lack of transparency in climate measurements, while the second dimension relates to the tribalism that characterized the behavior of some groups of climate scientists.

Hans von Storch, a professor of climatology at Hamburg University in Hamburg, declared that the University of East Anglia had broken the foundations of scientific research by failing to share their findings with other scientists, and treating the issue as a power conflict.

Formal Responses

It was a very natural reaction by Governments and scientific institutions to take some action after this storm. Eight different investigative commissions were formed. The most important of these committees were the Sir Russell Commission, the House of Commons Committee, in the UK and the Senate Committee in the US.

On 24 November 2009, the University of East Anglia initially rejected demands for the resignation of Professor Phil Jones as head of CRU; however, the university announced one week later, on 1 December, that he had been temporary suspended from work until the completion of the investigation. The University of East Anglia has also set up an investigative committee called the Independent Climate Change Email Review, chaired by ***Sir Muir Russell*** Former Vice President of the University of Glasgow, and Chairman of the Judicial Appointments Council of Scotland. This committee was later known as the ***Russell Committee***. Its assigned task was examining correspondences and assessing whether there was evidence of concealment or manipulation of scientific results. The Committee was also mandated to scrutinize the policies and practices of the Climate Research Unit during the measurements, building, review and dissemination of research results in accordance with best scientific practices. The Commission had also to investigate the adherence of the Climate Research Unit to the British Freedom of Information Act and to make special recommendations on the management, integrity and security of this unit. The Chairman of the Committee explained from the beginning that its mission is to find out whether scientists, researchers and administrators at the University of East Anglia have observed the correct scientific disciplines in scientific research and it is not the Committee's concern or duty to decide on the question whether global warming was caused by man or not. The committee will focus its investigations on the following points:

1. Examine the hacked e-mail exchanges, other relevant e-mail exchanges and any other information held at the Climatic Research Unit to determine, if there is any evidence of manipulation or suppression of data that is at odds with acceptable scientific practice and may therefore call into question any of the research outcomes.
2. Review the Climatic Research Unit's policies and practices for acquiring, assembling, subjecting to peer review and disseminating data and research findings, and their compliance or otherwise with best scientific practice.
3. Review the Climatic Research Unit's compliance or otherwise with the University of East Anglia's policies and practices regarding requests made under the Freedom of Information Act ('the FOIA') and the Environmental Information Regulations ('the EIR') for the release of data.
4. Review and make recommendations as to the appropriate management, governance and security structures for the Climatic Research Unit and the security, integrity and release of the data it holds.

The Commission's work took six months. It conducted investigations, interviews and many scientific studies, aided by independent scientists and computer programmers who used available data to redraw some curves for temperature changes. The Committee also examined the various procedures followed in the publication of climate scientific research papers, as well as the extent to which the University of East Anglia has cooperated with the

British Freedom of Information Act by responding to requests from other scientists. The Commission issued its final report on July 10, 2010. The report fell in about 100 pages, with a set of appendices in about 60 pages. The Commission findings are summarized as:

1. Advanced scientific analyzes have shown that some of the treatments used by university researchers have very little effect on temperature behavior and that the Commission team is convinced that these treatments did not have an important effect on published results.
2. The Commission found no direct evidence that members of the Climate Research Unit had misused their IPCC positions in order to prevent the dissemination of ideas opposing theirs
3. The Committee found that there was some lack of cooperation as far as the accusations of the commitment of the Climate Research Unit to the word and spirit of the Freedom of Information Act, by not responding fully to other researchers' requests for preliminary data for auditing them. The Commission also found evidence that some of the letters had been deleted from the records, with the aim of making them unavailable in the case of re-application, and that the higher administrations of the university should take a greater responsibility to comply with freedom of information act.

On 22 January 2010, the Science and Technology Committee of the British House of Commons announced that it would conduct an investigation into the matter, study its implications for scientific research, and review the report of the Russell Committee. The Commission declared on 31 March 2010 that it had found nothing that could discredit the scientific reputation of Professor Phil Jones. The Commission confirmed that global warming was indeed happening and that man was responsible for it.

However, the Commission report contained some criticism to the University of East Anglia for not complying fully with the requirements of the Freedom of Information Act. Phil Jones was then re-instated to the newly established position as Director of Research at the University.

Several committees in the United States have investigated the issue in general and with regard to Professor ***Mitchell Mann*** of the University of Pennsylvania, a co-author of IPCC reports, whose name has been in the published letters in particular.

The First Committee was formed by the United States Environmental Protection Agency (EPA), based on complaints from the states of Virginia and Texas, the American Chamber of Commerce, and a coal company, alleging that the published letters had indicated scientific misconducts. The Committee concluded that the contents of these communications were truncated out of context and their content contained nothing prejudicial to the integrity, transparency and professionalism of scientific research.

At the request of ***Senator Jim Anhov*** to the Inspector General of the US Department of Commerce, to conduct a review of the work of NOAA, on how it dealt with the subject of the above-mentioned messages, the report of the committee formed for this purpose concluded that NOAA did not do anything illegal or unprofessional.

The National Science Foundation of the US Department of the Inspector General concluded an investigation on August 15, 2011, of allegations of misconduct against ***Mitchell Mann*** of the University of Pennsylvania and found that there was no evidence of the validity of the charges, confirming other investigations conclusions.

None of the above-mentioned or any other investigations has substantiated any scientific misconduct with respect to the research on which the IPCC reports were adopted. However, the Commissions of Inquiry stressed that researchers should be more transparent and make the preliminary data of the measurements on which their research rely upon accessible to other researchers, so that they can validate the conclusions that are reached. These recommendations were general and not only related to climate research, but covered all branches of scientific research. This openness has given additional impetus to the scientific movement around the world. On this basis, the British Meteorological Office (BMO) decided to make all its compiled world temperatures data available on the internet worldwide. These data cover the period from beginning of the measurement of temperature to the date of publication. The data are updated monthly on the Internet. The data are called HadCRUT3. They consisted of 3780 files containing monthly temperature averages in various locations worldwide where metrological stations are available. These data vary in terms of the quality of coverage. Some data obtained from stations in developed countries cover a period of time since 1700, and without significant gaps, while others issued by some under developed countries contain only few temperature values for scattered few months over one or two years.

The author of these lines conducted a re-analysis of these data, using software programs different from those used by the British Metrological Office, to conduct an independent study of these data. The results of this study were published in the ***International Journal of Global Warming*** in February 2012. The results of the analysis showed that there has been a noticeable increase in the average temperature around the world since the industrial revolution by 0.75 degrees Celsius. The study also found that correlation of this increase to that of carbon dioxide in the atmosphere during the same period gives an earth's temperature increase by 0.0068 ° C for each additional one part per million in atmospheric carbon dioxide concentration. This will cause the earths' temperature to increase by 2 ^{o}C by the year 2050 and by up to 5^{o}C in the year 2100 if carbon dioxide continue to increase at the same rate. These conclusions are consistent with those of the IPCC reports.

Chapter Five

The Science of Global Warming

Prerequisite Basics

The subject of global warming is considered a multidisplanry one. It involves relations to physics, chemistry, biology and even social sciences. Fortunately enough, and in spite of the fact that some degree of familiarity with all these subjects is needed to understand global warming, these needs do not exceed knowledge of only few school level basics in those subjects.

The above introduction is to pave the way for reviewing few facts from basic physics, chemistry and biology needed to understand the role of carbon dioxide, which has been mentioned too often in relation to global warming. I will try to present those facts in as simple form as possible. However, I cannot commit my self to making the presentation enjoyable to read. Furthermore, I seek excuse from readers who find the presentation too trivial to them.

Carbon Dioxide (CO2)

Carbon dioxide is one of the atmospheric constituents beside Nitrogen, Oxygen and water vapor. Despite its very small ratio of about 0.005% in air, it plays a vital role in the establishment and continuity of life of earth. This gas consists of a single atom of carbon bonded to two atoms of oxygen. The carbon atom in this bonding occupies the middle position between the two oxygen atoms, each on one side. This bond is so strong that it is very difficult to break. However, this carbon dioxide molecule is not rigid in spite of the fact that acts as one unit. The oxygen and carbon within the carbon dioxide molecule perform few types of dances in harmony with each other. On some occasions, one oxygen atom moves away from the middle carbon atom as its companion approaches it from the other side, and vice versa. In another dance, both oxygen atoms may approach the carbon atom from both sides at once reaching a specified distance, to start moving back away. In a third, type of dance, the carbon atom jumps up and down or horizontally to the front and back, as if it is trying to entertain the two oxygen atoms on the two sides. Despite these movements, the bonding between these three atoms remains strong. The situation is as if three balls interconnected with two springs, expanding and shrinking, without breaking down, as shown in figure (9) below.

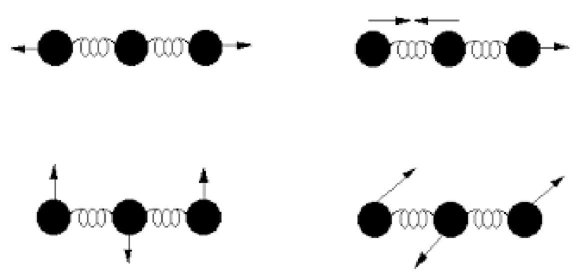

Figure (9) Oscillations of oxygen and carbon atoms within carbon dioxide molecule

These oscillations are not of a random type. They take place with regular distinct rhythms that characterizes each of the four types of oscillations. Each movement back and forth or up and down will last fixed time with a steady frequency that characterizes the movement. It is very much like a pendulum, or a swing of a child moving forth and back, with a steady rhythm. These rhythms in the oscillations within carbon dioxide molecules are of fundamental importance as far as the role of this gas in global warming is concerned.

These vibrational movements within the carbon oxide molecule represent three moods of harmonic dances, although they appear to be four patterns oscillations at first sight. The reason is that the last two movements are actually identical, because the molecule has no sense of up and down, front and back, or east and west. As far as the molecules are concerned, all directions are equal. Each of these three moods of oscillation has its own frequency. Consequently, the carbon dioxide molecule has three vibration frequencies. They are called the "**natural frequencies**". The presence of one or more natural frequency is not confined to this molecule, but rather is characteristic of all physical systems, from the smallest atoms to even massive structures such as buildings and bridges. Each having one or more natural vibrations frequency. Many of us may have heard that army solders March in "**break step**" not in time with each other. US military veterans will recognize this as being ordered to "*Route step, March*!" upon approaching a bridge and not resuming marching to cadence until the bridge is crossed. This is for the simple reason to avoid the situation where of the harmonized solders footsteps become consistent with the natural frequency of the bridge vibration. We also know that a small child can move a large swing if his push movements are consistent with the natural frequency of that swing, while the swing will not move even if a strong man shakes it if his movements are much faster than the swing natural frequency. The argument here is that any vibratory system can absorb energy strongly if it is supplied in the form of oscillations close to its natural oscillations one. This condition is called a **resonance state**, or the harmony between the power source and the vibrating body.

Physical systems differ in their natural frequency, the frequency of the carbon dioxide molecule is different from that of oxygen or nitrogen, the same way as the natural frequencies of the guitar body differ from those of the violin or drum body. The natural frequency of a system usually depends on the geometry of that system, its mass, and on the forces that interconnect the system parts to each other

Carbon dioxide molecules can easily acquire energy from the electromagnetic waves previously mentioned if the frequencies of these waves are close to the natural frequency of the molecule. Because electromagnetic radiation represents a very wide range of frequencies, this molecule can only receive a portion of this wide spectrum, while not being affected much by other parts. It is precisely this point that has made carbon dioxide so important in influencing the earth's climate. This molecule can absorb the waves of electromagnetic radiation if their frequencies fall within the heat wave range. These radiations are scientifically called infrared radiations. At the same time, the ability of these molecules to absorb other waves, such as light, ultraviolet radiation, X-rays, or radio waves, is very small or nonexistent. Carbon dioxide is thus considered non transparent to heat waves, while allowing light and other waves to pass through with high transparency. It is so much like transparent window glass, through which sunlight enters, but does not allow heat to seep out from inside the buildings. This is exactly what happens in greenhouses used for growing summer season crops during the winter season. The glass provides protection from the cold by returning the thermal radiation back to the inside of the greenhouse while allowing much needed sunlight to reach the plants. In short, carbon dioxide acts as a mirror as far as heat radiation is concerned, while its effect on ordinary light is similar to that of transparent glass.

The Greenhouse Effect

The above discussion explains the important role-played by the presence of carbon dioxide among the constituents of the earth's atmosphere in influencing its climate. Most of the radiation reaching earth from the sun consists of visible light waves that can penetrate the atmosphere easily, reaching the earth's surface. The earth absorbs this light when it falls on its surface, turning it into heat. The laws of physics state that any hot object must emit heat waves trying to get rid of it in order to cool down. The earth does not deviate from this rule. We have mentioned before, without its atmosphere, the earth would have become too cold to support life. The situation will become similar to that on Mercury or the Moon. However, the return of heat radiation from the earth to outer space is partially blocked by the carbon dioxide in the atmosphere. Increasing the amounts of atmospheric carbon dioxide will ultimately result in enhanced trapping of heat within the earth’s atmosphere, which leads to increase in earth’s temperature. This is demonstrated in figure (10) below.

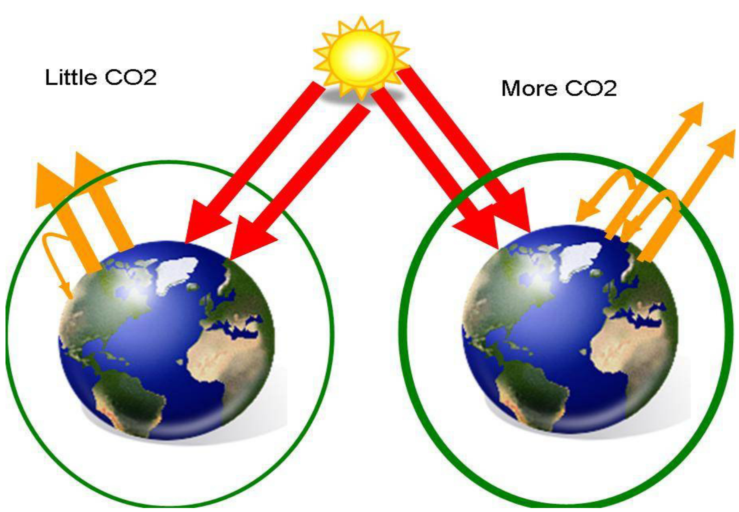

Figure (10) Effect of increased carbon dioxide in the earth’s atmosphere

This effect becomes clearer and more exciting, if we look at the solar system. The closest planet to the sun is **Mercury**. The distance of this planet from the sun is about 60 million kilometers. The Romans worshiped this planet under the name of **Mercurie**, the god of commerce and theft. The Greek worshiped Mercury under the name of **Hermes**, and considered him the Gods messenger responsible for their communications. The Sumerians named him **Nabo**, the god of writing and intellectuality. This may explains why contemporary astrologists consider him as the planet affecting transportations, communication, culture and intellectual activities. The fact is that this poor planet does not have a significant gaseous atmosphere. Consequently, the planet solid surface, which is much similar to that of the earth, receives all the radiation that comes from the sun. This leads to a massive rise in surface temperature to about 450 degrees Celsius during daytime. On the opposite side from the sun, where it is nighttime, the temperature drops to about 170 degrees Celsius below zero, because the planet's re-emits it heat into outer space quickly. This changes the temperature of a particular area on the surface of the planet up and down, over a range of 620 degrees Celsius over each planet full day, which lasts about 58.6 earth days due to the planet slow rotation about its axis. Mercury year is much shorter than that of earth, and it only lasts 88 earth days because the high speed of the planet circling the sun due to their close distance from each other.

Now let us compare the temperatures on Mercury with those on the planet next to Mercury from the sun. It is **Venus**, which 108 million kilometers from the sun. This distance represent about twice that of Mercury. According to the laws of physics, Venus receives one quarter of sun energy compared to that of Mercury. For this reason, Venus's temperature is expected to be much lower than that of Mercury. It may surprise us to learn that this beautiful planet, the God of love, beauty, and romance, Sumerians, Greeks and the Romans who worshiped him under the names of **Ishtar**, **Aphrodite** and **Venus** respectively, and which contemporary astrologists consider him responsible for romance, beauty and love, is nothing but a sample of Hell, as it is usually described. The fact is that this planet is the hottest planet among all planets. Venus maintains an almost constant surface temperature of about 462 degrees Celsius. This temperature remains almost constant between day and night throughout its year, which is an about 241-earth days. This temperature is sufficient to melt few metals such as Lead, Zinc, Lithium, Bismuth, and Cadmium.

The important question that arises here is why this extreme and paradoxical difference temperatures between planets Mercury and Venus? The answer becomes clear, and simple if we know that while Mercury does not have any significant atmosphere, Venus is enclosed inside a thick gaseous blanket consisting of about 94% carbon dioxide. This gas traps most of the sun's energy that reaches the planet, preventing its re-diffusion and leaking it into outer space again.

The Unique Earth

Earth may not be unique in this vast universe, but it is certainly unique among its sisters other planets. Earth is unique in its balance, which has provided the right climate for the emergence and continuation of life. It is not too close to the sun, to burn with its fire like Mercury and Venus. Earth is not too far away from sun, to freeze to death like Neptune, Uranus, Pluto and Saturn. The earth is not bare from an atmosphere that protects it from extreme heat during the day, and extreme cold at night, but its atmosphere is not as a dense with carbon dioxide to make it burn like Venus. Earth has a uniquely life supporting impressive atmosphere. This atmosphere contains only little, but just sufficient amounts of carbon dioxide, to make its climate what it is. Any significant change in this gas ratio must cause some change in the earth's climate. This is precisely the argument that drives global warming theory advocates to try hard to stop increasing gas emissions produced through burning gas, oil and coal. The burning of all these types of fossil fuels generates carbon dioxide, most of which goes into the atmosphere.

Danger of the Worse

The only way to get rid of carbon dioxide in the atmosphere and to break it down into its oxygen and carbon components is nature-created process of photosynthesis. This is a very complex method, involving a series of very complex chain of chemical reactions, during which plant leaves absorb sunlight energy, use this energy to disassemble carbon dioxide molecules into oxygen returned to the atmosphere, and carbohydrate compounds in the form of wood and cellulose. For example, a 100-year-old oak tree can release about 4,500 kilograms of oxygen per year, enough to breathe 11 people for a whole year. With a simple calculation, each green tree is responsible for sustaining the lives of at least ten people. This process has been, and continues to be the basis for the maintaining all life on earth. Forests that cover parts of the earth's surface play the largest role in this process, maintaining the natural balance of the earth. These forests are the real green lung of the earth through which we breathe. However, this breathing lung did not escape the abusing human hand, and his activities. In short, it can be said that these forests have shrunk in recent years. We will not go too far, but geographers' studies indicate that forests covered one-third of the surface of the Earth's surface 20 years ago, but now cover slightly more than a quarter of the earth surface. Forests in the world at present are about 4000 million hectares. This contraction occurred despite the increase in forest areas in Europe. This is because the loss of forests in the southern hemisphere was much larger than corresponding increase in Europe. Earth is losing an average of 12 million hectares of forest each year. Forests covered about 31.6% of the land in 1990, but fell to 30.6% by 2015. The causes of this loss are multiple, the most important of which is deforestation, land conversion for agriculture and food production, which is increasingly needed because of the increase in the world's population. The second and important reason, and also related to the first, is the cutting down of trees to convert their wood into industrial materials, mainly paper and building materials. It is unfortunate that a tree trunk turns into a paper cup of coffee, or a toilet paper. Another major cause is forest fires occurring throughout the world. Yes, there have always been fires in the forests because of nature, but the number and intensity of these fires seem to have increased in recent years because of the remarkable rise in temperature, which increases the ease of ignition on the one hand and durations of fires on the other. This effect is very dangerous, because it is compound one. Increasing temperatures increase the risk of fire, which in turn reduces the green forests, thus increasing the proportion of carbon dioxide in the atmosphere. This in turn, increases the temperature. It is truly a vicious circle, if it is allowed to continue. It is useful to know the shocking fact that the earth is currently losing forest areas at a rate of three hundred and sixty square kilometers (about 50,000 football fields) annually.

Nevertheless, there is some optimism, albeit simple in this area. This optimism comes from the fact that there has been some slowdown in deforestation around the world in recent years. The slowdown was the result of some actions taken by many governments to put forests under protection. The annual rate of forest shrinking fell from 0.18% annually in the early 1990s to about 0.08% during the period 2010-2015. This can be considered an indicator of the right direction, but it is not enough to correct the balance and reach a situation where forest areas are reintroduced. The world needs to do much more in increasing forest areas, as one of the solutions to control the increase in atmospheric carbon dioxide, as one of the proposed solutions to overcome the increase in carbon dioxide.

Chapter Six

Conferences and Summits

World Leaders Meetings

Everyone knows that it is naive to think that officials, ministers or heads of state visiting each other and meeting with their counterparts in other countries for social engagements, luxury dinners or tourism. This may happen sometimes with the leaders of some undeveloped countries, or some wives may exploit the times of those visits, to enjoy themselves with such events. It is certain that the real goals of these visits, or meetings, are to discuss and negotiate topics of great importance. The importance and urgency of those topics is related to the level of officials involved. When those meetings or visits are at the level of Heads of State, it means that the subject topics to be discussed are of the utmost importance, and cannot be decided upon through telephone communications or through any network communications, no matter how immune to penetration that network is. In these types of meetings, agreements are made and decisions are taken, the results of which can be swiftly demonstrated, or may not appear until many years later.

Although the debate over climate change or global warming between believers and skeptics still exists today, this controversy has in itself elicited some wisdom from global societies and policymakers in many countries around the world. Therefore, the United Nations, the international organization comprising most of the world, had to work in one way or another to discuss the issue at least, even if it was not possible to take swift action to resolve it.

The first step in this direction was the establishment by the United Nations, through the World Meteorological Organization (WMO) and in collaboration with the United Nations Environment Program (UNEP), of the Intergovernmental Panel on Climate Change (IPCC) in 1988. We have already discussed the work of this committee in detail in a previous position. Even so, it may be useful to recall here that the most important task assigned to this committee is the follow-up on all studies and research, which are published all over the world on the subject of climate change in the earth's atmosphere, and to prepare scientific reports, on the conclusions reached in this regard. These reports are submitted to all States Members of the United Nations for the purpose of assisting them in formulating the policies required, and following up on their implementation. These actions were followed by a series of global conferences to discuss issues related to the environment and pollution in its various forms in general, and climate change in particular.

Who are invited to the Banquets?

A series of annual conferences on climate change were held from 1992 until now. Many heads of state are keen to attend these conferences themselves, and the media are busy keeping up with the news and results of these conferences. An army of tens or even hundreds of the country’s best ecologists, economists, industrialists, agricultural experts, trading professionals, geographers, politicians, and many other disciplines usually accompanies each head of state or official who participates in these conferences. These, spend hours, and long days, negotiating with their counterparts in other countries, behind closed scenes. The subjects of their negotiations are about the numbers and the proportions that their country will commit to at this or that conference. They negotiate about each one tenth of a one percent or even less of a certain number, before advising their head of state to put his signature on Conference's decisions document. As an example, more than 10,000 representatives, delegates, scientists and specialists in various fields attended the Kyoto Conference, which is one of the most important conferences in this field. This hard work will certainly entitle all these people the right to participate in all the Banquets, festivities, visits, entertainment and tourism events that accompany these conferences. The following is a summary of these conferences held between 1992 to 2017.

Rio de Janeiro first Conference (1992)

This conference was the second important stage following the establishment of the IPCC. The summit main tasks were to discuss environmental and climate issues and to develop solutions to related problems. The Conference was held in Rio de Janeiro, capital of Brazil, from 3 to 14 June 1992, under the sponsorship and organization of the United Nations. It named as United Nations Conference on Environment and Development (UNCED). The conference was also called the ***Earth Summit***. 172 countries participated in the conference, with 116 of which were headed by heads of state or prime ministers. The conference participants discussed important issues related to pollution from industrial toxins, such as lead poisoning in gasoline, radioactive waste produced by nuclear reactors, and the potential for using alternative energies instead of fossil fuels to reduce the effects of climate change. The issue of reliance on public transportation instead of personal cars in order to reduce pollution in urban air and the resulting health risks was also discussed. The conference also discussed freshwater increased scarcity in various regions of the world.

In spite of the many differences among the participating countries on the various topics discussed, it can be said that the Conference has succeeded in making important decisions, including the so-called ***"United Nations Framework Convention on Climate Change UNFCCC"***, and opening the way for countries to sign it. The treaty came into effect about a month later after it was signed by more than 50 countries. The total number of signatory country at current time is 165. The treaty provides for the general obligation of signatory states to act on the stability of greenhouse gas emissions to the atmosphere, in order to preserve the climate of the earth from catastrophic changes in the climate system. It must be said that the treaty did not decide on practical solutions to the problem of climate change. Even so, this conference was one of the first actions through which, signatory countries expressed their intentions and commitment to work towards that goal. The treaty included the establishment of the so-called **Conference of the Parties (COP)**, held annually, to discuss the details of the topic. In short, it can be said that the outcome of this summit was an expression of goodwill rather than putting down practical solutions to the problems. This summit agreed to hold further annual conferences to continue follow-up on the issues discussed.

Who are the Parties?

Although most of the world countries participated in the Rio de Janeiro Conference, intertwined and conflicting interests of those countries on the policies to be followed soon emerged, and blocs formed. These blocs had both types of common and contradicting different interest at the same time. It was therefore necessary to identify parties of States, each of which had a common denominator, defining the course of its policies. Although everyone agreed that gas emissions affecting climate and other industrial air pollutants should be reduced in one way or another, the questions about who would reduce first and who could delay their actions proved to be difficult to answer. One of the most important arguments presented by developing country groups is that developed countries have built their industries and achieved technological development, which have resulted in accumulation of emissions in the atmosphere. It is thus not fair now to prevent developing countries from doing the same thing under the pretext of tackling climate change. The Rio de Janeiro conference adopted a non-binding document that affirms the determination of participating countries to take action to address the causes of climate change and that all participating countries should take into account the interests and circumstances of special groups of countries on their commitment and responsibilities to reduce emissions. On this basis, States were divided into several groups or parties according to their common circumstances. The first and important group, whose names were included in Annex 1 of the Conference, included the industrialized countries in general. These were the United States, the European Union (and the countries that were in due join it), the Russian Federation, Canada, Australia, Turkey, Ukraine, Switzerland and New Zealand, Japan, Greece and Cyprus. It was decided that these countries are to be the first to take measures to reduce climate change. The participants also stressed that the interests of all other ***Parties*** must be observed. These parties are:

1. **Countries that are small islands**, such as the Caribbean islands, which can be severely affected by global warming, due to the melting of ice in the North and South poles, turning into water, raising sea level, leading to submerging of many of these islands, or parts of them, as well as increased vulnerability to extreme climatic changes such as hurricanes, and increase the spread of some epidemic diseases such as malaria
2. **Countries with lower than sea level coasts**, such as the Netherlands, Belgium, and Luxembourg, which will lose areas of their beaches due to rising sea level
3. **Arid or semi-arid countries**, the most important of which are the African Saharan countries such as Chad and Mali, as well as some parts of the Middle East, which will suffer from the collapse of the already much limited agriculture.
4. **Countries prone to natural disasters**, most notably hurricane-prone countries such as eastern North America, South-East Asia, Bangladesh and Pakistan, which are already exposed to floods and hurricanes that are expected to increase because of climate change.
5. **Countries vulnerable to drought and desertification**, including North African countries such as Algeria, Libya and some Asian countries like Iraq, Iran and gulf countries, which have been suffering from desert encroachment and shrinking agricultural areas.

6. **Countries that suffer from severe urban air pollution**. These include many cities of the world, such as a number of cities in China, Tehran, and even Paris.
7. **Countries with critical ecosystems**. These countries rely for most of their income on the products of certain plants or animals, whose growth is related to the nature of the climate, such as Ceylon, where tea production forms an essential part of its economy.
8. **Countries that depend mainly on fossil fuels production for their economies**, and include all oil-producing countries, primarily the Arab Gulf states, Russia, the United States, and the coal producers, such as Europe, North Africa and Russia. It is natural to say that the economies of these countries will be adversely affected if any measures are taken to reduce carbon emissions
9. **Countries that do not have maritime access**.

Despite this division, many countries may be members of more than one of the above groups. The interests of the various groups to which a particular state belongs may be even contradictory. This is particularly the case with oil producing countries in the Middle East and North Africa. A particular country may be negatively affected by global warming through desertification, yet, any action towards reducing emissions, will negatively affect their oil exports and economies also. However, the Rio de Janeiro Conference constituted an important starting point for a series of subsequent conferences held annually in different parts of the world, attended by Heads of State, called Conferences of the Parties (COPs). Some of these conferences resulted in important decisions, while others failed to reach concrete results. It can be said that the United Nations has successfully maintained the continuity of these conferences on a regular basis to this day.

This continuity in itself represents a kind of success achieved by the world organization, despite the many problems and obstacles to reaching decisive decisions. Below are summaries of what has been achieved by each of these conferences listed in their chronological order.

Berlin Mandate 1995

The COP, which was established during the Earth Summit in Rio de Janeiro, held several meetings, the first of which was in Berlin, Germany, in March 1995. This Conference produced no significant decisions, apart from expressing concern, about the failure of States to meet their obligations in the light of the advice provided by scientific institutions.

Geneva Conference 1996

The conference was held in Geneva, Switzerland, in July 1996. One of the most important events was the United States of America's explanation of its position on climate change, which concluded that it accepted the Second Report of the IPCC in 1995 and its intention to adopt medium range policies, with achievable goals, with sufficient flexibility for States to pursue their respective policies.

Kyoto Conference Japan 1997

The conference, which was held in Kyoto, Japan in December 1997, was one of the most important climate conferences. It adopted several important and legally binding decisions in the so-called **Kyoto Protocol**, under which the Group of First Industrial States, Called Group B, applied a practical plan to reduce emissions by 6-8% compared to their 1990 levels over the period

2008-2012. The United States pledged at this conference a reduction in its carbon emissions of 7% from 1990 levels, but the US Congress did not ratify the agreement after signing it by US President ***Bill Clinton***. This was followed by a final refusal to comply with the provisions of the Convention by the United States in 2001.

Buenos Aires Conference Argentina 1998

This conference was held in Buenos Aires, Argentina, in October 1998. The outcome of this conference was very limited. The conference was supposed to reach decisions on topics that were not agreed upon at the Kyoto Conference, but the intensity of the differences prevented achieving these goals. The Conference adopted a two-year plan of action to find ways to implement Kyoto decisions. One positive outcome in this conference was the announcement by Argentina and Kazakhstan of their commitment to the emission reduction rates committed by the Group of Industrial States in Kyoto.

Bonn Germany 1999

This conference was held at the end of October and the beginning of November 1999 in Bonn, Germany, and it can be said that it achieved only little.

The Hague Netherlands 2000

This was an important conference, held in The Hague, Netherlands, from 13 to 25 November 2000. The United States made an important proposal at this conference, that it would be possible to compensate for the commitment of countries to reduce their carbon emissions if they equalize them by increasing cultivated green areas, or by finding places for their disposal in the ground. This proposal was in - if approved- sufficient to relieve the United States of a large proportion of its emission reduction commitment because of its considerable capacity to increase its cultivated areas. This proposal was rejected by the EU, except Britain. There have also been serious differences over the type and amount of aid to developing countries to help them work towards reducing their carbon footprint. Despite the failure of this conference to reach tangible results, it can be said that it was a platform for the launch of some new ideas, to address the problem of climate change.

Bonn Germany 2001

The conference was held from July 17-27, 2001, after President ***George W. Bush*** took office several months before, during which he announced his country's rejection of the Kyoto Protocol. The United States participated as an observer and did not engage in the discussions. However, the other participating countries have reached important decisions, the most important of which are:

1. Develop a flexible mechanism to allow countries to trade their share of emissions among themselves, allowing poor countries, which have surplus share of carbon emissions exceeding their actual uses, to sell the surplus to developed countries whose industries require additional emissions
2. Approve the mechanism of subtracting equivalent emissions by States that increase forest areas, agricultural land or technological storage from their emissions levels that exceed those in 1990.

3. States have agreed to establish financial support funds for poor countries to help them do their part to address global warming and to support them in order to minimize the damage it causes them.
4. The question of imposing sanctions on countries that do not meet their commitments to reduce emissions was postponed to the next conference in Casablanca, Morocco.

Casablanca, Morocco 2002

The meetings of the Conference continued between 29 October and 10 December, during which some of the issues deferred from Buenos Aires conference were completed, and the appropriate ground to give States the opportunity to ratify the Kyoto Protocol were established.

New Delhi India 2001

The conference was held at the ministerial level from 23 October to 1 November. The most important of the decisions of this conference is the Ministerial Declaration, which called on the developed countries to provide technology to developing countries to help them reduce the damage caused by climate change. During this conference, Russia expressed its reluctance to ratify the Kyoto Protocol saying it needed more time to think about issue. This hindered the entry of the Protocol into force. This is because the protocol requires ratification by at least 55 countries, including a number of developed industrialized countries whose total GHG emissions exceed 55% of the total world emissions. The shares of the United States and Russia in 1990 were 17% and 36.1% respectively. This brings their sum to 53%. Consequently, and since the US has already withdrawn from the protocol, it became impossible for other countries to reach the 55% ratio required for the implementation of the protocol.

Milan Italy 2003

The establishment of a support fund for poor countries was approved to help them adapt to climate change. The Conference reviewed reports submitted by 110 developing countries.

Buenos Aires II 2004

A comprehensive review of what has been achieved over the past 10 years has taken place since the Buenos Aires I Conference. The Conference also discussed some ideas for action beyond the expiration date of the first period of the Kyoto Protocol in 2012.

Montreal Canada 2005

The meetings and discussions of this conference and its committees continued from 28 November to 9 December. More than 10,000 delegates attended the conference and it was the largest international event in Canada. It was decided at this Conference to extend the Kyoto Protocol beyond 2012. The delegates also discussed the possibilities of increasing emission reduction rates.

Nairobi Kenya 2006

The conference did not have much success, and it did not address the issue of gaseous emissions very seriously. Instead, it put in place some mechanisms to help poor countries cope with the negative effects of climate change.

Bali Indonesia 2007

This conference was held for the period 2 to 17 December in Bali resort Indonesia. It discussed plans for the extension of the Kyoto agreement post 2012.

Poznań Poland 2008

For the period between 1 to 12 December, participants agreed on two important issues. The first was the agreement of taking into consideration nations efforts in protecting and expanding their forests. The second was the allocation of financial aids to the world poorest countries to assist them in dealing with damages to their economies resulting from global warming.

Copenhagen Conference 2009

This conference was held from 7 to 18 December. Previous conferences did not have much success in reaching compromises on many critical issues. It was thus hoped that this conferences would form a new start to make decisive decisions on the extension of the Kyoto protocol post its expiration date in 2012. The hopes for this conference were very strong; especially after US, President ***Barrack Obama*** took office in the United States at the beginning of the year, a Democrat who usually takes a more climate-friendly attitude. However, all these hopes dried up almost after the United States announced a month before the conference that President Obama and number of other world leaders have decided to postpone any politically binding decision on climate change to another date in the future. This postponement may have been made in middle of the media hype, after the publication of the letters hacked from the University of East Anglia, which cast a heavy shadow over the conference. This has made most of the participants reluctant to adopt crucial decisions on climate change until the picture becomes clear. However, some of the countries participating in the Conference, and in particular Europe, have made new commitments for the period following the Kyoto Protocol in 2012.

Cancun, Mexico 2010

This conference, which was held on 28 November to 10 December, did not reach agreement on the most important topics discussed including the extension of the Kyoto Agreement and the allocation of 100 billion US$ annually, called the Green Climate Fund as proposed. However, the conference adopted IPCC2007 Fourth Assessment Report on Climate Change. Resolving this issue paved the way for future policy development by ending the uncertainty generated by the publication of the famous e-mail messages. In addition, the Conference stressed that increases in emissions should be stopped at a maximum level, after which cuts will be made. There was also agreement to postpone commitments to cuts by countries that are in the stage of economic growth, such as India and China to a later date.

Durban South Africa 2011

The conference, which met from 28 November to 9 December, made some progress in preparing a plan for the establishment of the Green Climate Fund, which was discussed at the Cancun Conference in Mexico one year before. The conference succeeded in setting up the fund management framework in place. The purpose of this fund, which amounted to 100 Billion US$, is to help poor countries cope with the burden of climate change. The meeting also agreed to start negotiations leading to binding resolutions for all countries, to be adopted in 2015, during which actions to be taken by States after 2020 will be identified. The conference was criticized by climate scientists, declaring that decisions were insufficient to rein in the increase in global temperature to below 2 degrees Celsius, and that the situation required more rapid action.

Doha Qatar 2012

From November 26 to December 7, the Doha Conference did not make significant progress towards funding the previously mentioned Green Climate Fund. The Conference issued a set of documents called the ***Doha Climate Gateway Documents,*** which included an amendment to the Kyoto Agreement, covering the period 2012-2020 (to be approved by States). The plan includes a 15% reduction in carbon emissions for this period. Environment supporters considered this percentage to be less than what was needed, due to objections from Japan, Russia, Ukraine, Belarus and New Zealand, as well as the United States and Canada, which are not already committed to the Kyoto agreement. This extension also did not include India and China, which were not covered by the original Kyoto commitments, as they are countries in the economic growth phase.

Warsaw Poland 2013

This Conference, which took place from 11 to 23 November, produced no significant decisions.

Lima Peru 2014

The outcome of this conference, which took place from December 1-12, was similar to the one that preceded it in Warsaw.

Paris France and the famous Paris Agreement 2015

The Paris Conference, held on 30 November to 12 December 2015, is one of the most important climate conferences held after the Kyoto Conference in 1997. It is clear from the foregoing that the most important conferences held during the eight years post the Kyoto Conference have made little progress towards making important decisions on critical issues. In addition, the Kyoto agreement itself was also suffering from many flaws. The most important of these flaws is that its decisions were binding only on developed countries to seek to reduce emissions. The most important exceptions to those commitments were those of India and China whose gas emissions are high. Developed countries have been forced to exclude them because they have argued that it was the European countries, America and Russia who caused the current increases in carbon dioxide in the first place and not them. They also argued that they must first eliminate poverty in their countries before thinking about climate change, so it is unfair to demand that they reduce their greenhouse gas emissions, thereby limiting their industrial and economic growth. We have also noted that the United States has always been unenthusiastic to take action, limiting its industrial and economic growth. The US always preferred alternative solutions, such as increasing forest areas, using technology to eliminate greenhouse gases instead of directly reducing emissions. Therefore, most of the previous conferences, though widely covered, have often come short of what the environmental and climate advocates had hoped for, particularly the IPCC. The conference was held under a lot of domestic pressure inside the United States, which was heading for new presidential elections in less than a year. President Obama was seeking Democrats to continue to lead the United States. Therefore, he had to win the grassroots Democrats who were disappointed with the US reluctance to take actions that are more decisive on climate issues compared to those taken during most of the conferences held in previous years. At the same time, the United States was not prepared to make important concessions on its economy and its competitiveness with the world. There was also external pressure, by the EU on the United States, being the largest economy in the world, urging it to take steps that are more serious. Such steps would encourage other countries, such as Russia, Canada, India and China, to follow suit. For these reasons, it was necessary to reach a compromise that is satisfactory to all parties.

On these basis, the Paris Conference reached decisions, which appeared to be much advanced in the direction advocated by environmentalists, in spite of the fact that these decisions were not binding. Some 196 countries participated in the Paris Conference discussions, 172 of which committed themselves to reducing carbon emissions after 2020, so that by the end of the 21st century, global warming could be increased by no more than 2 ° C from pre-industrial value, and encourage efforts to reach 1.5 ° C if possible. To achieve this goal, the Conference agreed that each participating country should develop a national self-determined plan, which would decide on what it would do to address global warming by reducing its carbon emissions by at least 80% no later than 2050. The agreement did not impose any mandatory conditions on countries on the speed and manner in which they would make such a reduction. In addition, States that make plans will not be subject to any punitive measures if they do not comply with the plans they themselves develop. The decisions of the Conference indicated that the consequences for States that fail to the implement their own plans would only be punished by having their names on a **name and shame list**. States are required to report on their actions progress every five years. The decisions of the Paris document also set out the mechanisms States should follow if they wished to withdraw from the agreement. This enabled the United States to declare its withdrawal on August 4, 2017.

Casablanca Morocco 2016

The discussions of this conference, which lasted from 7 to 18 November, focused on the issue of water scarcity and cleanliness, which are considered important problems in the developing countries in general and in Africa in particular. Conference decisions also focused on the need to use low-carbon energy sources to reduce the effects of global warming.

Bonn Germany 2017

The conference took place from November 6 to 17. It was attended by a large number of leaders and heads of state as well as more than 30,000 delegates and specialists. The Conference discussed the practical mechanisms for putting into effect the Paris Commitments after 2020. The Conference adopted the so-called "**Fiji Momentum for Implementation**" in relation to the small State of Fiji, whose Prime Minstar chaired the conference. The document outlines what needs to be done during 2018, in order to put Paris commitments into practice. Differences between developing countries, including India and China, on the one hand, and industrialized countries on the other concerning carbon cuts dominated the discussions, and further negotiations have been agreed on. One important event at this conference was the submission of a document by 30 countries, led by Britain, Canada and New Zealand, proposing the end of the use of coal in the generation of electricity in the world by the year 2030.

Katowice Poland 2018

It is hoped that this conference will be held in Katowice, Poland, from 3-14 December 2018.

Where are we?

Twenty-five years have passed since the first climate conference in Buenos Aires in 1992 and twenty years since the Kyoto Conference, which resulted in the Kyoto Protocol in 1997. The Kyoto document was one of the most important decisions on reducing carbon emissions. Kyoto was a commitment from developed industrialized countries only, with specific targets, to reduce those emissions. Kyoto excluded China and India from its terms, and the United States and Canada withdrew at some stage. Now that the Convention has expired, the world is looking for what is beyond Kyoto. The general trend is to find a specific mechanism, including all countries without exception, under which each country will develop a national policy that sets voluntary targets for each country to reduce emissions as agreed in

Paris. It is true that this does not represent the ambition of the environmentalists, and may not satisfy the skeptics, who believe that all that is happening is nothing more than a waste of time and effort. However, it is fair to say that the media coverage of conferences held during the past 25 years and the eagerness of many heads of state to attend, have created a positive atmosphere around the world to reduce emissions. Such atmosphere involved even the skeptics also, not because of their own conviction, but for reasons that may be purely of economical nature. Continued interest in these emissions has resulted in many studies and experiments whose results suggest that it may be economically feasible to move away from fossil fuels or to use it more efficiently, whether to protect the earth's climate or for purely economic purposes. Perhaps this is one of nature's ways of maintaining its balance but by using the human’s nature, intelligence, wisdom, and even his greed this time.

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Chapter Seven

Hopes, Promises, and Realities

The Day After

Here they are returning. A scientist to his laboratory and library that is covered by dust. A farmer returning to a field that has not been plown for years. A worker to a factory or what is left of a factory. A young man, heartbroken, his sweetheart left him to another, after long waiting. A twenty year old putting a black cloth on lost eye. Another young man pulling one leg with the other replaced by a metal bar, others and others. They are all rejoicing despite their misery. Some of them singing, others dance, despite their pains and wounds. Yes, there is a tremendous incentive to rejoice in spite of everything. Finally, they are alive. They have to rejoice. Their share was not like that of millions of their comrades who were robbed of their life by a stab of a bayonet, or shot from gun, or a bomb that came out of a crazy cannon or a thundering airplane. They are luckier than others who have been frozen in a cold snow, or whose bodies have grilled by the sun in a strange desert, of which they do not know even its name. They return individually and in crowds, both the victorious and the defeated. They all share one common joy, that they are still alive. It is their second birth. The Second World War is over.

War is part of life. It has accompanied man since his inception on this earth. Perhaps it is one of the most vicious mechanisms of nature to maintain its balance, or for some other reason we do not know. War has been with us, and will remain with us as long as there are those who believe that they can impose their greed, or desires, or ideology, or belief, by means of a metaphor dagger, or pride in carrying a bandit, or possess a missile more deadly than that owned by others. Human wars have killed tens, hundreds and thousands across the ages of history. There were always victors and losers, but the course of history has changed after the Industrial Revolution. The world fought two wars, killing not thousands, but tens of millions. Weapons invented after the Second World War are capable of killing not only millions but also hundreds of million, or even wipe out life from the face of the earth.

Wisdoms Born out of Madness

The First World War of 1914-1918 broke out because of conflicting ambitions, in order to concur world recourses. The war ended, and the victors were convinced that they had to share these recourses with each other, without controversy. The world reached simple wisdom: that no one could possess the whole world, and the solution was to divide it. World War II broke out because someone wanted to achieve a dream that Hulaku, Alexander, Napoleon, and others failed to achieve. This dream was to rule the world. Tens of millions were killed to rediscover the second wisdom that earth refuses to be ruled by one person, or one ideology, no matter how tyrannical and well armed that person is, and no matter whatever ideology he believes in.

Never Again

The First World War killed 20 million people. The Second World War killed another 60 million of them. May be it was their spirits that awakened those two wisdoms, which made the victorious war giants of World War II meat in 1945 under the slogan "**Never Again**". They met to create an organization whose most important goals and duties were to prevent wars and to work for better life for all human beings. An organization led, guided, and decided by the adult victors. However, the younger "brothers", the weak ones can have their words heard even if it is not listen to. Yet, it still is better than nothing. That organization is the **United Nations**.

The United Nations is a strong and weak organization at the same time. In nearly three-quarters of a century, the United Nations has been able to prevent some wars and to extinguish other wars. This was achieved through quiet dialogues sometimes. Other dialogues were noisier. Even so, the UN also failed to prevent many wars, massacres, atrocities and persecutions around the world. The UN sometimes had her white hands on many matters, and often had her mistakes and sins. Most importantly however, it has so far succeeded in preventing a third catastrophic world war that, if launched, would have killed hundreds of millions again at various critical moments during the twentieth century. Yes, there have been many regional wars around the world, thousands of people have been killed, and millions of were driven out of their homes and lands hoping for return or no return. All this happened under the eyes and ears of the United Nations, but other millions lives were also spared. We should only console ourselves and consider this as a success. The United Nations has also succeeded in encouraging the United States and the former Soviet Union to reach an agreement to reduce their arsenals of nuclear warheads by 80 per cent, which makes them capable of destroying only one third of the world, rather than being able to destroy the whole world several times. Here again we may be able to console ourselves, and call this as some success.

In the area of improving human quality of life, the United Nations has done few positive things through its organizations. The World Health Organization (WHO) has done much to combat endemic and transitional diseases in many countries. United Nations Organization for Education, Science and Culture (UNESCO), has done much to disseminate science and culture, preserve human heritage, despite its inability to protect it at times. United Nations High Commissioner for Refugees (UNHCR), provided much help and shelter to those forced to abandon their homeland, despite the fact that added millions of refugees in recent years, have put burdens on the UNHCR that are beyond its capacity.

Perhaps, the most important concern that the United Nations has addressed in recent years is the issue of climate change. This was done through the establishment of the IPCC Committee, which operates under the umbrella of the World Metrological Organization (WMO), which all the World Climate Conferences are held under its auspices.

The United Nations, in spite of the humanitarian objectives for which it was created, and under the circumstances of its establishment and the nature of its legal, administrative and financial structure, remains an institution controlled by the great Powers. We see manifestations of this fact in most of the decisions and activities of the United Nations and its departments, including WMO. The extent to which the Organization successes or fails in any given activity is influenced by the degree of cooperation of major Powers in achieving that success.

The five-permanent Security Council members that include the United States, Russia, the United Kingdom, France and China at the UN have the final word in any decision. Even so, the economic and political developments that have taken place in the world over the past 75 years have necessitated consideration of the interests of other countries and blocs, as far as global warming gases are concerned, at least.

The Kyoto Protocol considered this fact and divided the world into three categories:

1. The major industrial countries, the United States, Russia, the European Union, Australia, Switzerland, Turkey, Kazakhstan and Ukraine. These countries have committed themselves to the required reduction of carbon dioxide emissions by 7% from 1990 levels during the period 2008 to 2012.
2. The Convention left other States free to exercise their carbon emissions for the same period.
3. The Paris agreement set a target for the world to reach, at least 80%, below its 1990 emissions in a period up to 2050. The agreement contained no determinants of how, or when, a state under which to reach this goal, but left each state free to set its own policies in this regard.

Before discussing the extent of commitment and the contribution of different States, it is very important to note that the series of conferences held, from Buenos Aires to Kyoto, have identified five important criteria for measuring carbon emissions. These criteria are:

1. **Total Carbon Emissions (TCE):** These are the true amounts of carbon dioxide produced by each country, usually measured in thousands of millions of tons (or Giga Ton). This quantity can be

measured accurately by knowing a particular country consumption of fossil fuels. For example, burning one ton of coal will generate about 3.7 tons of carbon dioxide, while one ton of crude oil generates about 3.2 tons of Carbon dioxide and a ton of natural gas produces only 3 tons of carbon dioxide. The reason behind the fact that coal is one of the most fossil fuels producer of carbon dioxide compared to other fuels, such as oil and natural gas, is that the latter contain quantities of hydrogen. Hydrogen produces water when burned. The amount of carbon dioxide produced is always greater than three times the amount of fuel burned. This is because when fuel is burned, it combines with oxygen in the atmosphere, adding the amount of oxygen to the amount of fuel burned to form carbon dioxide.

2. **Emission per Capita (EPC):** This is the second criterion that was agreed to be taken into consideration when determining the share of each country. This criterion is the sum of total emissions of a given country, divided by its population, measured in tons per capita. This measure represents the extent of each country's industrial progress and the extent to which each individual takes advantage of the fuel used. However, this measure may sometimes be misleading. For example, Qatar is the world's highest-ranked country with a record of 37.78 tones per capita in 2013 because of its low population. India on the other hand has not exceeded two tones per capita, despite its large carbon emissions. Its large population has led to the decline of this scale for her. This helped both India and China, to avoid any commitments in Kyoto.

3. **Emission Intensity (EI):** This criterion relates to how efficiently fuel is used to produce one unit of a particular commodity. For example, for a car factory, this metric means the amount of carbon dioxide produced during the process of producing one car. While it represents the amount of carbon dioxide produced during the process of making one loaf of bread for a bread bakery. The agreement was reached to adopt a special metric, which is the amount of carbon dioxide resulting from the production of $ 1,000 of the gross domestic product GDP of a country. For example, if the total value of what a particular country produced, of goods and services is $ 1 million in a certain year, and they emitted 5 tons of carbon dioxide in that period, the emission intensity would be 5/1 million = 0.000005 tons per dollar, or 5 Kg per thousand dollars. Calculating this indicator for a particular country is a complex matter. It requires the knowledge of quantities, and the types of different products and services. However, it is enough to say that the low value of this indicator in a given country is evidence of increased efficiency in the use of fossil fuels. It is worth mentioning that this indicator can fall in any country, even if the country's carbon emissions increase, if it is accompanied by a faster increase in the value of domestic production and economic growth. This is happening in countries such as India and China. Since most fossil fuels in most countries are used for electricity and transport, the commitment of any country to reduce this figure will mean that it will increase the efficiency of its generating stations. This is usually achieved through the replacement of coal by natural gas or renewable energies, the expansion of forest areas, the installation of technological equipment that collects the carbon dioxide emitted by

the stacks of these stations, using underground CO_2 storage, preventing its transmission to the atmosphere, and the use of more fuel-efficient transport.

4. **Forests Area:** The process of increasing the area covered by forest trees is an important factor in addressing climate change because of the pivotal role forests play in eliminating carbon dioxide in the atmosphere. Increasing the forest area by a certain percentage in a given country is counted in its favor, as a percentage in reducing its carbon emissions.
5. Base Year: The rates of reductions or increases for any country are compared to a given year called the ***base year***. Emissions are compared for the following years relative to that year. For example, most of the EU and Russia have committed themselves at the Kyoto Conference to reduce their emissions by a certain percentage compared to 1990, while others have chosen 1995 as their base year. Japan and the United States prefer 2005 to be their base year for reducing emissions. It is worth mentioning that the adoption of 1990 as the base year resulted in the exemption of Russia from any obligations to reduce emissions in the Kyoto Protocol for many years. This was despite Russia's approval and commitment to the protocol, as it appeared that Russia's emissions are lower than in 1990, and thus did not has to make any cuts, as we shall see later.

Most of the discussions and negotiations, which took place between the large numbers of specialists who accompanied their heads of state at the World Climate Conferences, focused on these five criteria. Each country preferred to abide by the measure it deemed more appropriate to its interests.

Therefore, as we shall see later, the nature of the commitments made by States are different in nature. On the other hand, the flexibility resulting from the use of several metrics in determining emissions allowed each country to design its policy more appropriately for its specificities. However, it is necessary to say that the final measure of emissions should ultimately be the first metric, which is the total amount of carbon dioxide generated and discharged to the atmosphere by that particular country.

Despite the participation of all the member countries of the United Nations in all the work of international conferences on climate change, it is very difficult to discuss the specific activity of each country. Many of these countries produce almost no carbon emissions, or their carbon emissions are already negative. This means that they contribute to clearing the atmosphere of this gas in larger quantities than their emissions. Examples are African countries with large forest areas. Therefore, the focus will be on the performance of 5 major countries as well as the European Union (28). These six countries are responsible for putting 61% of carbon dioxide into the atmosphere. In addition, these countries play the main role in the development of the policies and decisions of global climate conferences. Table (2) shows total and per capita carbon dioxide (CO_2) in these countries. It can also be said that most of the other countries that have started to adopt policies geared towards industrial growth are economically linked to one or more of the six countries mentioned. Furthermore, actions and technological developments on climate change in the six major groups are likely to extend to the rest of the world in one form or another.

We will discuss the evolution of these emissions for the five countries as well as the group of EU countries, their implementation of their commitments under the Kyoto Protocol and their plans for the implementation of the Paris Convention, using graphs prepared for this purpose. It is useful to note that the actual emissions since 1990 base year for all these countries are drawn in the constant black line, representing real emissions over the years 1990 to 2016. These emission figures are derived from World Bank publications and other global institutions. The dotted line for the years after 2016 represents the expectations, or commitments, of each country for its post-2015 carbon emissions. These are taken from figures published by trusted international institutions such as the United Nations, the World Bank, databases of the EU Research Center, ministries and agencies of energy, environment and agriculture in those countries, and climate conference reports. It should be said, however, that access to such information would not have been possible had it not been for the culture of transparency and freedom of information that most countries began to adopt in the twenty-first century. This culture itself would perhaps be one of the most important achievements of this century.

Table (2) Carbon Dioxide Emissions of major industrialized countries forming 61% of world emissions in 2015

Country	Total Carbon Emission (TCE) x1000000 Ton	Ratio to the World	Emission per Capita Ton/person
China	**10,641**	**29.51%**	**7.7**
United States	**5,172**	**14.34%**	**16.1**
European Union	**3,469**	**9.62%**	**6.9**
India	**2,454**	**6.81%**	**1.9**
Russia	**1,760**	**4.88%**	**12.3**
Japan	**1,252**	**3.47%**	**9.9**

China

The Kyoto Protocol excluded China from any commitment to reduce its carbon footprint. Because of the massive industrial development after 1990, China replaced the United States as the first carbon-emitting country in 2005. China's emissions of these gases are nearly double that of the United States in 2015. Therefore, it became essential that China contribute seriously to any global effort to reduce emissions. On this basis, China pledged in Copenhagen to reduce carbon intensity per dollar of GDP by 40-45% by 2020. Under the Paris Convention, which it ratified, it pledged to increase that ratio to 60-65% in 2030 compared to that of 2005. It appears from figures published by the World Bank shown in Figure (12) that Chinese has reached a 37% reduction in emissions intensity by the end of 2014. This indicates that it will be easy for them to reach the goals they have undertaken in Copenhagen and Paris, if their current climate policies continue.

One of China's commitments to the Paris Convention was also to bring its total carbon emissions to a fixed level (stop increases) by 2030 or before that date. Figure (11) and figure (13) show that these emissions are beginning to stabilize from 2014, although it is too early to confirm this trend.

China intends to achieve these goals by switching from the massive use of coal to natural gas in its electricity generation. China seems to have already started this transformation since 2014, with coal consumption rates falling by 2.9 percent, 3.7 percent and 4.7 percent for the years 2014, 2015 and 2016, respectively. These declines are believed to have come for two reasons. The first is the slowdown in economic growth in the construction sector. The second lies in the urgent need to combat air pollution in many Chinese cities, caused by the use of coal.

China also intends to increase the contribution of clean energies in the areas of transportation and electricity generation by nearly 4% per year until 2030. China does not believe that it will be very difficult to achieve these goals if there is no sudden change in global oil and gas markets that prompt China to return to the use of coal for electricity generation. Some observers worry that the unpublished figures for China's 2017 carbon emissions are not encouraging, and may reflect a certain increase, given the belief that China has already returned to reliance on coal for electricity generation more than the previous three years.

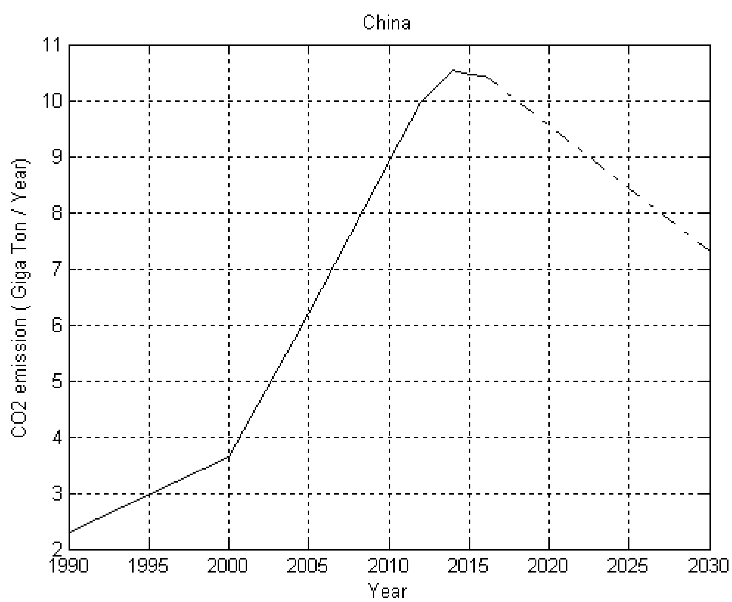

Figure (11) Total China's Carbon emissions in Gega Ton per Year. Actual emissions (solid line). Future expected emissions (dashed line)

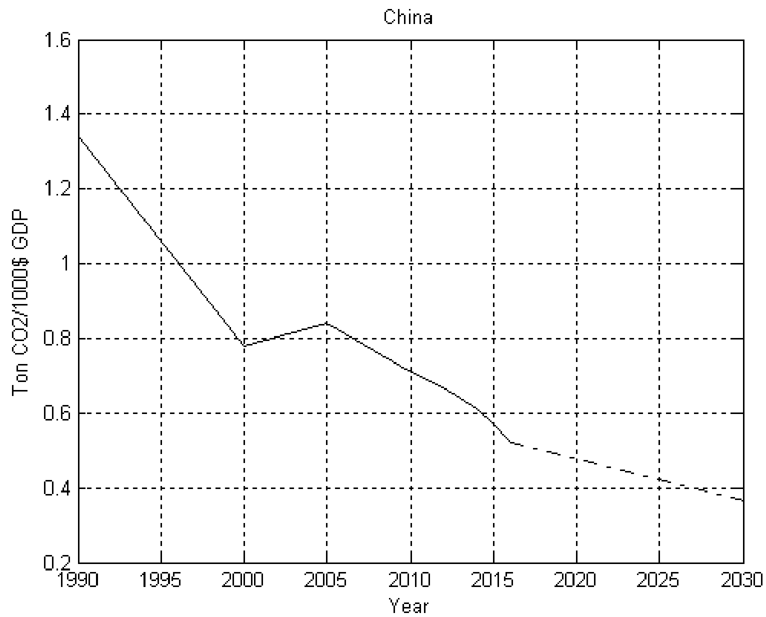

Figure (12) Total China's Carbon emissions Intensity in Giga Ton per 1000 $ of GNP. Actual emissions (solid line). Future expected emissions (dashed line)

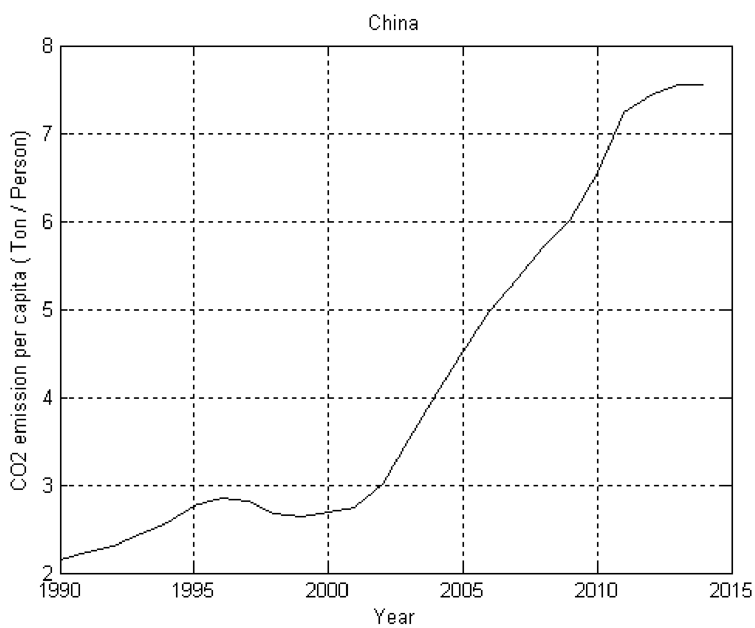

Figure (13) China's Carbon emissions per capita

China's commitments to reduce its carbon intensity in 2030 to 60-65% from 2005 levels, shown in Figure (12) above were tied with other commitments related to increasing forest areas. China has promised to increase its green forest area by 20 percent between 2005 and 2020. China is also unlikely to face any difficulties in increasing the green forest areas it has pledged under the Paris Convention, given that these areas recorded annual rate increases of up to 1.25% even before the signing of the Paris Convention.

The United States

The United States was the largest contributor to total carbon emissions and per capita until 2005, when China surpassed it in terms of total emissions, and with 1990 emissions averaging 19.3 tones per capita. Before discussing the performance of the United States on the issue of global climate, it should be noted that the United States has a more special status than others, in being the leading among countries in the pursuit of market economy policies regarding supply, demand, and competition. This policy, despite its advantages and criticisms, represents a general culture among Americans, encompassing all aspects of life, and the issue of climate change is no exception. The follower of all American policies notes that there is a historical rivalry between the two sides. The liberals, who support more centralized policies and the conservatives who prefer to follow the principle of central non-intervention in market policies. Both sides have their arguments and justifications that are beyond the scope of our current discussion. However, generally speaking, this divergence of views has also been reflected in the United States' plans and policies on climate change.

Figure (14) shows the total carbon emissions of the United States. At the time of the signing of the Kyoto Protocol in 1997, the United States committed a reduction of 5.2% over its total emissions by 2012, compared to the 1990 base year. The United States emissions in 1997 were around 5.7 Giga tons. It appears that, although the US Congress did not ratify the agreement and the resulted final withdrawal of the United States in 2001, the United States agreed at the Copenhagen Conference 2009, to reduce carbon emissions by 17% from 2005 levels, and reach the levels of 1990, or less, by 2020. A simple observation of Figure (14) shows that the United States has been able to reach the second goal, which is the levels of 1990, approaching the realization of achieving the first goal of reaching 14% in 2016 compared to 2005 within seven years, four years ahead of schedule. This means a rate of reduction of 2% per year, which indicates that it will be easy to reach the ultimate target of 17% by 2020. In addition, the United States has achieved a significant reduction in the amount of emissions intensities associated with 1000 US$ of GDP , which dropped from 0.8 tones of carbon dioxide per thousand dollars in 1990 to only 0.3 tones in 2014, as shown in figure (15). This decline is associated with more advanced technological methods, which led to the use of fuel in a better efficient way. A simple comparison with this figure in China shown in Figure (12) indicate that fuel efficiency in the United States is about 40% better than that in China.

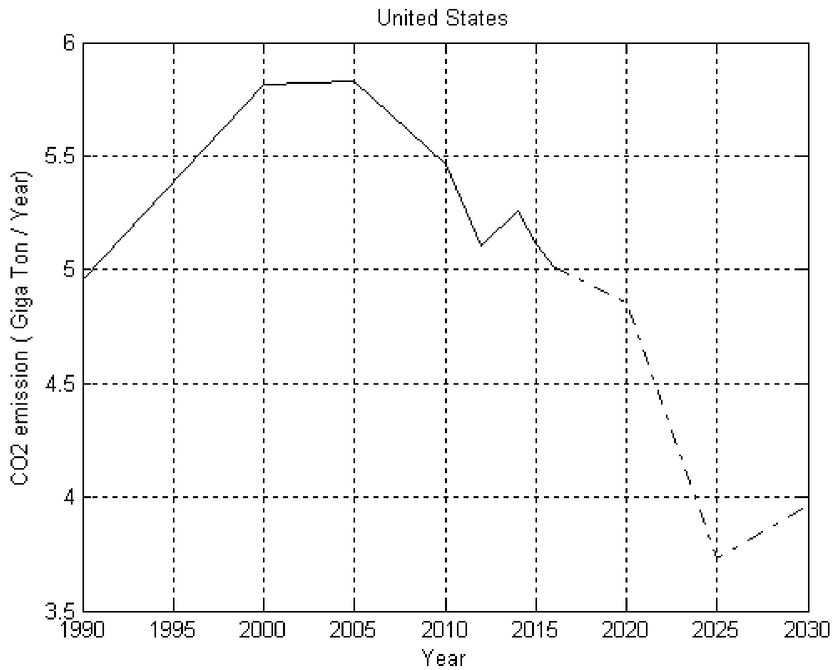

Figure (14) Total United States Carbon emissions in Giga Ton per Year. Actual emissions (solid line). Future unratified expected emissions (dashed line)

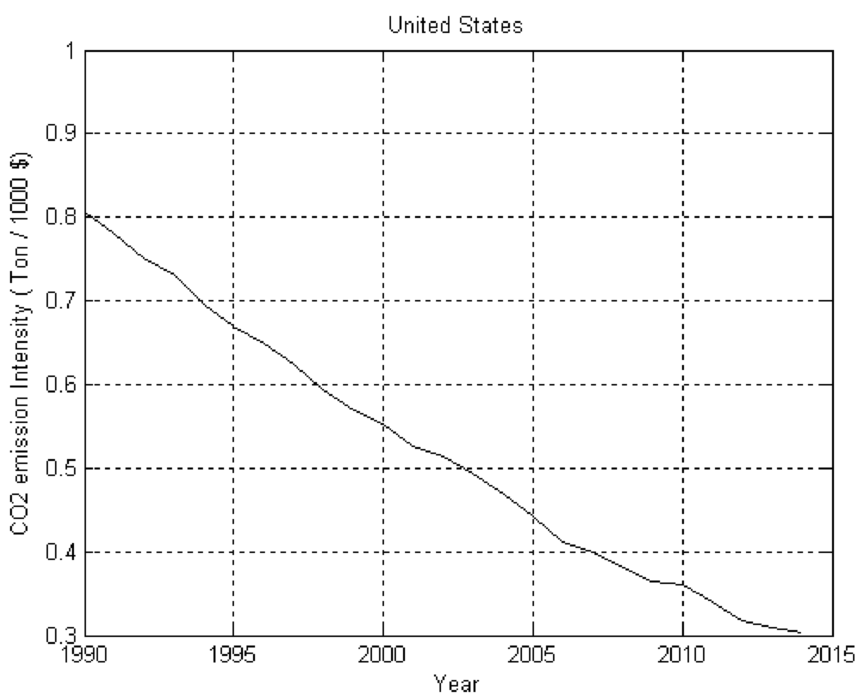

Figure (14) Carbon emission intensity in the US in Ton per 100 $ GNP

There are those who believe that one of the reasons for this decline in emissions was due to the economic recession in the United States, which began in 2011. However, this belief cannot be accurate, because as figure (13) shows, the 2011 recession has only helped in this respect rather than being its main cause. Many analysts agree that the main drivers that helped reach the targets set for the decline were three important reasons. The first is the transformation of many power plants from the use of coal to the use of natural gas, which is more efficient, and produces less carbon dioxide gases. The second is the development of transportation technology and the most importantly cars, and the start of production, and use of electric and hybrid cars. Sales of electric vehicles in the United States have achieved a huge boom up of nearly 20% annually over the past 10 years. The third reason is the increase in the use of clean alternative energies, such as wind power, hydroelectric, solar energy, and biofuels. These alternative energies accounted for 12.2% of the total energy in the United States in 2016. Biofuels accounted for 46.8% of these alternative energies, while hydropower energy accounted for 24.4%, wind by 20.8%, solar energy by 5.8% of alternative energies. On the other hand, in addition to the construction of relatively large solar power plants, legislations, easy credits and tax exemptions on the use of such energy have contributed to the increased proliferation of the use of solar energy on household level. Many states are committed to repurchasing electricity from consumers who install solar panels to generate electricity in their homes or plants. It is worth noting that the state of California has passed legislation in 2018, requiring the installation of solar power units in all homes to be built in the future.

Many analysts believe that the US withdrawal from the Paris climate agreement will not have a large impact on a significant reduction in US carbon emissions. They further believe that expected actual reductions will come close to the previous commitment of 26-28 percent below 2005 levels by 2025. These analysts build their optimism on two reasons. The first is that although the United States announced its withdrawal from the Paris Convention, this withdrawal will only be in effect three years after its declaration, i.e., in 2020, as stipulated in the Convention with regard to the terms of withdrawal of any country. The second reason is related to the expected technological development, especially in the automotive industry, and the shift to electric cars. This will produce significant emissions reduction if we remember that 35% of carbon emissions are due to transport. Consequently, development in this area will have an important role in reducing those emissions. In addition, the evolution of the emission per capita shown in figure (15) indicates that this metric has decreased in the United States from 19.3 tones per capita in 1990 to 16.3 tones per person in 2012, which is the Kyoto Protocol expiration date. This represents a decrease of 15.5% indicating an important shift to use energy more efficiently. Even so, this figure is still considered higher than corresponding ones in other countries.

Figure (15) Carbon emissions Tons per capita in the US

The United States achieved a good 1.8 percent increase in forest area during the period 2005-2014, while forest areas worldwide fell for the same period by a frightening 9 percent, according to figures released by the World Bank. It is worth noting that the US forest area currently accounts for about 8% of the total forest area around the world, compared to the US area of the world, which is only 6%. The increase in forest areas has been caused by two factors. The first is the existence of legal legislation that defines many forest areas as national reserves and does not allow for deforestation, and other areas whose forests are used as wood sources under conditions that ensure the sustainability of these forests by replanting new trees that are cut. The second reason concerns the market economy philosophy of forest investment. Companies and individuals who acquire forest investment rights consider these forests to be invested capital, and their perpetuation and increase is a priority of any investor. Thus, there should be no irreparable loss of trees. This is simply based on the economic principle of the need for capital development rather than consumption.

European Union

The current EU's 28 member countries constitute the third largest economic group in terms of total carbon emissions and occupy medium level of per capita emissions. The majority of public opinion within the EU is a strong lobbying group demanding their governments to pursue committed policies toward reducing carbon emissions. The pledges of the EU were therefore more ambitious at Kyoto, Copenhagen and Paris conferences, and their commitments to reduce aggregate emissions were more specific and clear. The commitment of the EU countries in the first phase of the Kyoto Protocol was to reduce total emissions by 8% compared to 1990, during the period 2008-2012. In the second phase (Kyoto extension), the EU pledged 20% reduction in the period 2013-2020, and in Copenhagen it undertook to increase this to as much as 30% and to consider the previous 20% as a minimum. Figure (16) shows that the EU has managed to reach a reduction rate of more than 26% in 2016, putting it in a comfortable position to achieve its goals. This success came for two reasons. The first is a series of practical measures taken to increase dependence on alternative energies. These energies include biofuels, hydroelectric, nuclear power, wind, tide, solar energy and geothermal energy. These contributed nearly 20% of total energy consumption. It is useful to note that trends in alternative energy types adopted by each member country differed according to the circumstances of that particular country. While countries such as Iceland relied more on geothermal energies, Germany and Spain focused on the use of solar energy, while Countries such as Britain and the Netherlands have expanded their use of wind power. France has the largest share of nuclear energy.

The second reason that enables EU countries to meet the emission reduction targets was the selection of the 1990 base year for reductions. A large proportion of the EU countries in 1990 were part of the Eastern bloc, whose industrial establishments were technologically obsolete and with low energy efficiency. The modernization of these installations after the collapse of the Eastern bloc and the accession of many of their countries to the European Union led to an increase in their efficiency and productivity.

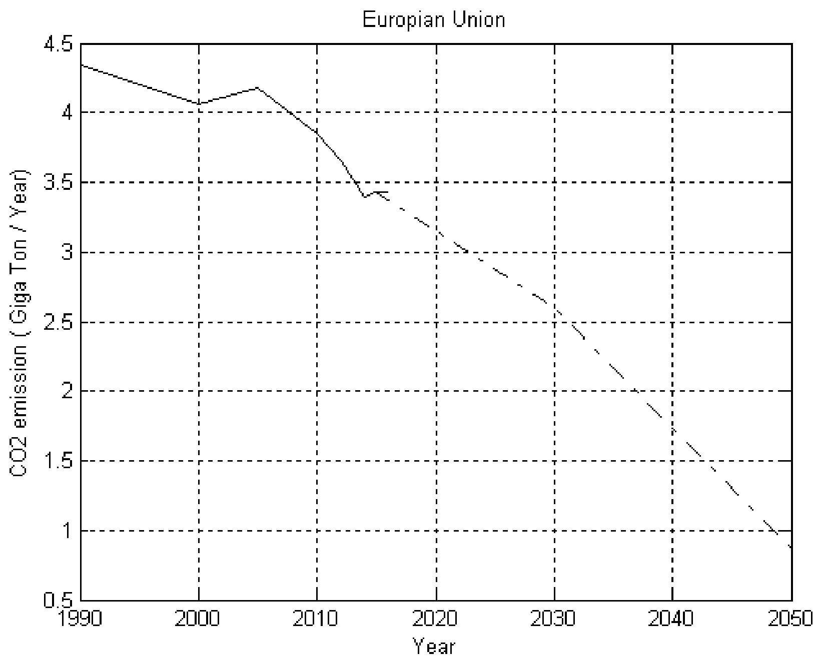

Figure (16) Total Carbon emissions in EU countries in Giga Ton per year

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The EU countries have also succeeded in reducing both the emission intensity and the amount of emissions per capita significantly, as shown in Figures (17) and (18). These were the results of policies and strict legislation aimed at increasing the efficiency of fossil fuel consumption on the one hand and the shift to renewable energies, on the other hand. In addition, the development of legislation that provides easy credits, and tax exemptions to encourage individuals and industrial institutions, helped much in switching to those energies

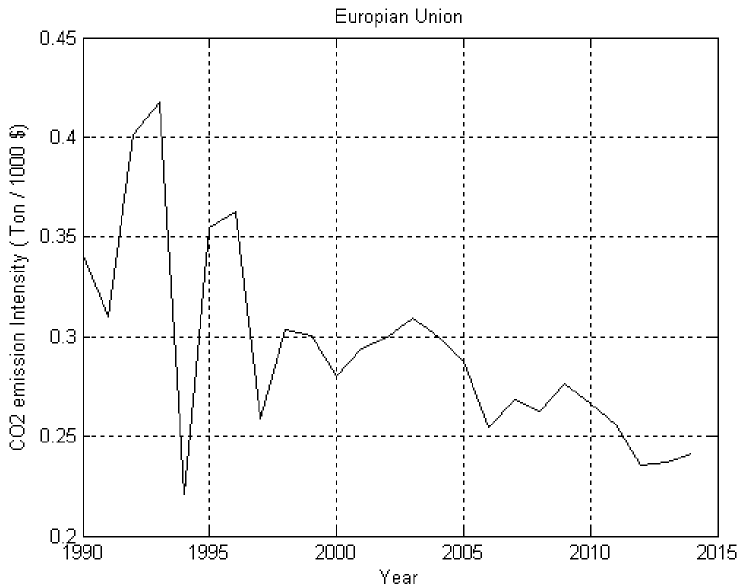

Figure (17) Carbon emission intensity for EU in tons per 1000 $ GNP

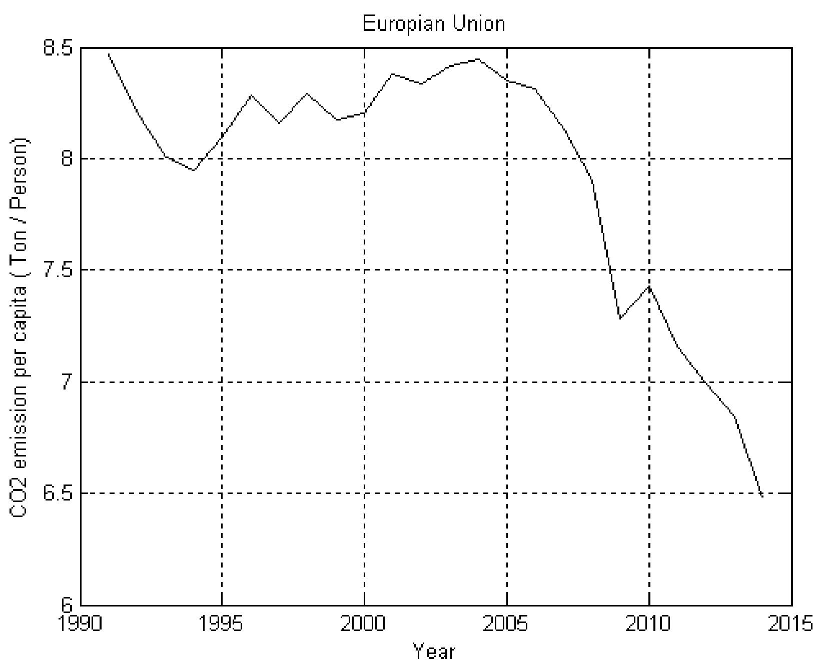

Figure (18) Carbon emissions per capita in the EU

The EU countries have made good progress in increasing forest area and have achieved a growth rate of 5.2% in 1990- 2015, an average of 0.2%

annually. This is equivalent to an increase in the sum of the total area of 1500 football fields per day. This increase was the result of legislation and systematic management, in forest investment and wood production, in order to ensure that more areas are cultivated compared to those that are harvested.

India

Although India ranks fourth country in generating carbon emissions after China, the United States and the European Union, it has managed to excluded it self from the Kyoto Protocol commitments. This was due to its small emissions per capita, which was only 0.4 tons in 1990. This exception allowed it to increase carbon emissions significantly to enable it to grow economically and industrially, and to combat poverty. This exception also made it possible to increase its carbon emissions four fold in 2016 compared to 1990, as shown in figure (19) below.

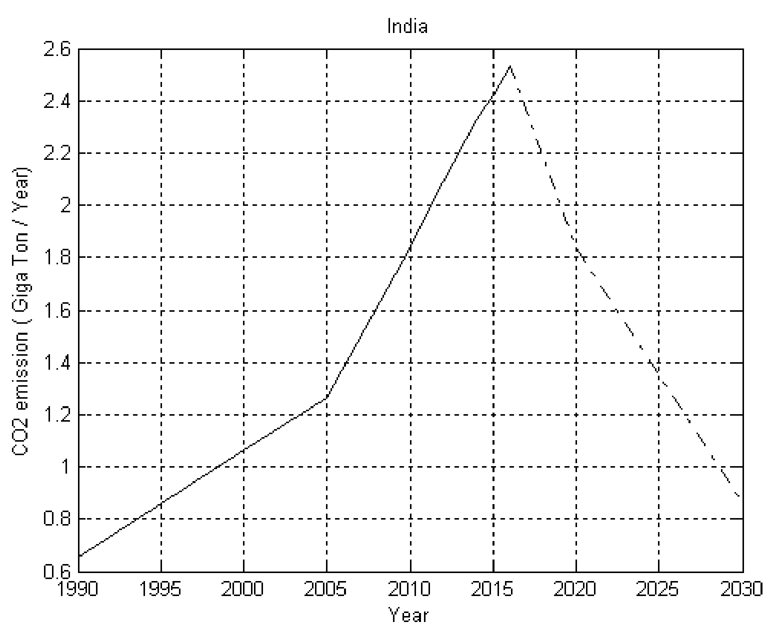

Figure (19) India Carbon emissions Giga Ton per year

India pledged at the Copenhagen climate conference to reduce emissions intensity (not total emissions) by 20-25% from 2005 levels by 2020. It is very difficult to translate this reduction into an actual reduction in total emissions because the emission intensity - as we have mentioned - is a measure based on the efficiency of the particular technological process and on the proportion of carbon in the fuel used in that process. However, rough calculations by the author show that India has achieved a reduction in emissions intensity of 18% in electricity generation sector in 2016 compared with 2005. This indicates that it will be able to reach, or may exceed its 20% reduction commitment in Copenhagen by 2020, as well as a reaching the target of 33% reduction at least in 2030, as stipulated in the Paris Conference shown in Figure (20). India also pledged to increase the contribution of non-fossil fuels to electricity generation to 40%. This reached 33% level in 2016, including hydropower, wind and solar power. This seems to indicate that reaching the 40% goal in 2030 is very much possible.

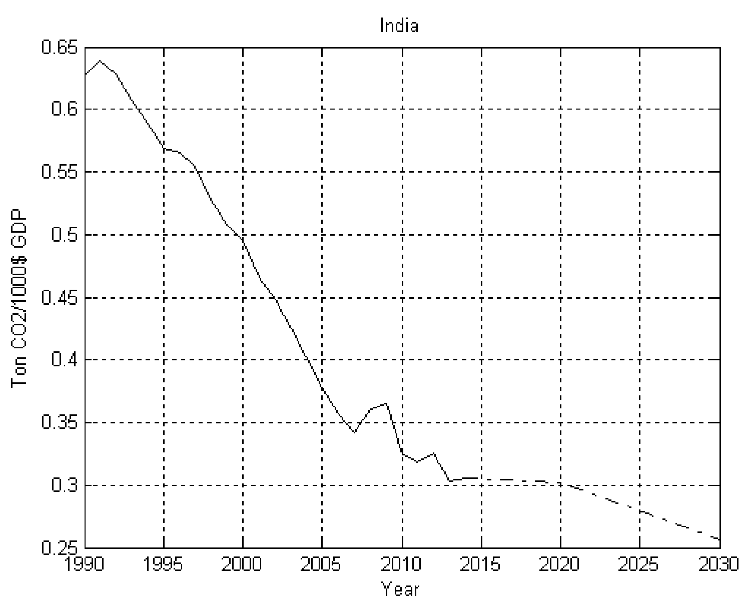

Figure (20) India Carbon emission intensity in Ton per 1000 $ GNP

India has achieved these goals by using several methods, the most important of which is through its increased reliance on clean energies from 30% in 2005 to 33% in 2016. In addition, it has increased forest area by 0.34% for the same period, compared to earlier periods between 1995 and 2000, when India suffered from shrinking forest areas because of over-logging and conversion of forests for other purposes. Under the Paris Convention, India also pledged to increase its total forests areas to the extent that it would allow the removal of more than 2.5 Giga tons of its carbon dioxide emissions in the atmosphere during the period 2005-2030 out of an expected total of 38 Giga tons. This seems too ambitious and may be difficult to achieve, because India will have to increase its forest area by 0.8 percent by 2030, which far more than in the previous 10 years average.

On the negative side, the figures indicate a significant increase in the use of coal compared with other fossil fuels for electricity generation. This increased from 82% to 88% for the same period, possibly due to higher oil and gas prices in that period.

India pledged in Copenhagen that its carbon emissions in 2020 would not exceed five times that of 1990, but as Figure (19) shows, these emissions for 2016 already reaching four times as high as 1990. The continuation of this pattern of increase will create great difficulty for India in implementing its obligations under the Paris Convention.

India has huge problem of population increase. This can be seen by from the significant increase in total carbon emissions in Figure (19) and comparing it with the amount of per capita emissions in Figure (21) below, which has achieved an increase of only about 50% , Although total emissions have quadrupled during 1990- 2014.

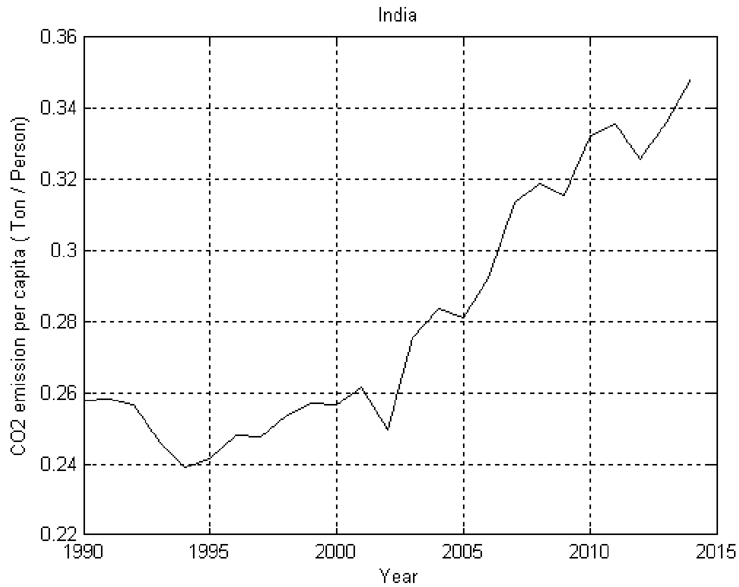

Figure (21) India carbon emission per capita in Tons per capita

The Russian Federation

Although Russia is a high-carbon emitting country, it has found itself in a very comfortable position at the Kyoto conference. Considering 1990 as the base year for any gas cuts was an important factor in considering Russia not obliged to make any commitments in this regard. The reason for this is that Russia's carbon emissions in 1990 were high, reaching about 2.4 Giga ton per year, when it was within the former Soviet Union. The collapse of the Soviet Union and the ensuing economic recession led to a significant reduction in Russia's GDP. This in turn reduced carbon emissions by a significant 30% when the Kyoto Protocol came into effect. This is much higher than the 8% imposed by the Kyoto Protocol on industrialized countries until 2012. In addition, Russia's commitment to the Copenhagen Conference not to increase its emissions by more than 25% by 2020 is already within Russia's 30% level. Consequently, Russia did not have to make further cuts to those emissions until that year, as shown in Figure (22).

Russia was a signatory to the Paris Convention, pledging a reduction of between 25-30% by 2030, but has not yet ratified it. No detailed plans have been presented, except for its general pledge, to increase the forests areas as far as possible.

The Russian Federation has largely succeeded in improving the efficiency of its carbon emissions as seen in figure (23). This metric has fallen from two tones per 1,000 dollars of GDP before 1995 to less than half a ton in 2014. Even though, this figure, is still relatively high compared to that in the United States and the European Union. The per capita emission index recorded a significant increase after 1997, as shown in figure (24).

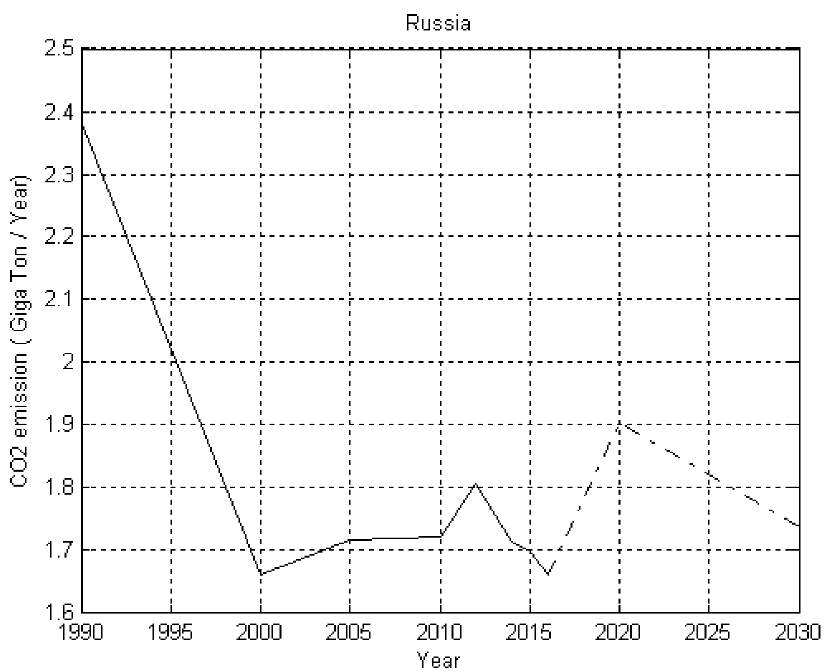

Figure (22) Russia total Carbon emissions in Giga Ton per year

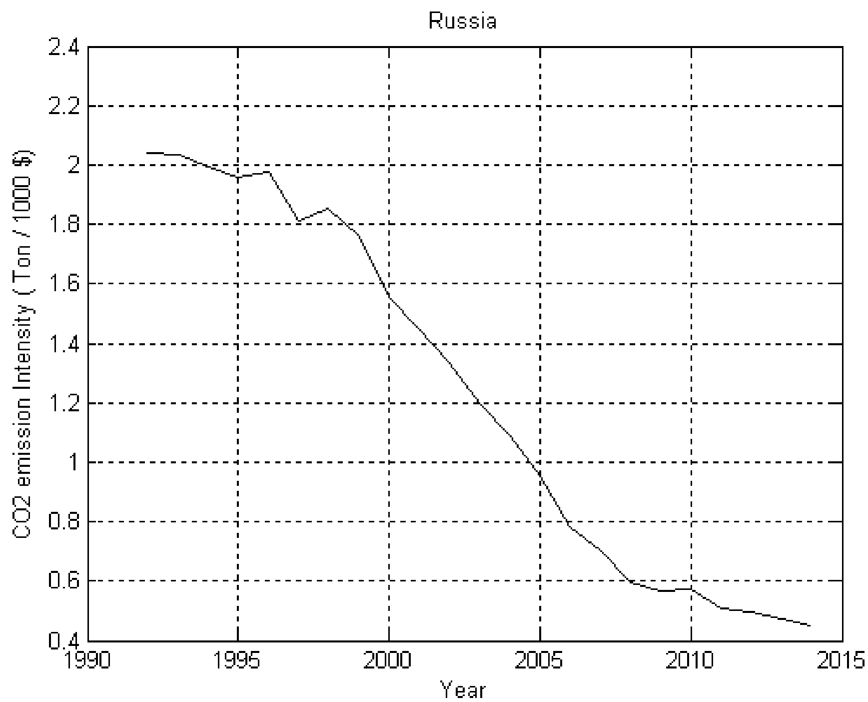

Figure (23) Russia carbon emission intensity in Ton per 1000 $ GDP

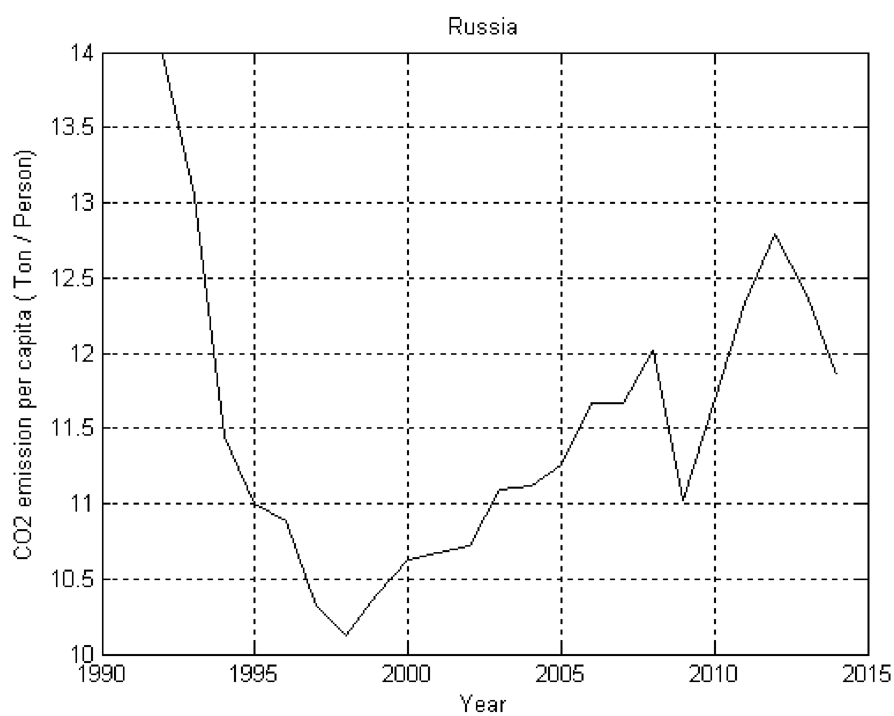

Figure (24) Russia Carbon emissions per capita

Forests cover almost half the territory of Russia and make up one fifth of the world's forest areas. However, these forests suffer from many problems related to their logging and re-planting cycles. A high proportion of newly planted or re-planted forest trees suffer from diseases, fires and poor care during early growth. Although these forests account for one-fifth of the world's forest area, the amount of wood produced for industry and export does not exceed 6% of the world total. According to some studies, Russia's forest area is expected to increase between 2010 and 2030 by only 1.5% or 0.075% annually. This represents a low percentage compared to other countries if the current situation of forest management in Russia continues.

Japan

Japan's climate change policies seem to be somewhat complex. Japan signed and ratified the Kyoto Protocol, and Japan's share of reductions under this agreement was supposed to reach emissions of 6% less than that of 1990 in 2012. It is noticeable from Figure (25) below that emissions increased by 9.5% for the same period. Furthermore, Japan has pledged at the Copenhagen conference to reduce its emissions by 3.8% compared to a new base year, 2005, by 2020. Figure (25) shows that it reached that level in 2016, reducing its emissions by almost 4%. However, this raises further doubts about whether it can meet another commitment of its 2020 emissions not to exceed 9% higher above those for 1990, given the fact that this increase is already at about 7% in 2016.

Japan signed and ratified the Paris Convention, and its commitment was to make reductions of 26% of a new base year of 2013 by the target year 2030. There was a slight decrease of 4% in the years 2013-2016, at an annualized rate of 1.25%. If the current rate of emissions continues to decline at the same pace, the overall decrease could be 20-21% in 2030. This is still below its 26% commitment. Japan has made another optional commitment under the Paris Convention that its total reduction in 2050 will reach 80%, but it is not known what the base year of this reduction is and how is it going to be accomplished.

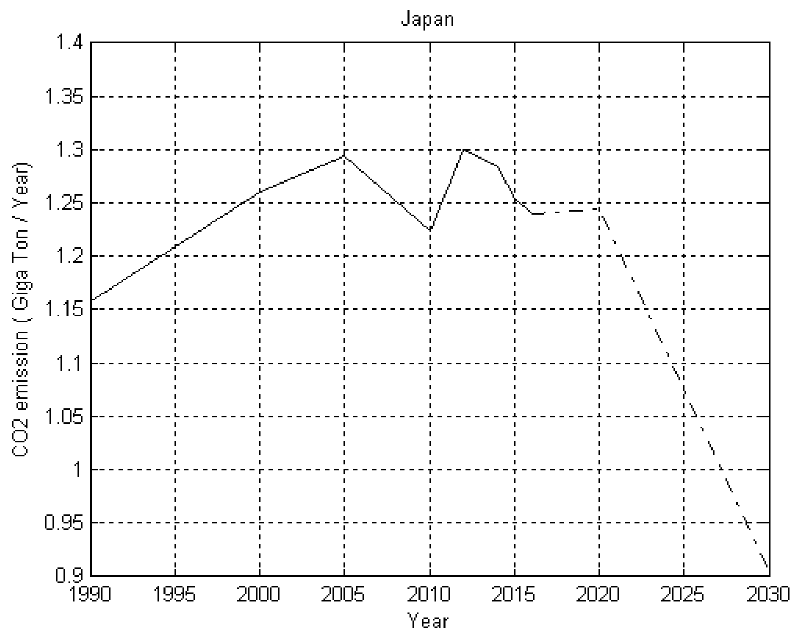

Figure (25) Japan total Carbon emissions in Giga ton per year

Japan currently relies in 10% of its electricity generation using clean, non-carbon energies. It has plans to increase this to 24% by 2030. These include geothermal, hydroelectric, solar, wind, biofuels and tidal energies. In addition, over the past 40 years, Japan has adopted a policy of expanding the use of nuclear energy to generate electricity, contributing 30% of total electricity produced in 2011. The earthquake of 2011 and the subsequent tsunami caused significant damage to one of its nuclear reactor resulting in radioactive leaks. Amid fears of further possible earthquakes that could damage other reactors, Japan decided to close all its nuclear reactors until safety measures were confirmed. The last reactor was shut down on May 5, 2012. Japan began reactivating the reactors in 2015 after its ruling party changed. The new government announced a plan to increase the share of nuclear power by 2030 to nearly 36% of Japan's total power generation capacity. Increased dependence on renewable energies has significantly reduced carbon emissions per $ 1,000 of GDP, as shown in Figure (26). In addition, the emissions per capita showed fluctuations around a rate of less than 10 ton per year per person, as Figure (27) shows.

Japan has some of the world oldest forests. Although forests cover about 68% of Japan's area, the economic exploitation of these forests in wood production is very limited, and Japan relies on import for most of its timber needs. This is because of the high cost of production, because most forests are located in mountainous areas. Japanese traditions retain certain sanctity for mountains and forests, to the extent that there are certain forests in Japan that acquired the reputation as attraction places for those who want to commit suicide. The Aokigahara forest in Japan is the most famous world suicide center. Lack of trimming and logging to control tree densities has resulted in weaker trees, reducing their efficiency in absorbing carbon dioxide from the atmosphere. The process of increasing the efficiency of these forests in the absorption of carbon dioxide requires the disposal of old trees and the planting of new trees in place according to plans considered for this purpose. Statistics show that Japan's forest area shrank by 0.03 per cent annually during the period 1990-2000, falling to 0.01 per year between 2000 and 2005. This means that Japan lost 0.3% of its forests during the period 1990-2005. In its efforts to reduce carbon emissions in 2012, Japan introduced new laws on forest management and exploitation and trained its employees through a program called **Green Driver Employment Program**.

However, there is no confirmed information on the extent of any decline or rise in forest areas in Japan after 2005.

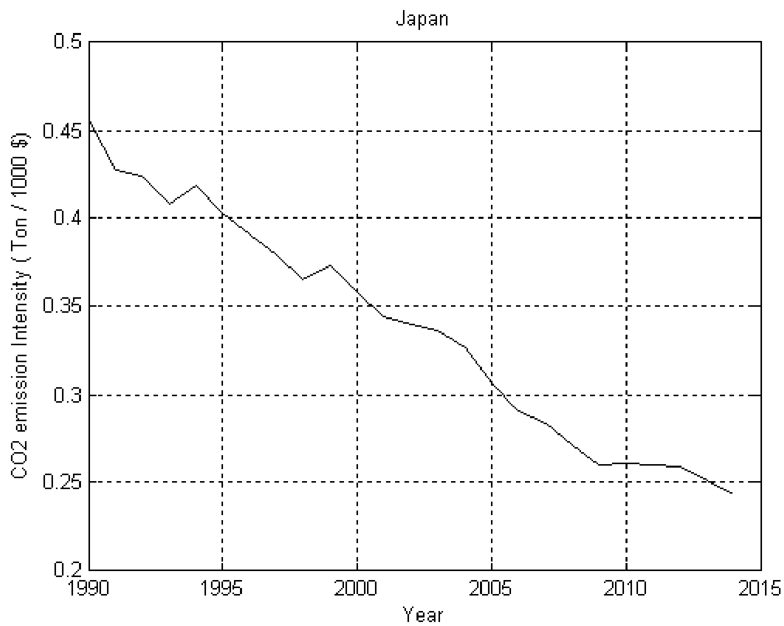

Figure (26) Japan emission intensities in tons per 1000 $ GDP

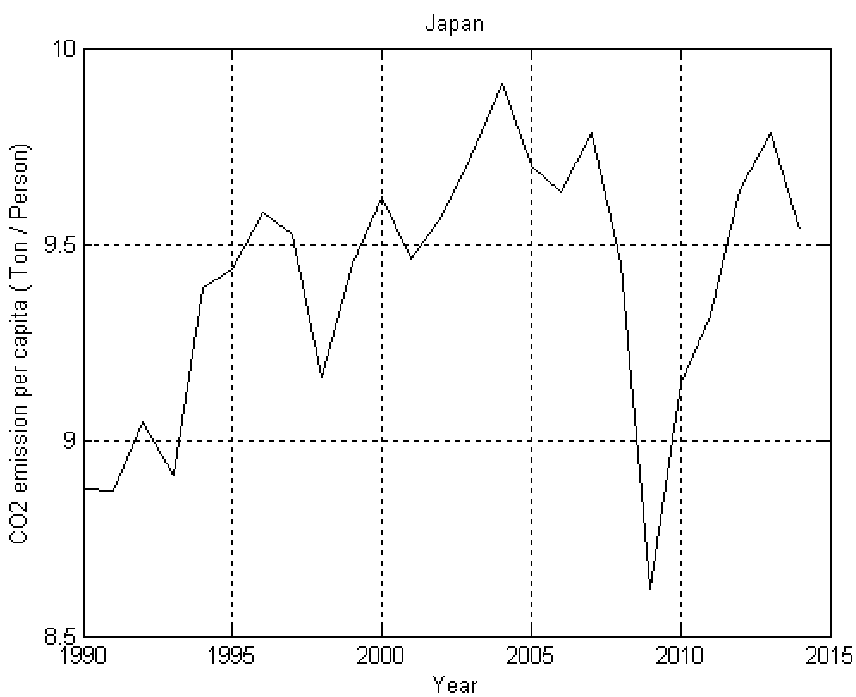

Figure (27) Japan carbon emissions per capita

The World

The above five countries, together with the European Union, represent the world's largest contributors to carbon emissions, accounting for 61% of world emissions. The Kyoto Protocol was mainly concerned with putting the basis for reducing emissions of those countries. Other countries were left until the Copenhagen and Paris conferences. A brief look at the total carbon emissions of all world countries from 1990 to date, shown in figure (28) below, indicates that total carbon emissions have increased by about 60%. This rise is expected, due to the significant contribution of India and China, as well as other countries. Although the first view of this rise may not encourage optimism, there is a fact to be observed, that this rise has almost leveled during the years 2014 - 2016. This may indicate that a larger number of countries have become closer to achieving the goals they set for themselves in Copenhagen. However, the fact that this assertion is observed in the last three years will be a continuous pattern for the years to come, or is it merely a result of a set of circumstances remains unanswered question for some time. However, an overview of the behavior and evolution of the emissions of the major industrialized countries over the past years and the future commitments of these countries - which have been presented previously – involves remarkable pattern that may give a clue to the answer.

This pattern of behavior is that each of these industrialized countries has passed through three periods. The first period is characterized by continuous increases in emissions, up to some limit, which is a natural result of the industrial growth of those countries. The second period shows semi-constant emissions at the upper limit reached at the end of the initial growth. This almost constant emissions period continues for several years. This is followed by a third phase, characterized by a start of reduction in those emissions. This decline reflects the fact that these countries have begun to give greater priority to the issue of climate change. Note, for example, that the period of the largest emissions in the European Union came early before 1990, while delayed in the United States until the period from 2000 to 2005. It can also be said that this leveling period ended in 2012 in Japan, after it had started in 2005. For China, if the slight decline observed from 2014 to 2016 continues, this will be evidence of China entering the third phase. The situation may be different for India, which has yet to show any evidence that its emissions could reach a maximum constant level before starting to decline, despite what appears to be its ambitious commitments in this direction, which it pledged at the Paris Conference. Much cannot be said about the direction things are going as far as Russia is concerned so far.

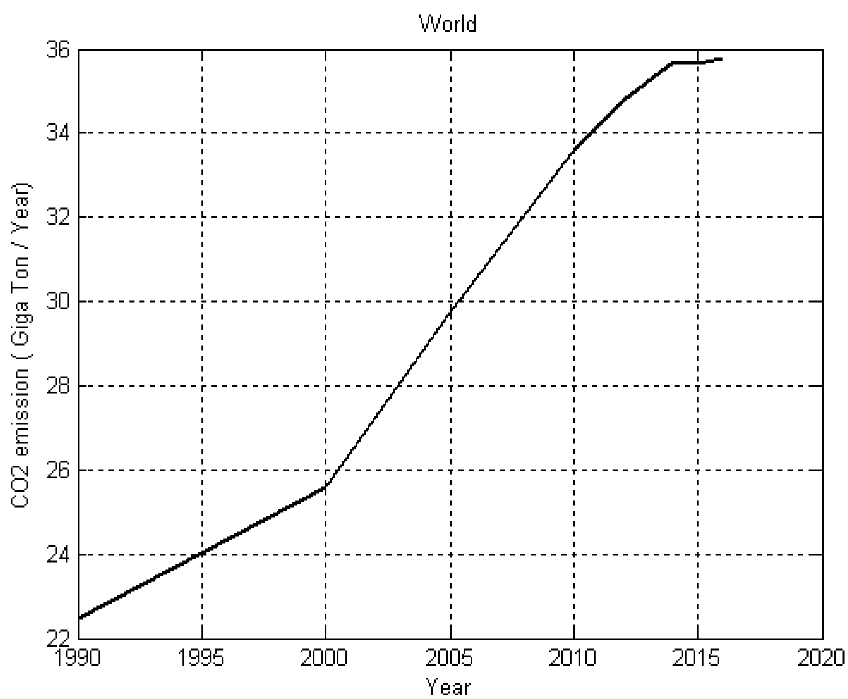

Figure (28) over all World Carbon emissions

Although our overall focus has been so far on carbon emissions from burning fossil fuels, at this stage, we would like to say that carbon dioxide is not the only gas that can cause climate change, though it is the most important one. There are other gases, which have the same effect as carbon dioxide in a way or another. These represent up to 30% of the emissions. The most important of these gases is methane, which is produced by some industries, as well as from the decomposition of animal waste, and constitutes a significant proportion of emissions by countries whose economies depend on livestock breeding. Other gases, such as nitrogen oxides and sulfur oxides, have similar effects as carbon dioxide in terms of climate change, as well as other environmental pollution impacts, affecting the overall health of humans. In addition, the emissions of some other industrial chemicals such as chlorofluorocarbons, which reduce the proportion of ozone gas in the atmosphere, resulting in more susceptible to ultraviolet exposure that cause skin diseases. The latter will be discussed in a special article later. World climate conferences have not neglected to pay much attention to these gases, and have set ratios for their reduction that bind the countries concerned. However, it is practically and technologically much easier to reduce the world emission of these gases compared to carbon dioxide. This fact is reflected in that the world countries have achieved high rates of emission reductions of these gases during the last few years. The 2012 emissions of these gases fell by about 19% compared with 1990. This is a remarkable achievement when compared with the continuing sequential rises of carbon dioxide recorded for the same period.

The relationship between the total amount of the world carbon emissions and the concentration carbon dioxide in the atmosphere is almost linear. This means that each additional fixed amount of emissions results in an almost a fixed proportion of gas in the atmosphere, after dissolution of another fixed proportion of the gas in ocean waters. The bulk size of ocean water is almost constant, it is thus reasonable to exclude its effect from consideration. This approximation is justified because the oceans are consistently taking their share of carbon dioxide. The situation is quite different when it comes to the performance of vegetation from forests. It is well known fact that despite the efforts that have been made in recent years, and the promises made by countries at the climate conferences, the world's forests are still experiencing systematic annual shrinking. It is true that the pace of this decline has tended to slow down in recent years, but the situation is still that the forest areas around the world are becoming less and less year after year. Forests in the world recorded a decrease of a total 1.7%, or 0.11% annually, in the years 1990-2005. It is important to note that this percentage has been declining because of the efforts made by some countries in the development of their forests, which has reduced this deterioration of forests, except in some tropical regions of the world. The over all current pictures are that world forest areas now are less by 2% Compared to 1990.

The following simple calculation demonstrates the effect of reduced forest areas on the concentration of atmospheric carbon dioxide. For these calculations, we need to keep the following fact in mind:

1. The concentration of carbon dioxide in the atmosphere was 284 parts per million before the industrial revolution when industrial carbon emissions were zero.
2. Concentration of carbon dioxide in the atmosphere became 354 parts per million, an increase of 70 parts per million in 1990, when carbon emissions became 22.5 Giga tons per year.

3. This means that an increase of one Giga ton of emissions contributes to the increase of the concentration of carbon dioxide in the atmosphere by 3.12 ppm (70 divided by 22.5).
4. Now, if we use this result to calculate the atmospheric carbon dioxide concentration in 2017, where total emissions were 37.6 Giga ton (without considering the shrinking forest areas), we would reach a value of 3.12x37.6 = 117 ppm added due to the industrial revolution emissions. This means that if the forest area had remained constant for this period, the concentration of carbon dioxide in 2017 would have been only 284+117= 401 ppm, instead of the actual current measured value of 408 ppm.
5. If we add a 2% correction to the above figure to account for the 2% forest loss during this period we will get $401+\frac{2}{100}\times 401=409$ ppm. This is very close to the actual value of 408 ppm despite our simple and crude calculation. This means that if the world has only maintained its forest areas at their 1990 level, we would have had atmospheric carbon dioxide concentrations at 401 instead of 408 ppm.

This demonstrates the importance of serious action by the world to stop forest degradation first and then to reverse this downward trend as an important part of efforts to halt climate change around the world. This can be achieved by stopping the removals of forests in order to turn them into field farmlands, because the leaves of a tree covering a certain area of land are hundreds of times more efficient in handling carbon dioxide than seasonal field plants. In addition, States should enact strict legislation limiting forest cutting for urban expansion purposes. Some countries, such as the United States and the European Union, have demonstrated that the existence of sophisticated scientific and economic systems for managing forests, and investing in them in a manner that ensures their expansion beside the production of timber, can have great economic benefits, in addition to being an environmental necessity.

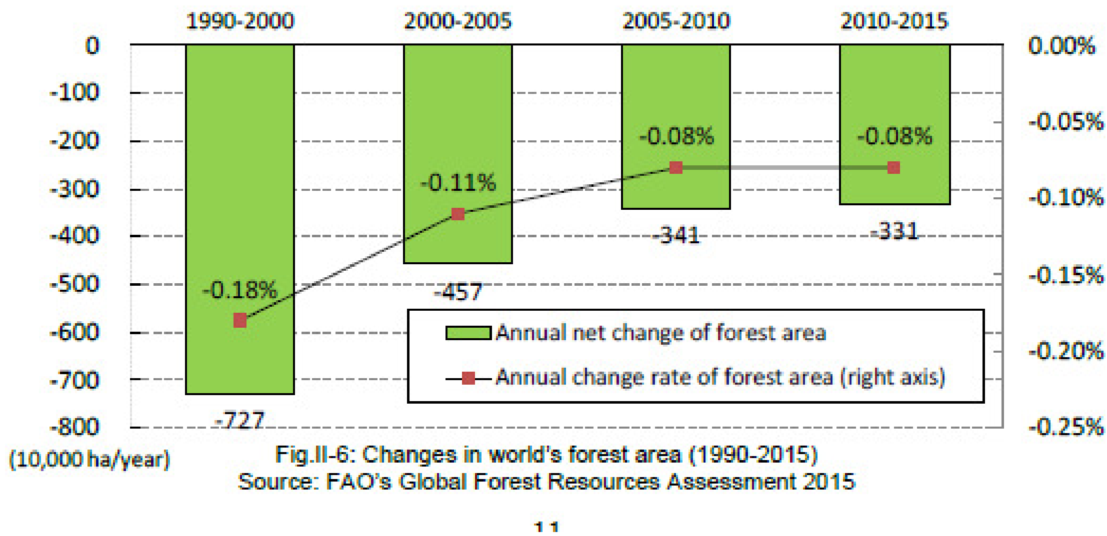

Figure (29) Negative changes (reductions) in world forest areas. Left green are actual reductions in Hectares. Right percentage reductions.

Chapter Eight

Dooms Day Prophecy, Will It Come True?

Systematic of Scientific Research

The Arab scholar ***Ibn Khaldun*** (1332 – 1406 AD) in his book ***Muqaddimah*** classified prophecies into three categories. The first is what was inspired to the prophets, and the apostles who were the owners of heavenly messages. He also classified dreams and visions within this category. The second is what he described in the explanations of what he called the science of the priesthood, fortune telling, astrology and the trade of extracting prophecies from letters, numbers, names, planets, reading sand patterns and the like. These kinds of prophecies depend on the probability at best, rather than on absolute truth. The third category, which, may have some sort of connection to the second one, since they both rely on the harnessing of the human mind, but it, differs from it in that it adopts absolute facts rather than possibilities. This type of prediction depends on the realization of the mind, to arrive at future expectations, based on its experiences of what has happened in the past, and what can be derived from it concerning what can happen in the future. This is the type of goal pursued by all contemporary natural sciences. These have devised clear systematic methods and ways, called methodologies of scientific research. This methodology is what we will focus on here, because the question of the earth's climate is a matter of scientific research and inquiry, based on the available facts. Based on these facts, future predictions and prophecies are made.

Any scientific work passes through four important stages. These are **observation**, **classification**, **hypothesis**, and finally the **theory** stage. We will discuss each of these stages briefly, using a simple factual but typical example, about the stages that passed, until ***Isaac Newton***, reached his famous law of gravity.

1. **Observation**: It is the inherited nature of man to observe things and events around him. There are people who observe things that others do not notice, or do not even care to. Humans differ in what they like to notice, and they generally convey what they perceive to others. We do not know who was the first person to observe the tides, but this observation has become common to knowledge all humans. There was always some one, who noticed each single fact and triviality in our life for the first time. People vary in what interest them to watch or observe. Some types of people are interested in observing certain things more than others do. It may also be true to say that, everyone has greater pleasure in observing something more than other things. Some one is known for his like of watching birds, another is more interested in cars, and a third observes the planets and their movements. Among the latters were a wealthy Danish nobleman, astronomer, and writer who lived in the seventeenth century AD. His name was ***Tycho Brahe*****.** Brahe's name does not appear often in science history books in spite of the fact that he spent the greater part of his life observing the planets and recording their movements in a

very precise way. He managed to collect stacks of records and data of his observations, which filled a large room before he died.

2. **Classification**: This is the process of distributing and dividing information observed and collected into categories. Each category contains observations that have a certain common systematic characteristic in their behavior. ***Johannes Kepler*** was a student and assistant to Brahe. He worked with him during the last year before Brahe's death in 1601. After Brahe's death, Kepler stole all records and files, which contained year's work of precise measurements of positions and movements of planets in the solar system. Kepler worked hard to classify these records and observations with the aim of finding systematic patterns in planets movements. His efforts resulted in his discovery of three laws named after him. Kepler's three laws of planetary motion can be stated as follows: (1) all planets move about the Sun in elliptical orbits, having the Sun as one of the foci. (2) A radius vector joining any planet to the Sun sweeps out equal areas in equal lengths of time. (3) The squares of the sidereal periods (of revolution) of the planets are directly proportional to the cubes of their mean distances from the Sun. This clearly demonstrates that it is not only important to stress oneself in certain measurements, but it is also important to try to explore, and devise what these variations hide in the form of regular changes that are subject to laws, which can be expressed mathematically. It is also worth mentioning that Kepler was also the first to link the tide and the moon motion.
3. **The Hypothesis:** It involves the development of ideas about the causes behind each classified observation. The hypothesis may be true or false. The hypothesis phase is a deficient stage in itself if that

hypothesis does not provide a starting point for the next stage, the stage of theory development. Many subjects have not been able to cross hypothesis stage. Therefore, they fell short from being on the list of real accepted sciences. One of the examples of some of the sciences that stopped at the stage of hypotheses, despite human interest in it for thousands of years is astrology. Workers in this field have observed that certain phenomena are more frequent or more likely to happen, when a particular planet or group of planets takes a certain position in the Planetarium. Based on these observations, they try to make certain prophecies about what might happen in the future if these planets come back to the same position. However, no one can for sure say that this or that thing will surely happen.

4. **Theory:** After placing one or more hypotheses for the causes of a particular phenomenon, it is necessary to examine the validity of this hypothesis by applying it to all previous cases. If this hypothesis is able to explain all these cases, attempt is made in using it to describe similar future cases. If successful, the hypothesis becomes a **theory**. It is necessary to say that a successful theory cannot be produced from a particular hypothesis unless both hypothesis and theory are connected to logic. The laws of Kepler were at the disposal of many scientists and geniuses of their times, but ***Isaac Newton***, the contemporary of the seventeenth and eighteenth centuries, was the only one who developed the hypothesis of the movement of planets under the force of gravity into a theory. He speculated that gravity draws objects always close towards each other along the line connecting their centers. We do not know exactly how true the story of the apple that fell from the tree, which stimulated Newton's mind to develop this

hypothesis. There was no mention of the apple story in his published research work on gravity, and we do not know whether that apple actually fell on his head. All what we know about the story of that apple is what he said at the end of his life to one of his closest friends. Newton spent nine years, trying to put his hypothesis of gravity under multiple tests, using the mathematics of calculus he developed. His main goal was to use his gravity theory to reach mathematical formulation of Kepler’s Laws. No one knows how many wrong mathematical forms for gravity Newton had tried. No one also knows how much calculations Newton performed on each hypothesis, to end up with tearing down or burning those calculations, before succeeding to reach his famous law of gravity. This law states that the force of gravity is inversely proportional to the square between the distances between two objects and directly proportional to their masses. This hypothesis was the key that eventually led him to develop a mathematical equation that describes planetary elliptical orbits. Newton's mind may have been sporting this mathematical formula at the first attempt, or he might have tried many other hypotheses before like saying that the force of gravity is directly proportional to the distance between the two bodies. He may have put dozens or hundreds of other hypotheses before reaching the hypothesis that turned into a theory.

Perhaps, one irony is that ***Stephen Hawking,*** who until recently sat on Newton's chair, at Cambridge University, has made a prophecy regarding global warming short time before his death in 2018. Hawking speculated that earth’s temperature might become similar to that of Venus, if the world does not take rapid action on climate change. According to Hawking, who is the author of the famous 10 million-seller book "**Brief History of Time**", the planet Venus, which we mentioned earlier, had a temperate climate similar to that of earth millions of years ago. That temperature increased dramatically due to increased amounts of carbon dioxide in its atmosphere, to reach the point of ***"no return"***, leading to what it is now. Hawking added that if things continue to go as they are, man has to find another planet to live on within the next 200 to 500 years if humanity is to survive. We do not know on what bases did this esteemed prestigious scientist base this prophecy, but without a doubt, it has sounded a certain alarm. This world's most famous scientist in his field must have followed the correct scientific systematic methodology to arrive at what he has declared about the inevitability of a future catastrophe. We do not know if the day Hawking died, March 14, 2018, is just a random coincidence, or it is an encrypted message that requires decoding. This date coincided with the anniversary of ***Albert Einstein's*** birth, and Hawking was born on January 8, 1942, exactly 300 years after ***Galileo's*** death. The question of calculating the probability of the random coincidence of these dates may be a topic of research, or an interesting intellectual exercise, for a statistician. However, this does not interest us in any case, but before discussing Hawking's prophecy about the fate of our planet, we need to review few presently available, accepted and recognized scientific facts.

1. Although climate science has gone through most of the stages of scientific development, it has not yet reached the stage of becoming a full theory, which can predict future events based on previous data. In other words, there is no mathematical equation, which inputs a number of information to give a precise prediction of the climate on a particular day, week or year. Although there are many mathematical

models that try to reach this goal, none of them has yet succeeded in reaching the full theoretical stage. It is sufficient to remember in this regard the number of times the weather bulletin proved fault in predicting following day forecast in part or in full.

2. It is now certain that the average temperature of the earth has risen by at least 0.75 ° C than it was before the industrial revolution
3. Historical studies of global temperature indicate that the earth was exposed to previous elevations in temperatures above 1 ° C, as a result of natural causes in the run-up to the small ice age, when carbon dioxide ratios were low
4. There is a belief that this current rise has resulted in phenomena of the onset of climate extremes in many regions of the world. These phenomena involve hitting historical records of extreme maximum and minimum temperatures, increases in the intensity and number of hurricanes, severe declines or massive increases in precipitation and snow in this or that part of the globe. . However, these changes have not yet exceeded the observation phase and the beginning of the classification phase
5. This rise in temperature, and observed changes in climate happened at the same time when there was increases in atmospheric carbon dioxide concentrations resulting from fossil fuels combustion.
6. The correlation between this synchronization of climate change and carbon dioxide is a matter of discussion among believers in the causality in this synchronization, and skeptics who consider it merely a coincidence of two events, and the interdependence between them, is weak at best.

7. Some mathematical models and computer simulations suggest that a 2 ° C rise in global temperature will represent the point of no return for earth's climate, whose change will not be possible to stop. On this basis, carbon emissions must stop, to prevent reaching such no return point by 2050.

To complete the picture of climate changes that coincided with carbon dioxide increases, we will try to review some of the statistics issued by international and scientific institutions on the extremes in some aspects of climate that are believed to have been observed in recent years.

Increase in Strengths and Numbers of Tropical Cyclones

It is known that some areas close to the equatorial oceans are highly vulnerable to strong hurricanes, which strike land, coming from the ocean. These hurricanes are classified into categories, according to the speed of their winds, and the amount of atmospheric pressure drop at their center, caused by cyclical movement of the hurricane. Strong hurricanes cause extensive material damage in land areas they pass through. It is very difficult to compile all the information on the numbers and the strength of all the hurricanes that hit all regions of the globe, especially those that occur in areas of poor countries, which do not have the means of advanced monitoring and measurement. However, United States Environmental Protection Agency (EPA) publication concerning hurricanes that formed at the North Atlantic, during the years 1880 - 2015, contains enough information to form a good idea about this manifestation of climate change.

Figure (30) shows the numbers of hurricanes over the years. The green curve shows the total numbers of hurricanes believed to have been formed in the North Atlantic, but as the EPA notes, this figure needs some adjustment for the pre-1960s period. This is necessary because the inaccuracy in the count of hurricanes during that period. Some hurricanes may have been missed to count by ships before the start of use of aircraft and satellites for this purpose. Therefore, the agency introduced a correction to those figures, giving the orange graph, which shows higher numbers of hurricanes before 1970, because of the added correction. This orange curve representing the result of adding the number of hurricanes that were not detected, because they occurred in ocean, missed by ships and did not reach the land to be registered. The introduction of these corrections gives a different picture of the situation. The corrected graph shows that there is no significant change in the number of hurricanes over the entire period, and there is no evidence that the annual rate of hurricanes has changed in recent years compared to what it was since 1880. The red bottom curve represents the number of hurricanes reaching land areas in the United States. This number is accurately recorded and does not need any correction. Again, here the curve does not show any significant changes in the number of hurricanes. It can be said that the annual number of hurricanes does not provide tangible evidence of any climate change so far. This means, that the current climate change did not significantly affect the annual numbers of hurricanes in the North Atlantic.

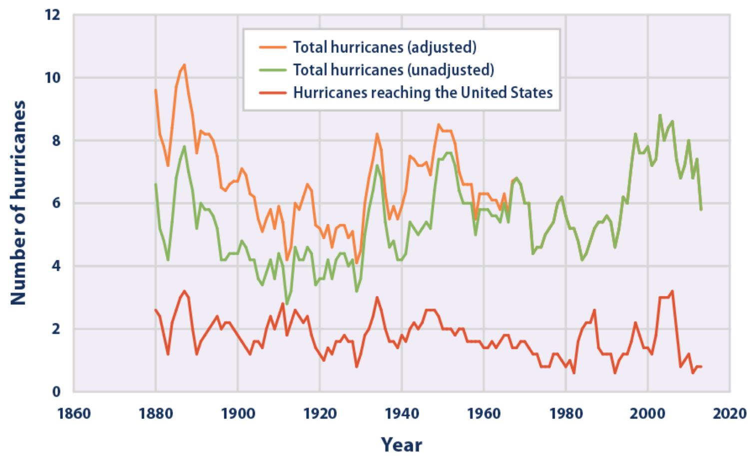

Figure (30) Yearly number of North Atlantic Hurricanes from 1880 – 2015 (EPA publication)

Figure (31) shows the distribution of the so-called the *Cyclones Intensity* also known as the *Accumulated Cyclone Energy Index* (ACEI), which is a measure of the total sum of energies carried by all hurricanes for one year. This metric is reached through very complex calculations of the wind speed of each hurricane, its area, its duration, and the value of atmospheric pressure in the center of each cyclone.

This figure shows some increase in the total annual hurricanes energy that occurred during the years following 1990 compared to the previous period, with an increase in the number of years in which these energies were higher than the upper horizontal red line. This red line represents the boundary between what is considered normal, and what is considered higher than normal. It should be noted, however, that the EPA has stated that this increase in recent years may be due to the advancement and increased sophistications of measuring instruments in recent years, compared with those that preceded them, and that it is too early to say that hurricanes energies have actually increased. The reports of this government agency also indicate that it is too early to talk about any link between earth's climate change and hurricane activity, based on information available to date.

There is an indirect measure of the severity of hurricanes and their annual numbers by knowing the cost of economic and material damage they produce. These costs are usually known, and the process of obtaining this value is calculated by calculating the sum of these costs per unit of the value of the GDP of each country. These calculations indicate that this measure has not changed significantly in recent years after considering the inflation rate of course

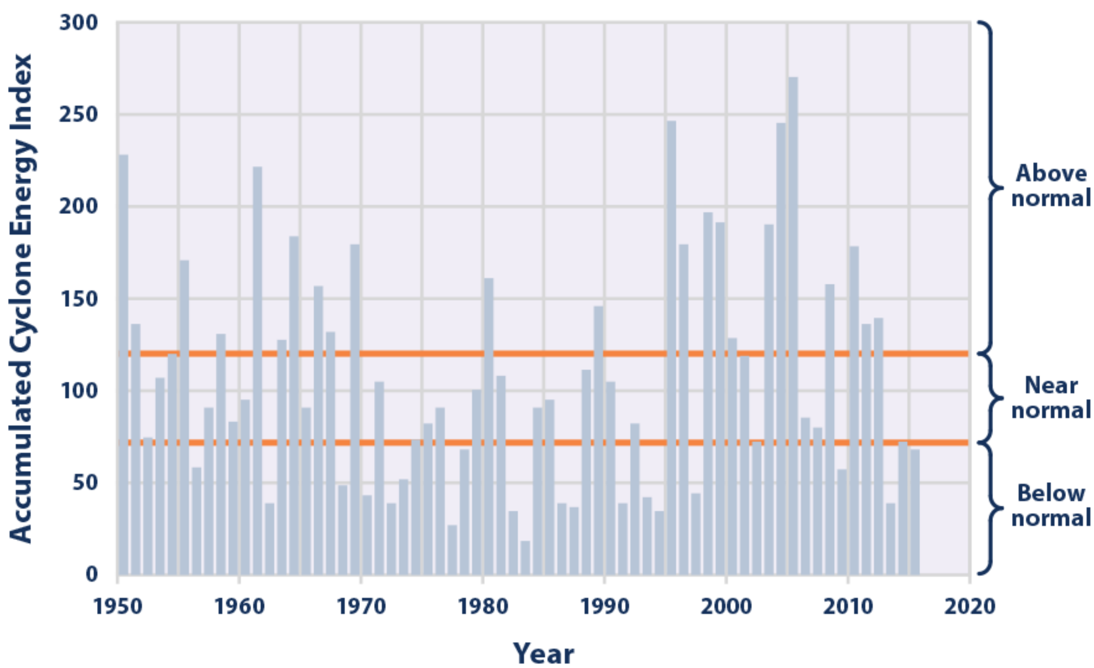

Figure (31) Yearly Accumulated Cyclones Energies Index in the North Atlantic for 1950 to 2016 (EPA publications)

Extreme temperatures

Many studies suggest that rising global temperatures do not necessarily mean regular increases in all regions, or even within a given spot. The general belief is that this general rise will lead to records of extreme high temperatures in summer, coupled with records low temperatures in winter. The frequency of high temperatures events is expected to be greater than that of the low ones. This means that the climate may become warmer in the summer and cooler in winter, in such a way that the summer heat is more severe than the winter cold. Figure (32) shows a NOAA publication, showing annual percentages, of the number of extreme days, in which the maximum temperatures are higher than their overall average or those with lower temperatures than their general average during the period 1910 – 2017. This figure shows an almost annual increase of about 20% in the number of days when temperatures either registered record high or record low, after 1990. This indicates a significant climate change during this period. However, the correlation of this change to carbon dioxide in the atmosphere remains controversial among global warming theory advocates and skeptics.

Using publicly available climate data from the British Metrological office (BMO) and the US National Oceanic and Atmospheric Administration (NOAA), the author carried out a separate study regarding the evidence of global warming in five Iraqi cities for the period 1900 - 2015 as far as temperatures and precipitations are concerned. Results indicate that there was an overall increase in mean temperature of 0.007 oC annually. This is expected to result in an overall increase of about 2.2 ^{o}C by the year 2050 if the current trend continues. The study also showed that precipitation rates for the same period decreased by 9.6 mm per year on average. This indicates that it may fall by 25% in 2050 from its 1900 level.

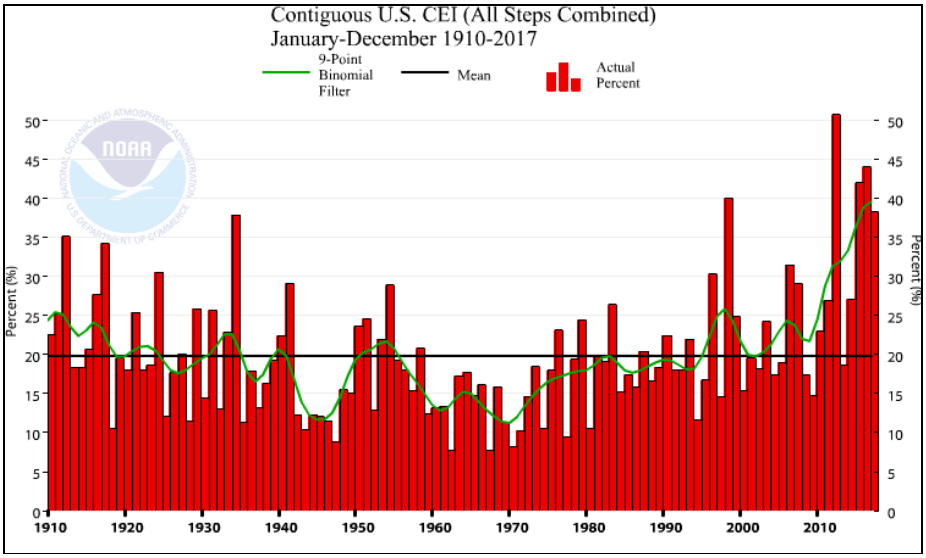

Figure (32) Number of days for 1910 to 2017 when temperatures in the US scored record maximums or record minimums (NOAA publications)

Other changes

There are huge numbers of similar studies and research that point to phenomena related to climate change in different regions of the world, such as increasing temperatures, reduced precipitations, increasing desertification, late autumn, changing areas of growth of certain flora and fauna in certain areas of the oceans, and other phenomena that our space here restricts their mentions or discussion.

Can We Take the Risk?

The result that the unbiased neutral reader may find, through what has been presented so far, is that the past 20 years have seen manifestations of climate change, which are not easy to ignore. However, the question of whether these changes are natural or not are is still controversial. Despite all this controversy, a simple but important question poses itself strongly to the world now. The question is, "**Is it risky?"**

Many believe it is not a risk and even if there is a risk, it is of calculated consequences. They wonder what will happen even if temperatures rise by 1 or two degrees or even five degrees. Many cold places will become better livable, and the hot world deserts are already almost uninhabited. All we have to do is adapt a little to the new climate, as we always do every year, moving between summer and winter and to let nature find a new balance the way it has always done. After all, they say, it would not be a bad thing for polar continents to become summer resorts. If man does not like this new balance, he can always return things to what they were, or nature itself will eventually return to what it used to be, after depleting the earth's reserves of coal, oil and gas. Their argument, according to some studies, is that the world's oil and gas reserves will be enough for only 30 to 50 years from now, while coal can continue to be a source of energy for another 80 years before depleting, if the consumption of these fuels continues at current levels. On the other hand, oil and gas companies are giving estimates beyond previous dates because of their predictions of discoveries of new reserves. However, even the best predictions; do not give man more than a hundred years, to enjoy fossil fuels. At that point, all carbon emissions will stop, carbon dioxide will fall in the atmosphere, and the earth's climate will return to pre-industrial levels. This situation, of course, will be convenient for everyone, especially those who are very concerned about this matter.

Earth’s Outrage and the Point of No Return

The picture above looks very rosy, but the reality is not. The risk here may be dire consequences, for a very simple reason. Many scientific studies predict that a certain rise in earth's temperature will make it reach a point called the “***point of no return***”. This means that the climate will change irreversibly, and will not return to what it was, even if all carbon emissions were stopped. Scientists estimate this rise by about 2 degrees Celsius, above its pre-industrial value. These studies have had the most significant impact on the Paris Convention setting a major objective, namely, not to allow access to such a dangerous degree. The question that arises here is why climate scientists confirm this degree, considering it a dangerous barrier that should not be reached in any way.

The answer may seem a little strange, if we know it is related to the Bacteria! Most of us know a lot about bacteria. There are millions of bacterial species. Some are useful while others cause all types of illnesses. Some of the useful types work to dissociate organic wastes; otherwise, the waste would have accumulated over millions of years. One example to mention is the accumulation of tons of human wastes of climbers on the slopes of Mount Everest because such bacteria are absent from there due to the very low temperatures. Bacteria also live in our bodies, helping them ferment and digest food. Some other bacteria’s are harmful, causing diseases and epidemics. Bacteria are everywhere around us, and humans learnt to deal with many of them. The most important places where bacteria are present are soil. We know that most types of bacteria prosper under warm conditions, where they grow and multiply. They also shrink, decrease their effectiveness and proliferation in cold climates. Life scientists believe that warming the soil by two degrees will help the rapid growth and reproduction of many species of bacteria that live in cold areas, and areas covered by snow all year round, if their snow cover is removed. These bacteria are living organisms, breathe oxygen, and release carbon dioxide. A number of scientists, led by climatologist ***Thomas Crowther***, in a paper published in the prestigious journal Nature, estimate that a one-degree rise in global temperature could make the total carbon dioxide emissions from these bacteria reaching 5.5 Giga ton by 2050, which is equivalent to US emissions. The launch of these additional quantities of gas to the atmosphere will increase its proportion. This in turn will lead to faster temperature increases, which will lead to more gas release that result in higher temperatures and so on. These compound events will enter the earth's atmosphere in a vicious upward spiral path, which would not stop. Such a situation would also release amounts of methane from the soil. For this gas, the effect is similar to that of carbon dioxide, but to a lesser degree. This scenario will make the issue of returning earth’s climate back very doubtful, if not impossible.

Still, some skeptics, who rule out this gloomy scene, argue that increasing temperatures will evaporate larger amounts of ocean water, forming clouds. Clouds by nature will reflect the sun's rays into outer space, thereby reducing the amount of energy reaching the earth's surface. This leads to a drop in temperature, thereby preventing the earth's climate from reaching the point of no return. However, the prevailing view among the scientific community is towards the first scenario. More than 15,000 scientists from 182 countries around the world signed a document addressed to the Paris

Conference warning that the climate is reaching this point of no return and urging heads of state to take decisive decisions about the subject. It should be noted that at the time of writing, the results of research published by the famous journal Nature, on January 17, 2018 by two climate scientists have suggested that the planet may be more resilient than previously thought. They argued that even if the amount of carbon dioxide in the atmosphere doubled, the temperature would not rise by more than 3.5 degrees, excluding the so-called point of no return.

Will Nature Surprise Us With Its Wisdom?

Nearly 40 years have passed since the conflict over the earth's climate began, when the United Nations established the IPCC to follow the development of the earth's climate and report to successive earth conferences over the years. After all these years there are those who believe that little has been achieved in the direction of saving the earth from burning. Others say they are doing what they can. An overview of what has really become known is that the question has shifted from being "*Do we have to do something?*" to another one which is, "*How and when to do something even if it is not necessary?*" The current conflict is about finding an answer to the second question that suits everyone. It took the world 40 years to replace the question, but it may not have another 40 years, to answer the last question. If the goal is not to reach the point of no return, studies suggest that carbon dioxide should be prevented from exceeding 460-480 parts per million in any case. This gives man until the middle of the twenty-first century, to stop any further increase, and reach a so-called "*zero-carbon*" point. This point does not necessarily mean stopping all emissions, or completely abandoning fossil fuels. It simply means making vegetation able to absorb amounts of carbon dioxide equivalent to the amount of emissions. This objective is, in short, what the Paris Convention aspires to achieve.

There were several scenarios for the Bonn Climate Conference, which took place from November 6-17, 2017, to reach zero-carbon in 2050, as shown in Figure (33). The first scenario suggests reaching the upper limit of emissions in 2016, giving the world an opportunity until 2045-2050, which is ample time to reach zero emissions state. The second scenario suggests postponing access to the upper limit to 2020 and reaching the desired reduction in 2050. The third scenario involves reaching the upper limit of emissions in 2025, but this will lead to the need for a very rapid reduction thereafter until 2050. The conference could not reach agreement on a specific road map. In addition, Germany's Chancellor ***Angela Merkel***, one of the most enthusiastic countries on the climate issue, said that Germany considers itself too slow to reach the cuts it promised at Paris conference and most other countries are believed to be in the same situation.

This situation has been a major disappointment for climate enthusiasts. However, in spite of all this pessimism, a close look at Figure (28) may lead to a tendency to believe that one of the first or second scenarios has begun to appear since 2014 showing that global emissions began to slow. The continuation of this situation for the next three to four years will make it clear whether or not this slowdown really exists.

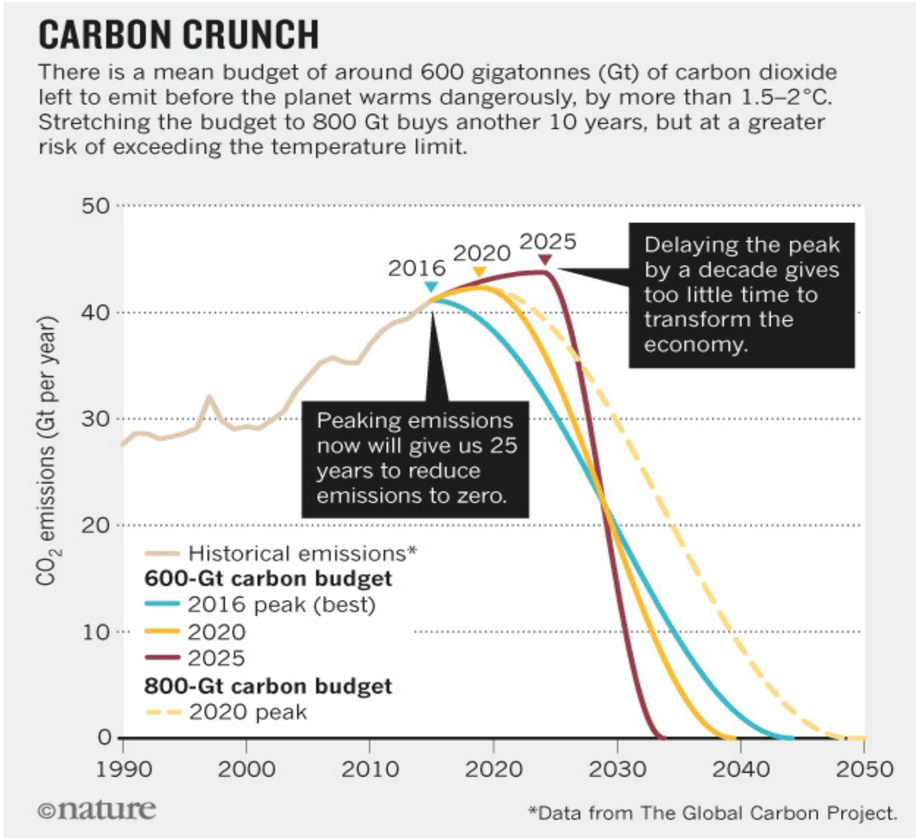

Figure (33) the three scenarios Nature presented to the Bonn climate conference. (From a paper by Christiana Figures, Hans Joachim Schellnhuber, Gail Whiteman Johan Rockström, Anthony Hobley, Stefan Rahmstorf published in Nature 28 June 2017)

Last Nature's Weapon

The planned and programmed actions and commitments of states may not sufficient in themselves be to stop or reduce carbon emissions, but this time nature may have other plans to save the situation. The mind is part of man, and man is part of nature and nature has kept is balance throughout history. Nature has proved that it uses all its weapons to achieve this balance. Will the mind of man be another weapon used by nature to achieve its balance? Man is a selfish being by nature. His mind works according to one principle, the principle of profit and loss. Everything that makes a profit, whether material or moral, is good. Everything that is the opposite is bad, regardless of the nature of this profit, or that loss. We do not evaluate moral profits and losses. They differ from one person to another, but the accounts of losses and material profits are always clear and measured with unquestionable numbers. This makes the issue becomes simple. Regardless of what conferences and policy decide, profit and loss interest will have the final ultimate say in what will happen on the issue of carbon emissions, with or without the policies of governments. Admittedly, there is not enough logic in trying to convince any individual that it is necessary to minimize his or her carbon emissions, which could adversely affect the lives of their children or grandchildren. The individual may be an enthusiastic believer in this cause, and he is keen to participate in annual rallies and demonstration, wherever meetings of the summits of climate summits are held, calling upon the heads of States to make decisive decisions. However, he forgets to drive his car in a way that saves as much fuel as possible, or to give up that luxury car for smaller one. Let us take a simple example. It is estimated that the number of cars actually on the roads in the world in 2010 was more than a billion (thousand million) cars. Let us assume that everyone driving one of these cars decides to save at least one liter of gasoline every day through smooth quit driving or using a smaller car. This would have contributed to reducing carbon emissions by 2.5 kg per day, because every liter of gasoline burned generates approximately 2.5 kg of carbon dioxide. With a simple arithmetical calculation, we arrive at an important conclusion that he will reduce emissions by $3 \times 365 \approx 1090$ kgm or 1.1 ton each year. This will bring the total reduction by all cars round the world to more than one Giga ton.

This is equivalent to about 3.2% of total world emissions in 2010 which were about 34 Giga ton, without the need for conferences and summits.

The above example paves the way to what we want to say here. If we assume that the price of car fuels is high enough to the extent that the person thinks about every drop he consumes, people will acquire the habit of saving more than the liter we assumed above through avoiding so called sports driving and rapid, and sudden braking. Most drivers know that such driving can increase fuel consumption by as much as 40%. This issue is not related to conference decisions or commitments by states. It is part of the human's nature, which operates on instinctive principle, linked to profit and loss considerations. The discussions and negotiations behind the scenes of all the global climate conferences that have been held so far have been about the profit and loss for each country, more than anything else has. Therefore, any solution or set of solutions directed towards preserving the climate of the planet must fall within the boundaries of the principle of profit and loss.

A Successful Forgotten Experiment. Can it be repeated?

At the beginning of this book, we talked about the problem of decreasing ozone in the atmosphere. This caused a significant decrease in concentration in the Polar Regions, which was called the ozone hole. Many of the decisions and recommendations of the Montreal Conference concerned carbon emissions. However, an important part of these decisions was directed at addressing issues related to all emissions and other environmental pollutants, including so-called chlorofluorocarbons (CFCs). These gases, as their name suggests, consist of a chlorine and fluorine union with carbon.

These are very chemically stable gases, which do not decompose rapidly, and they remain in the air for years. These gases are used in refrigeration units (E.g., Freon gases), the manufacture of plastic foams, hair spray cans, and fire extinguishers. These gases have the ability to destroy ozone molecules that protect the earth's surface from ultraviolet rays, which cause skin cancer. Each of these gases molecules can break up a very large number of ozone molecules, one by one, without decomposing itself.

The ozone story began in 1973 when two chemists, ***Sherwood Rowland*** and ***Mario Molina***, published their research on the impact of CFCs on the ozone layer in the atmosphere. They were awarded the Nobel Prize in Chemistry in 1995 for this discovery. Once the research was published, the sales of cans of hair stabilizers declined, as people replaced them with mechanical sprays, and there were calls to stop their other uses. It was agreed in Montreal to halt production of these substances entirely by the industrialized countries by 1995. Chemicals producers have been competing for alternatives, and have already done so in two phases. The first was the substitution of these substances with alternative chemicals, called hydro chlorofluorocarbons (HCFC), by replacing one or more of the chlorine or fluorine atoms in these in these gases by one or more atoms of hydrogen forming HCFC compounds. The latter have a less severe impact on ozone, as they decompose more rapidly than CFCs. These gases were used in old refrigerators that used CFCs, after simple modifications to these devices. The transition to the production of new devices, using gases such as carbon dioxide and ammonia started to take place afterwards. This happened despite the warnings initially made by some companies that produced CFCs about the high economic costs of these transformations. It has emerged from an early stage that the shift to the use of these alternatives has led to a reduction in economic costs. On this basis, the ban on the production of CFCs was extended to become worldwide in 1995. This collaboration between individuals, governments and states has spared the lives of millions of people worldwide from skin cancer. Satellite measurements have shown that the ozone layer, or (*ozone hole*), is now the smallest since 1988. All this success has been achieved because of the rise in the prices of CFCs, after the ban of their production in the industrialized countries. The question here is can this experiment be repeated on carbon dioxide. The answer lies in prices and profit and loss matters rather than in the technology or industry. The simplest example of this is the reduction in carbon emissions, when oil prices fall, and countries switch from coal to oil instead and vice versa. The simple wise answer here is to make alternative energies more affordable than fossil fuels. This will be linked to the profit and loss accounts led by the human mind, which is in itself a part of nature, and may be one of its means to maintain its balance, through his technological innovation, working towards reducing the costs of alternative and clean energies. The question that repeats itself here is not "*whether the world will move to alternatives,*" but "*how will this transition take place and when?"* This will pose a greater challenge to economists and technology experts, which we will discuss in the following chapters.

Chapter Nine

A March towards Cheap Alternatives

Economics Will Have the Final Say

With or without global warming, civilization craving for energy will go in one direction, trying to get cheaper energy. It will not be difficult for institutions, states and the media to find evidence and justifications, which exempt oil, coal and gas-burning processes, from the sin of doing harm to the climate, provide that the prices of these types of fuel are the ones that result in highest economic profits. This is the nature of man in every time and place. The situation will be the opposite if the world finds other sources of energy, cheaper, and do not result in unaccountable side losses. It would also be useful and convenient if these sources had less impact on the environment, nor does their promotion requires effort or cost. In this world, everything has its price. Energy has its price, scientific research has its price, propaganda has its price, and the pollution that causes diseases has its price. The price of pollution is determined by the extent it places economical burdens on health institutions and governments. For example, despite the world's success in solving the ozone problem, the problem would not have been solved had it not been for the losses that health sectors would have had suffered in all countries because of the diseases that would have happened had the world not found a solution to the problem. Urban air pollution in Europe and America during the second half of the 20th century caused diseases, costing economies huge amounts of money due to the cost of treatment, and the loss of a large percentage of working days. This was the main reason that prompted governments to legislate clean air acts that limit gases emissions from transports and industries.

In such a situation, it is very reasonable to consider addressing the issue of global warming from a purely economic point of view, regardless of what the previous climate conferences have decided upon, and what the subsequent ones will decide. The reason for this is that the events and decisions of those conferences have always been linked to the economic dilemma. This dilemma at its best good intentions, works towards minimizing losses in cases when profits are not achievable. It is important to say here that the calculations of profit and loss in developed countries tend to have far-reaching expectations rather than shortfalls. While a government of a poor country struggles to make plans to provide bread for the next week or month for its citizens, developed countries are drafting and choosing the best of plans and objectives on how their industries, science, agriculture, armies, and the average age of its citizens will be in the next 50 or 100 years. Based on these principles, the discussion of the alternatives to fossil fuels will be mainly from economic point of view. For this purpose, consideration of historical evolution of the prices of these energies, with a view to developing features of what the future might have and the implications for climate change are discussed.

Free Alternative Energies, But?

It is no surprise to know that the ranges of alternative energies to be talked about are in fact freely available ones. Solar energy reaches earth free.

Wind power is also free. Tidal energy is also free. Geothermal energy, lying underneath some areas of the earth, waiting for those who will use it free. Also are hydropower recourses. The cost of nuclear power is less than the cost of fossil fuels. All that these resources need to exploit is the establishment of industrial and technological facilities that are appropriate to take advantage of these energies. It is also reasonable to say here that the technology needed to exploit these energies is already available to humans. Scientific and technological development during the twentieth century has enabled humankind to find solutions and means to transform all these energies in a way that ensures their benefit. The current main dilemma, which stands as an obstacle to making the most of these free energies is the financial costs required to set up facilities for their exploitation. It is worth mentioning here that costs of sustaining the operation of such facilities are usually much less than those of fossil fuels ones.

The invention of electricity was the greatest scientific and technological achievement that took place during the Industrial Revolution after the use of steam. Electricity has become an integral part of contemporary human life. It is likely to remain so for the foreseeable to come. The secret to the success of electricity in taking this essential role in contemporary human life is the ease of conversion it to all other forms of energy, and benefiting from it in all areas of life. Electricity can power a car, run factory machines, and be used for heating, cooling, lifting, cutting, lighting and everything. This is in addition to their ease of transport and distribution to areas of consumption. For this reason, it is reasonable to say that the best way to use most alternative energies is to find the cheapest ways and means to turn those energies into electricity.

The main problem with the nature of most free alternative energies is that they are not stable and time-bound. Solar energy, for example, is available during the day but is interrupted at night, and is also affected by the degree of clarity of the sky. Wind energy is also variable with wind speeds, while the energy derived from the tidal movement changes depending on the monthly cycle of the moon. These temporal variations in energy supply present problems that still require further technological development of energy storage systems. In any case, even if there is no new technological leap in this direction in the coming years, the development of appropriate systems to manage the production and distribution of alternative energies can greatly limit this problem, although this may be at some additional costs. Based on these principles, our next discussion will focus on some technical and economic aspects of each type of alternative energies mentioned above, current and future possibilities for exploiting each of them, as well as a special section on currently available ways to store these energies.

Solar Energy

Naming solar energy as the first on the list in our discussion of alternative energies is not accidental. The reason for this is that it is simply the main source of energy on earth in spite of the fact that it does not currently have the largest contribution compared to other forms of alternative energies. Solar energy will ultimately become the major source of world energy eventually. This inevitability comes for the simple reason that the sun is the only source of all other energies on earth. Sun's energy is the original source of Wind power. The same is true for tidal and hydropower energies. The energies found in oil, coal and gas are only energies that came originally from the sun and were trapped and stored in these fossil fuels during the deep past.

The use of solar energy is nothing new to humans. Historical evidence dating back to the 7th century BC shows the use of magnifying lenses to focus the sun light to ignite fire. There is a story that the famous Greek scholar and philosopher ***Archimedes***, who lived in the second century BC, used concave shining copper shield armors as concentrating mirrors to focus sunlight in the direction to burn the Roman ships, which besieged the Greek **Syracuse** city on the island of **Sicily**. Despite the lack of historical evidence of this incident, the Greek Navy, repeated the experiment in 1973 and succeeded in burning a wooden boat 50 meters away. The Roman baths from the beginning of the first century had glass windows on their south sides, aiming to use sun heat. By the sixth century, glass ceilings and glass windows became a common feature in Roman architecture to the extent that Emperor ***Constantine*** legislated a law called the "*Sun Right Law*", whereby every citizen has his share of the sun. What concerns us here is to focus on using this power to generate electricity, which is the key to all other uses.

Electricity can be generated from sunlight in two main ways. First, directly, second indirect. The first method relies on the use of solar photovoltaic cells. Discoveries of the ability of certain substances such as selenium to generate electricity when exposed to sunlight have begun since 1873. Solar photovoltaic cells that use selenium have been efficient at no more than 1%. Such efficiency was not suitable for any practical use of generating electricity, except for certain scientific purposes. To illustrate this, it suffice to say that the area of the solar cell operating at such efficiently, which is required to illuminate one ordinary light bulb, may reach more than four square meters. The practical uses of solar cells began after the invention of the first solar cell that uses silicon in 1959. These had up to 10% efficiencies. The first uses of this type of cells were in satellites and spacecraft powered by direct sunlight. Since then, most electronics manufacturers around the world have been in frantic competition to produce more efficient and less expensive solar photovoltaic cells. Solar cells that are able to convert 35 percent of sunlight into electricity are currently available. We can get a greater understanding of the importance of solar cell efficiency through the following example. The rate of falling solar energy at midday, on an area of one square meter on the surface of the earth is about 1000 Watt. Suppose we use a 4% solar cell, one square meter in size. This would be enough to light a single 40-watt bulb. It is possible to light two such lamps if we use a cell of the same size, but with an efficiency of 8%. It is also possible to use a cell of half a square meter with this efficiency, to operate one lamp. In summary, the efficiency of a cell is determined by its area that can generate a certain amount of electrical energy. For this reason, the prices of solar cells are not determined by their size, but by the electricity, they can generate. On this basis, the solar cell prices are in units US $ per Watt. These prices have fallen dramatically since they entered the market on a commercial scale in the 1970s to the present. Figure (34) shows the evolution of the decline in those prices, where in 2014 fell to about one third of dollars, after it was about 77 US$ per watt during the seventies of the last century.

Despite the drastic decline in solar cell prices over the past four decades, the total primary prices for the construction of solar power systems still do not attract many compared to other energies. This is due to the cost of other components needed by these systems. The most important of those are storage batteries, and inverters that convert DC current generated by these cells, to the alternating current AC, which is usually used in most electrical devices. In addition, installation costs add significant amounts to the overall price, which may add up to, about 3-4 US$ per watt at 2018 prices.

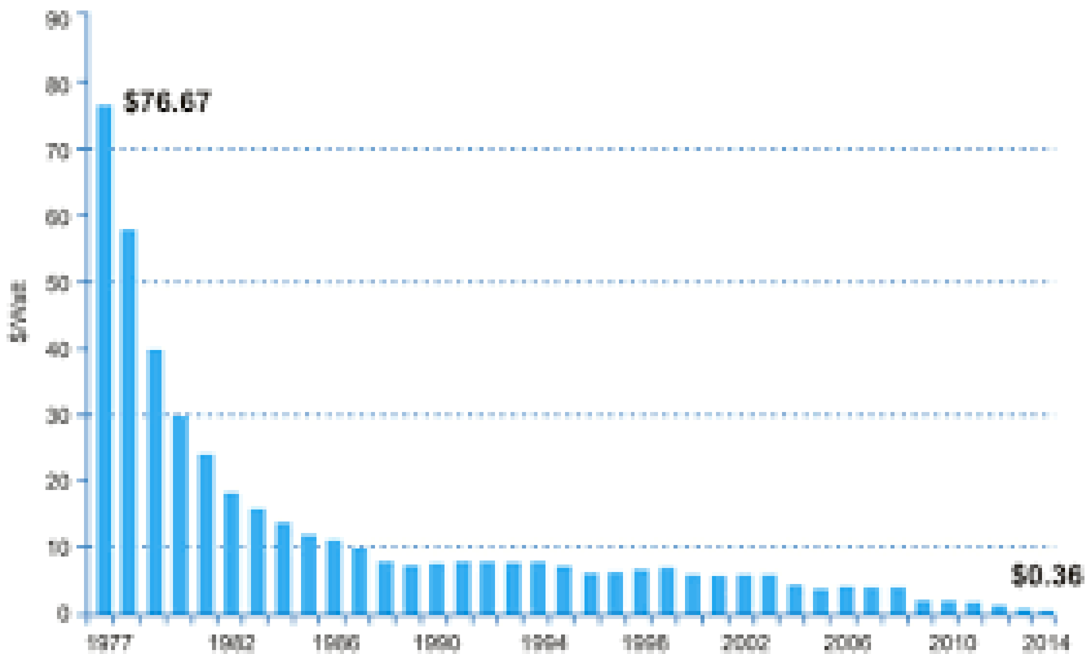

Figure (34) Development of solar cell prices 1972 - 2014

For example, at 2018 prices, it is possible to have a medium-sized solar generating system with a capacity of 100 kW (enough to supply approximately 40 homes) at a price close to 300,000 $, while the price of a diesel unit with the same capacity, the type used in residential neighborhoods, in countries with a shortage of electricity, is about 10,000 $. It seems at first glance that the solar module is very expensive compared to the diesel unit, but we have to remember that the diesel fuel consumption of this capacity is about 7.5 gallons per hour, or 180 gallons per day, at an approximate price of 2.5 $ per gallon. The annual fuel cost is about 165,000. $. This means that the solar module will have repaid its cost in less than two years. This is a good investment by most economic standards.

Nevertheless, high primary investment costs remain a barrier in this direction.

In the last ten years, many countries in the world have moved rapidly to use solar energy to produce electricity, especially after the breakthroughs in the battery industry. The use of lithium-ion batteries (the type used in mobile devices) is replacing Lead-Acid batteries, which have been in use for, more than 150 years. Lithium batteries, in addition to their small weight compared to lead batteries, can withstand a much larger number of charging-discharging cycles of about 5,000 times, compared to about 50-100 times for lead batteries, giving the lithium batteries a much longer life.

Two types of solar power generation systems are now being used round the world. The first are small or domestic systems, where solar cells are installed on the roofs of homes and buildings, and provide electricity in part or in total to the inhabitants. There is a potential in some developed countries to sell surplus electricity generated to the national electricity grid in that country. There are also legislation, financial facilities and tax exemptions in many developed countries to encourage their citizens to install these systems in their homes. The generation capacity of these systems can range between 1 - 300 kW as shown in Figure (35)

Figure (35) typical rooftop solar installation

The second type of solar installations is the large power plants, which have a capacity of several hundred or thousands of megawatts. These are of two types. The first type uses solar photovoltaic cells and batteries in the same way as small systems, as shown in figure (36). The second type involves the use of reflective mirrors that concentrate and direct sunlight to focus where there is a water boiler. The concentrated light heats up the water in the boiler and converts it into steam, which is used to drive turbines to generate electricity, in the same way as current thermal plants. There are two ways to use mirror systems for this purpose. The first method uses a large number of mechanically interconnected plane mirrors, which move jointly, tracking the sun and reflecting light to the boiler as shown in figure (37). The second type uses cylindrical concave mirrors with water pipe along their axis. Light reflected from the mirrors heats up the water in the pipe to produce steam, which drives the electricity generating turbines as in figure (38).

Figure (36) Solar panels arrays in a large solar power plant

Figure (37) Thermal solar electric power plant using plan mirrors system and a boiler

Figure (38) solar electric power plant using cylindrical concave mirror and axial steam pipe.

It is encouraging to say that the developed countries in general, China and the United States, as well as Southeast Asian countries in particular, have achieved significant upward leaps of about 30% annually over the past 10 years towards the use of solar energy in generating electricity. This is shown in Figure (39) which is published by the International Energy Agency (IEA). The total global production of solar electricity reached 420 GigaWatt in 2017 compared to only 5 MW in 2007, with an annual increase of 30%. This increase includes total domestic and industrial generated energy. It should be noted that the increases in the EU countries for the same period were much lower than those of the rest of the other industrialized countries. The rates of increase in the EU did not exceed 10% per year. This is because many EU countries do not enjoy the amount of sunlight, which makes their use of electricity generation less attractive economically. These countries, however, have turned to other energies such as wind and tides, as we shall see later. It should also be noted here that the exploitation of solar energy in the Middle East and North Africa did not achieve significant growth rates during the same period. However, some countries in the region, including Morocco, Algeria, the United Arab Emirates, Jordan, Egypt, Saudi Arabia and Kuwait, have recently begun projects to increase current generating capacity from around 700 megawatts to 3000 megawatts. In addition, these countries have other projects being contracted to reach an increase in generating capacity to 4000 megawatts by 2020, with an annual increase of 15%. However, the use of solar systems on a household scale still represents great potential, which has not been optimally exploited yet.

India has also tried to make rapid progress in solar energy in the last three years, having a generation capacity of only one Gigawatt in 2014, but doubled that capacity to 2.5 Gigawatt in 2016 and has projects, and contracted, to reach 6 and 9 Gigawatt by 2017 and 2018 respectively. It is worth mentioning that India has achieved for the first time in history a price of electricity generated by solar energy, to be below those generated by burning coal. In addition, India has achieved significant development in the field of solar panels production and systems, with the emergence of a large number of manufacturers for this purpose. One of the main obstacles to the development of solar energy in India was the scarcity of land for with respect to its large population and the difficulty of sacrificing agricultural land for constructing solar power plants. There are proposed solutions in this regard, which are the installation of solar cells on the surfaces of channels, lakes, and the surface of the sea. India has also installed these photovoltaic panels in between the wind towers generators. These solutions are worth to reflect about as far as the abilities and potential of the human mind, to solve difficult technological problems.

Japan is adopting plans that are somewhat different from those of other countries in that it seeks to focus on increasing solar power generation from the sun on household level. Since 2008, it has started a plan to requiring 70% of the newly constructed homes to include solar electricity generation systems. To achieve this, Japan's laws stipulate that electricity producers buy excess electricity from homes at twice the price at which they sell electricity to the homes themselves. In other words, the owner of the house or building will make financial profits if his rooftop solar electricity production is in excess of his actual need. The Japanese government's plans included total solar power reaching 28 Gigawatt by 2020, but in has fact it reached that goal in 2015, and is expected to exceed this goal in 2018. Japan's plans also include reaching at least 10% of Japan's total energy from solar by 2050.

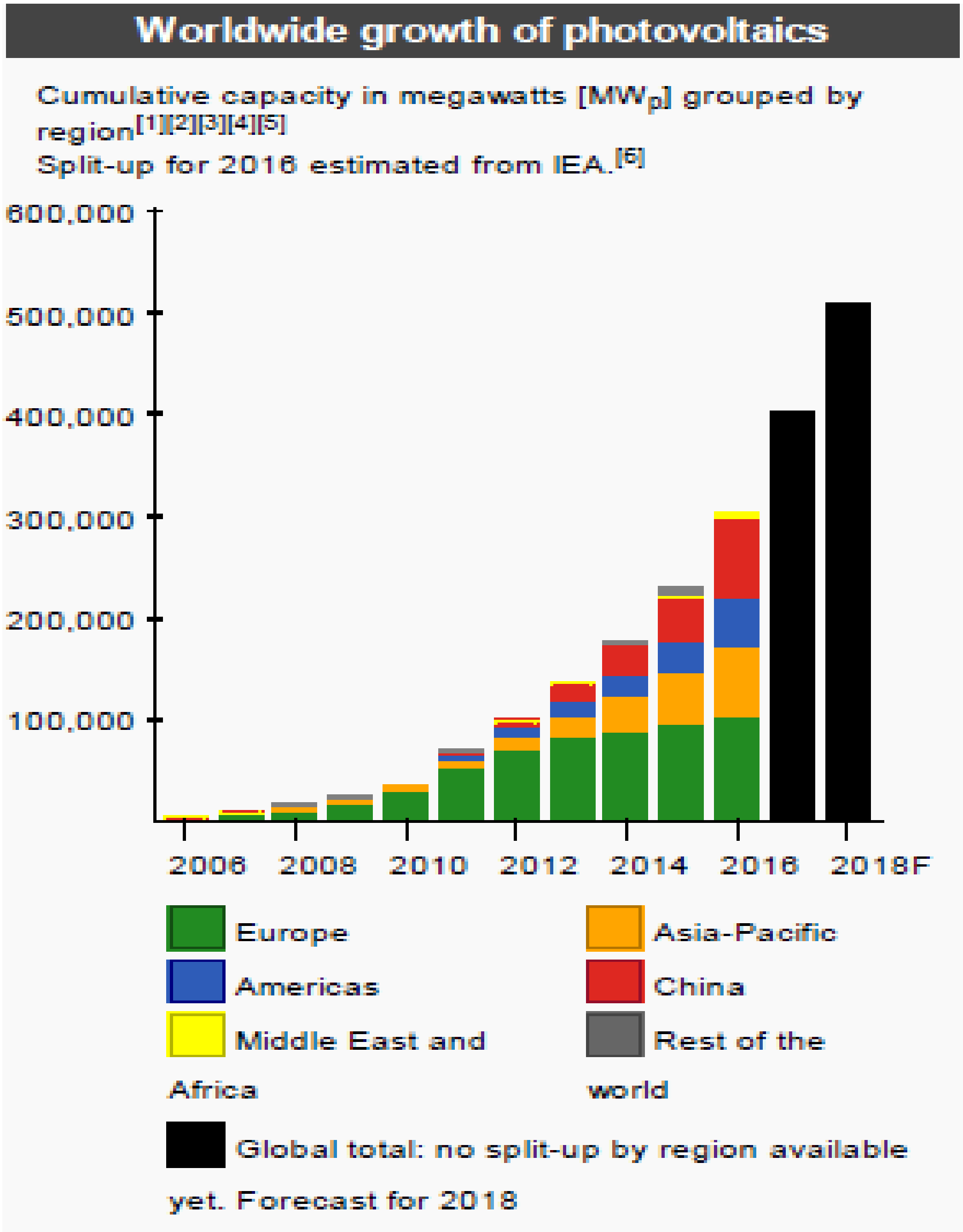

Figure (39) Development of the world solar photovoltaic electricity Generation (IEA publications)

An important word to say here is that the rapid development over the past 10 years in the growth of solar energy use in the world has come as a surprise to many. This may be due to the development and the huge number of innovations in solar cell manufacturing, electronic circuits design for battery charging and discharging, and the transformation of direct currents into alternating currents. The connection of a small home unit to the public network requires very precise specifications, related to the matching of the electrical properties generated by the system with those in the network, in terms of voltages, frequencies and phases. These requirements make the process of connecting the small unit quite similar to the introduction of an additional large power station into the network. This would not have been possible had it not been for the great development of electronics. Another beautiful idea that is used to store solar energy is to place solar cells near the bottom of the water dams that generate electricity in hydropower plants where. Solar cells generate electricity during the day, to run pumps that restore the water from dam discharge back to the reservoir to be reused to generate electricity during the night. Specialists in this field know how far the human mind has come to devise highly intelligent ways to solve complex problems that seemed impossible a few years ago. Perhaps this human mind is one of nature's weapons, in maintaining its balance. This is what the coming years will reveal.

Wind Energy

For more than 5,500 years, man has harnessed the power of the winds to run sail ships, which traveled across seas and oceans. It is also believed that the Babylonian king ***Hammurabi*** used wind power to draw water for irrigation in the 17th century BC. Historical evidence suggests that the first use of a wind-driven wheel was in Egypt during the Roman rule in the first century AD. The Persians used the wind force to grind grains and draw water from wells in the ninth century BC or even at earlier date. Windmills entered Europe in the twelfth century.

The first recorded use of wind energy in electricity generation was in 1887 by ***James Blyth*** a professor at the University of Glasgow. Blyth installed an electric generator with fans on the top of a tower 10 meters above ground. He used electricity produced by the generator to charge the batteries, which then used to light the electric lights of the country house. A year later in 1888, on the other side of the Atlantic, ***Charles F. Brush*** of Cleveland, Ohio, US, built a relatively large-scale wind electricity turbine. It generated 12 kW of power. Similar sized wind turbines proliferated in both Europe and United states by the beginning of the 20th century. This took the form of relatively small turbines, generating 5 - 25 kilowatt of power, for use in remote areas not connected to electrical grids. In 1941, the first wind turbines with a capacity of more than one Megawatt were connected to the electric grid. The contribution of wind energy to electricity generation took a big step forward after 1973 oil crises. This involved building large units with a capacity of more than one Megawatt each in the United States and Europe. Wind power was one of the alternatives of choice at that time especially since solar cell prices were very high then.

Interest in the construction of larger wind turbines increased at the turn of the 21st century due to increased concern about climate change. This led to an increase in capacity to eight Megawatt per turbine. Around 2014, total units around the world were about a quarter of a million units of commercial type, generating 336 Gigawatt of electricity. This represents about 4% of total global electric power. Many of these turbines have been installed on concrete bases not only on land, but also in shallow waters off the coast for land saving purposes. At the beginning of the 21st century, attention was directed to the construction of floating deep-water turbines using technologies borrowed from Oil Sea drilling platforms. The platforms are anchored to the seabed using steel cables. Several such designs are currently being tested. Research and experiments are under way on the design of airborn wind turbines. These have revolutionary designs where winged turbines are airlifted to some attitude where wind speeds are higher, and more stable. After the initial lift, part of the wind energy is consumed in keeping the winged turbines in position, while the rest of the energy is transmitted back to surface via cables or as microwaves or laser beams. Such designs if successful will eliminate the cost of building supporting structures. Some designs have been presented but this idea has not yet been applied on commercial scope.

The electrical capacity of the wind farms, where large numbers of turbine towers, whether at sea or on land, has grown well since the beginning of the 21st century. Annual growth ratios ranged from 13 to 17%, during the period 2001-2016, as illustrated in Figure (40) published by of the Global Wind Energy Council (GWEC). Total capacity generated in 2016 was 490 Gigawatt, and is estimated to have reached 520 Gigawatt in 2017. These figures are in comparison to that of solar energy, which is 420 Gigawatt,

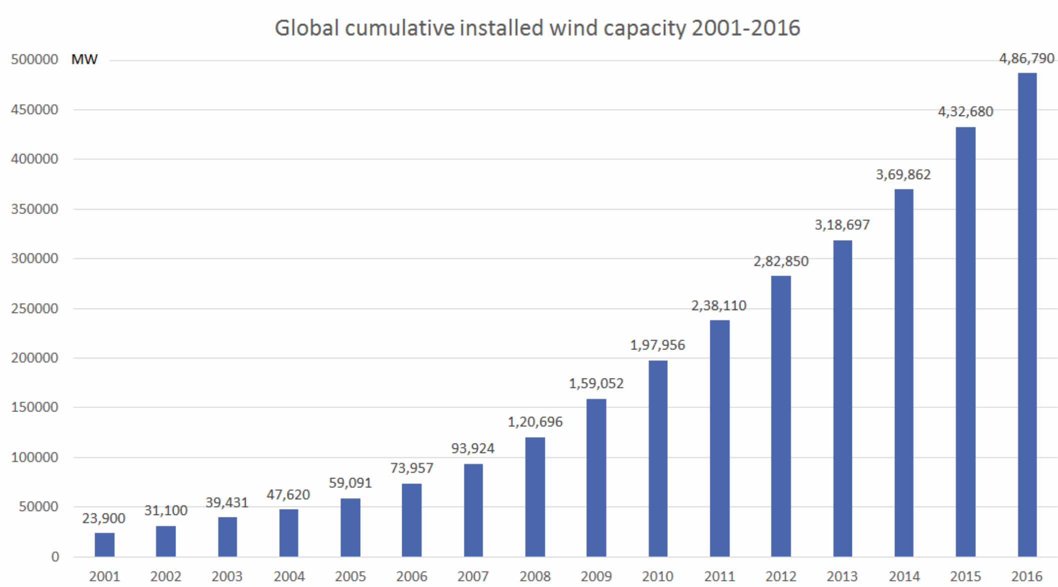

Figure (40) Development of world wind energy for 2001 – 2016 (GWEC publications)

The EU is still the leader in the use of wind power. In 2016, its generation capacity reached more than 154 Gigawatt, equivalent to 37% of the world's total wind electricity production. This figure represents 5% of its electricity needs. Denmark has been the leading country in the European Union in the field of wind energy and wind turbines manufacturing since the 1970s. Danish turbines make up more than 50% of the world market. Denmark exports 90% of its production of these equipments to the rest of the world. It also relies on wind energy to provide nearly 39% of its electricity.

China and the United States come after Europe in wind energy use, with wind power contributed for 2.7% and 2% of their electric generations in 2016 respectively. The share of wind power generated electricity in the world today is around 1.7%. These rates are expected to increase rapidly in the coming years. This is because experiences of many countries have shown that the electricity generated by the wind is much cheaper than that produced by burning coal, oil and gas. This will make the use of wind investment a profitable one. As said earlier, economic consideration form the strongest drive towards the use of clean energies, which will inevitably improve the situation related to carbon emissions and the earth's climate.

Tidal Energy

Tidal movement is a potential future source of power generation, despite its current low utilization rate of just over half a Gigawatt, and the existence of projects in construction stages that will add another half a Gigawatt. There are also proposed projects around the world with a total capacity of about 180 Gigawatt.

Tidal energy has been used since the middle Ages to drive grain mills. The occurrence of tides depends on the effects of moon's gravity and earth's rotation about its axis on ocean waters. These lead to a rise in sea level in a given area, offset by a reduction in another area in a cyclic process. This process repeats twice a day in most areas. In some otherworld areas, this process takes place once a day. In addition, there are places where both types of cycles occur. The height of the tide in a particular area depends on the astronomical position of the moon. It is the largest possible when the moon is full, and the lowest when it is a crescent.

The most common way to use tidal energy is to build dams at the seashore, forming huge reservoirs. High tide water fills these dams during high tide through channels, which are also used to discharge the water back to sea during low tide. The water streams though the channels drive electric turbines installed inside the channels during both filling and emptying processes.

The first such plant was built in France in 1966 with a capacity of 240 megawatts generated by 24 turbines. It is still operating until now and has been the largest such plant until 2011, when South Korea built a 10-turbine plant that generate up to 254 megawatts of electricity.

A second method of using tidal energy depends on the position of the turbines or other moving structures in the course of the tidal movement. Tidal water cause these turbines or structures to move driving attached electric generators.

The issue of the use of tidal energy faces many environmental challenges, whose effects must be known before further expansion. These challenges include the extent to which these dams affect marine life in the region, as well as the effects of turbine's noise on marine life, because it is known that the transmission of sound in water is stronger than it is in air. The potential for rust, corrosion of turbines, salinity or sea crustaceans are also important problems that need to be studied carefully before any station is built in a particular part of the world.

Nuclear Energy

Nuclear power is an important source of electricity in 31 world countries, which have nuclear reactors to produce energy. These contribute about 11% of electricity generated in these countries. France leads the list of these countries, where the share of electricity generated from nuclear reactors accounted for 72% of its total electricity. France is followed by Slovakia 54%, Belgium 52%, Ukraine 52%, Hungary 51%, Sweden 40%, Slovenia 35%, Bulgaria 35%, Finland 34%, the Czech Republic 30% and

South Korea 29%. While the ratios for the rest of the countries ranged between 2% - 20%.

The world's nuclear energy programs usually come under heavy criticism by environmentalists in general and residents of areas close to nuclear reactor sites in particular. These criticisms and objections are based on fears of potential contamination from radioactive materials, which may leak from nuclear reactors, in the event of certain incidents in those reactors. Nuclear reactors history registered three major such incidents. The first was in **Three Mile Island** reactor in America in 1979. The second was the **Chernobyl** disaster in present-day Ukraine, which was part of the former Soviet Union in 1989. The most recent was the **Fukushima** reactor accident in Japan in 2011. The latter caused most countries to review their nuclear energy policies. These resulted in Italy shutting down all its nuclear reactors since 1990. Kazakhstan and Lithuania have since declared prohibiting construction of any future nuclear reactor on their territory. Countries such as Germany, Belgium, Switzerland, Spain, the Netherlands, Austria and Taiwan have already begun or intend to phase out their reliance on nuclear power in the future or have halted commissioning of reactors they had built before the Fukushima reactor accident.

Figure (41) shows an illustration of historical evolution of the total power generation capacity of all nuclear reactors around the world in Gigawatt, published by the International Atomic Energy Agency (IAEA). It is noticeable from the figure that these capabilities have grown rapidly from the beginning of the nuclear age era in the late 1950s until the Chernobyl accident in 1986, reaching about 350 Gigawatt, as shown by the blue line in Fig. It is also noted that the Three Mile Island reactor incident did not have a significant negative impact on this development, as it was considered an accidental incident at the time. No reactors shutdown took place during the period following the accident. On the contrary, this period witnessed the addition of new capacities annually during 1984 and 1985, which witnessed the addition of about 30 Gigawatt per year, as shown by the vertical lines in the figure. The situation changed significantly after the Chernobyl accident, where there was a marked slowdown in capacity increase, unlike in previous years, with generation capacity not exceeding 380, Gigawatt. It is also noted that some states have shut down some of their reactors as shown by the bottom vertical orange lines in the figure. The situation drastically changed after the Fukushima incident in Japan, where the figure shows a sudden decrease, bringing the capacity down to about 350 Gigawatt post that date.

In spite of this, some countries, notably China, India, Russia and South Korea have ambitious plans to increase dependence on nuclear power by building more power generation reactors. Even so, it seems that total global capacity will remain constant for a number of years to come. The reason for this is that the new reactors built in these countries will almost equal to the number of reactors that will be dispensed with in some other countries.

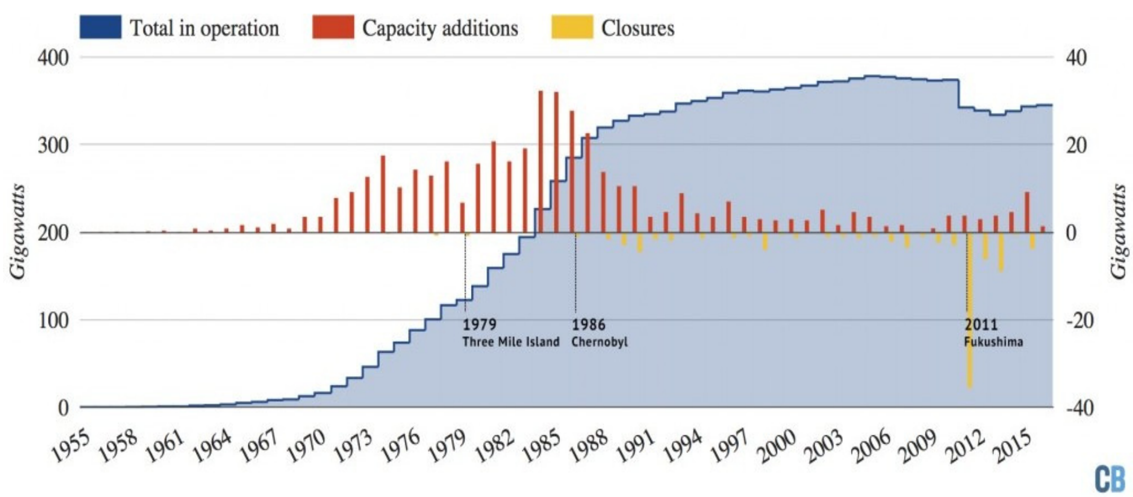

Figure (41) World Nuclear energy growth 1955 to 2016 (IAEA publications)

Another important problem associated with nuclear energy relates to radioactive waste produced by nuclear fuel consumed in reactors. These wastes are of two types. The first is plutonium, which is the main material in the manufacture of nuclear weapons, and the fears of acquisition of such material by terrorist or criminal organizations, despite the measures and strict control exercised by the International Atomic Energy Agency (IAEA), to ensure full control of operations regarding replacing reactors fuel. The second type of waste is other radioactive elements, with a very long life that can remain radioactive for thousands of years. This represents a worldwide problem. Many countries are struggling with the issue of finding places and ways to dump such waste materials. The wastes are currently being buried inside concrete blocks on the seabed or in deep caves in the mountains, which may pose unknown dangers to future generations.

In spite of the competitiveness of electricity generated by nuclear reactors compared to that by fissile fuels, it is logical to say that the future of nuclear power in the world depends on the risk possibility of a major nuclear accident in a reactor, similar to the three important incidents mentioned earlier.

Nuclear reactors that have been discussed so far are the so-called nuclear fission reactors. These are based on the splitting of the nuclei of heavy uranium or plutonium atoms when they are bombarded with neutrons. The nucleus is split into two smaller nuclei with a number of neutrons. These produced neutrons are slowed down and used to bombard new nuclei, creating what is called a ***"chain reaction***" where each of the new neutrons produced, triggers another reaction, producing new neutrons and so on. The sum of masses of the fission products in each reaction is always less than the sum of masses of the bombarded nucleus and the bombarding neutron. This means that there is a net mass loss at each fission process. This lost mass is transformed into energy, according to ***Einstein's*** equation, which states, "The energy produced by the loss of any mass of matter is equal to the value of the missing mass multiplied by the value of the square of the speed of light". For this reason, the loss of a mass, even if small, will generate very large amount of energy, because the speed of light is too large (300 million meters / second)." For example, a mass loss of only 100 grams is equivalent to 250 Megawatt of electric power for approximately one year.

There is another type of nuclear reaction in which mass loss and conversion into energy, occur as a result of the collision of two light mass nuclei, such as those of deuterium, which is a hydrogen isotope. Deuterium has mass twice that of normal hydrogen. Hydrogen in seawater contains 0.0156% deuterium. Combining two nuclei of this type of hydrogen together to form a new nucleus such as helium nuclei releases enormous energy due to the loss of mass. This type of reaction is the source of sun’s energy. However, the process of using this type of nuclear reaction to produce energy faces an important problem. The problem is that this type of reaction can occur only when the hydrogen is at a temperature of several million degrees Celsius, as is the case in the sun, or in explosion of so-called hydrogen bombs. Scientists have been making great efforts to try to generate sufficient and steady such high temperatures to generate and control these reactions continuously since the 1950s. However, no actual reactor has yet been built. These efforts can be likened here, as if trying to detonate a hydrogen bomb, in a very slowly, controlled manner, in such a way that its explosion, which takes no more than a fraction of a second, turns into a slow combustion that lasts for many years. In other words, it is like trying to imitate sun on earth.

Geothermal Energy

We mentioned earlier that the earth's core, in the layers that follow the crust, is very hot molten metals, of which molten iron is the bulk, with temperatures up to 4000 degrees Celsius,. Part of this heat usually leaks through the earth crust to the surface in areas where the crust is thin enough or fractured. Hot springs waters are nothing but part of the leaked heat. The water of these springs has been used in bathing since prehistoric times. The Romans also used this water in heating and it is still being used for this purpose in some regions of the world. Hot steam from the ground have been used to generate electricity on a commercial scale since 1911, when the first power plant using steam from the ground was used to drive steam engines that drive electric generators in the United States. Other plants in countries, such as Italy and New Zealand, followed this. The total generation capacity in 70 countries around the world in 2015 reached about 13 Gigawatt, achieving a growth rate of 5% per annum during the three years proceeding the year 2015. This capacity is expected to reach between 15-18 Gigawatts by 2020. The United States and the Philippines are leading the rest of the world in exploiting this energy, with the Philippines receiving 27% of its electricity from geothermal sources. At present, there are countries that receive more than 15% of their electricity needs from geothermal underground heat. These include Iceland, El Salvador, Kenya and Costa Rica. All of these countries have areas with high volcanic activity, i.e. the crust in these areas contains cracks, allowing the leakage of heat to shallow depths that are nearby and easy to exploit.

There are three main methods currently in use for the exploitation of geothermal energy from the ground for electricity generation. The use of any particular one of these methods depends on the nature of the earth's crust in a particular area. The first direct method is used in areas within the tectonic-zone that include cracks in the earth's crust, where the hot steam comes out from close depths to be used to drive the turbines. In other areas, where the earth's crust does not have these advantages, wells are drilled down to a few kilometers deep to reach hot rocks in the ground. It is known that the temperature of the earth's crust increases by 30-35 ° C per depth of one kilometer away from the earth's surface. On the other hand, the steam temperature required to operate the turbines at the optimum efficiency is about 200 degrees Celsius. This dictates the need to drill wells up to 6 km or more and this is what is happening now, where the steam from these wells is used to generate electricity. A third method is used in areas where the deep underground hot rock bed does not contain nearby water that can convert into steam as in the previous method. In such cases, two adjacent wells are drilled. The first one is used to inject water or liquid carbon dioxide through down to the dry hot rock bed, turning into steam that comes out of the second well and used to generate electricity. The condensate water is then recycled from the steam to water which is pumped back again through the first well and so on.

The use of geothermal energy to generate electricity is economically competitive with other electricity generation methods. The main costs of any such project are the exploration, drilling and construction of equipment. The operating costs are usually low compared to other methods. On the other hand, for projects of this type, some environmental considerations must be taken into account. The most important is the release of gases and toxic substances that cause environmental pollutions. These usually come out in conjunction with steam from the ground. The gases include methane, hydrogen sulfide, carbon dioxide and ammonia, while hazardous substances include metals such as mercury, arsenic, bismuth and boron. Modern projects rely on sophisticated technological methods to separate these materials from steam and re-pump them back into the ground.

Another problem that faces geothermal energy projects is the possibility of land down settlement due to the withdrawal of large quantities of water from underground. This usually happens in the oil and gas fields also. There is also the possibility of land bulges in projects that rely on pumping water into the ground for heating and steam production. In addition, events of this nature may result in movements of tectonic rocks in the ground, leading to earthquakes in some areas. An example of this is what happened to a geothermal power project in Basel, Switzerland, where more than 10,000 earthquakes, some of which reached 3.5 on the Richter scale, were recorded during the first days of pumping water into wells. This prompted officials to stop pumping water, and completely abandoning the project.

Biomass

Human has used biofuels, including wood and agricultural, animal and human waste since the earliest ages. This fuel has been the main source of energy for cooking and heating from the inception of man until the beginning of the industrial revolution. This remains the case in many villages and primitive agricultural communities in many parts of the world. This fuel, being combustible, can surly is used to generate electricity. The use of biofuels results in carbon emissions, but these emissions are not usually counted as additional ones. This is because these substances will either naturally decompose, or burn any way. This means that the same quantities of carbon dioxide will be produced in both cases whether they burn naturally of used as fuels. For this reason, various biofuels become an important source of renewable energy. This is in addition to the role such use plays in the disposal of waste and the preservation of the environment. Despite the very old history of biofuels, interest in using them as source in electric energy production did not gain much attention until the 1970s, after the known oil crisis. It was only at that time when the names "***Biofuels***" and "***Biomass***" appeared. Attention then concentrated on the extraction of alcohol from corn and other grains. These are the so-called first generation of biofuels. However, the need for these grains for food has stood a barrier to the evolution of their use, and the emergence of second-generation biofuels extracted from timber and other organic wastes.

Biofuels are often used to generate electricity by following the traditional method of burning fuel in boiler furnace to generate steam at high pressures, and using it to run turbines that generate electricity. In this case, the fuel is used as solid, in the form of wood cut or sliced, or sawdust beside other plants and animals waste. Liquid fuels extracted from solid biofuels are obtained using an industrial process called ***pyrolysis.*** This process involves heat treatment of raw materials in an oxygen-free atmosphere. This process produces oil-like combustible liquids called bio-oil, which can be used as an alternative to oil, as boilers liquid fuel. It is also possible to extract natural gas, which is actually methane from the raw material through fermentation with the help of bacteria called ***anaerobic bacteria.*** The conversion of organic waste into methane takes place through a series of complex chemical processes. A specific type of bacteria is concerned with the implementation of each certain phase of the conversion process. The first phase involves conversion of insoluble solids into water-soluble substances.

Another bacterium called ***Acidogenic*** bacteria, transforms these soluble substances into carbon dioxide, hydrogen, ammonia, and organic acid. A third bacterium, called ***acetogenic*** bacteria, converts the organic acids to acetic acid and additional amounts of ammonia, carbon dioxide and hydrogen. These intermediate products are converted to methane by other bacteria called ***methanogens***. This process can convert most types of plant and animal waste, food residues, laboratory water, fats and garbage into methane in a continuous way. It is noteworthy that a large number of companies around the world, collect the waste oil and fats consumed from restaurants, and process them into the so-called biodiesel fuel. This is much similar to ordinary diesel fuel used in transport. Solid residues from biofuel production are also largely converted to organic agricultural fertilizers.

Mixing a certain percentage of solid biofuels with coal in power plants is one of the ways currently used to replace a certain percentage of coal and reduce its carbon emissions. This process contributes to reducing the economic costs of generating electricity beside its important positive effect in reducing carbon emissions, Coal forms 40% of the fuel used in electricity generation around the world. Therefore, a 1% reduction in coal consumption through its replacement by biofuels will reduce carbon emissions by 60 million tons per year. However, many experts believe that the contribution of this type of alternative energy in the generation of electricity will not achieve large growth rates in the coming years for several reasons and obstacles. The most important are those related to the high transportation costs of waste from city centers to the electricity or treatment plants, especially since these materials contain high ratios of water, which greatly increases the weight. The second problem is that burning these materials in steam boiler furnaces will generate unacceptable gases and odors, whose treatments require complex technologies. Industrial installations and biomass processing systems are usually associated with high maintenance costs due to high corrosion rates of the equipment that handle these materials. These problems make electricity generated from biofuels more of a by-product of waste treatment plants rather than being a goal in itself.

Despite the problems related to electricity generation, the use of biofuels in some countries, such as Brazil, has been a good success. Brazil is currently using ethanol from sugar cane as a fuel to generate 7% of its electricity. Brazil has also enacted legislation that gasoline must contain 25% ethanol alcohol, and Brazil has produced highly flexible cars that can use this mixture instead of ordinary gasoline alone. Experts believe that the success of this experiment in Brazil was due to the country's large sugar cane production. On the other hand, any rise in global sugar prices may hinder sugar cane conversions to produce ethanol and trigger a switch back to sugar production. Brazil currently uses only 44% of its sugar cane for sugar production, while the rest is directed to the production of ethanol.

Some countries, such as Sweden and Norway, have relied on biofuels made up of wood and waste to generate up to 30% of their needs because of the availability of forests in these countries. On the other hand, these countries faced some problems in providing sufficient quantities of waste to operate some power stations, forcing them to import quantities of such waste from neighboring countries.

A Race between Competitors

We have already emphasized that regardless of carbon emissions, and whether they may or may not cause thermal trapping or climate change, the decisive factor in the issue of human access to energy is the economic one. It is reasonable to say that many public opinions around the world, particularly Europe, have highly romantic feelings about global warming and climate change. These feelings have been and continue to be an important factor influencing political election results in many of these countries and the choice of governments that adopt environmentally friendly policies in general, and aiming to devise solutions to emissions in particular. However, despite the strength of these feelings, and whatever the arguments and proofs that motivates them, they must at some stage clash with the economic obstacle. This obstacle can be summarized by the price to pay for energy. Anyone holding such romantic feelings may be willing to afford an increase of 10-30% on their electricity bill if the electricity is generated using an environmentally friendly source of energy. It is doubtful however if the same person is ready to pay twice as much for clean energy compared to that from coal. It is very difficult to imagine that a worker or employee of a coal or oil company would be willing to give up his lifelong job for preventing climate change. Many other examples can be listed to show that the economic factor will be the ultimate determinant of the success or failure of any energy policy. On this basis alone, a presentation of the current state of the costs of electricity production from the various alternative sources described above, and their comparison with the costs corresponding to production by conventional means, would be useful in identifying some of the features of the future.

Table (3) below shows the cost of producing one kWh (the cost of operating an electric appliance of one kilowatt for one hour) using each of the currently common methods of generating electricity. The costs presented in this table are from two different sources. The first is the REN2 report of the "*Renewable Energy Policy Network for the 21st Century*", an independent scientific organization supported by the United Nations, the European Union and American institutions. The second source is the publications of the US Energy Information Administration (EIA), an official government body. Preliminary comparison between the two sets of numbers shows some differences in corresponding values. Even so, the two sets tend to show approximate consistency.

To explain the picture, one must say that the metric for the cost of kilowatt-hour, called the **Levelized Avoided Cost of Electricity** (LACE) in question, is a standard that requires complex calculations. The inputs include all direct and indirect construction and running costs of a particular project. Examples of such costs are those spent on construction, operation, maintenance, and expected life of the project, banks interests, taxes or tax exemptions, type of project, the number of work hours, annual downtime, wages and any anticipated financial costs over the period of the project life. For this reason, there may be sometimes large differences in the value of LACE between one country and another, or even between regions within the same country. As an example, a solar project in the Middle East or North Africa will be able to produce electricity for more hours during the year, compared with its counterpart in Europe. In addition, the electricity produced by small generating stations used only at peak electric loads hours is usually more expensive than that produced from large stations that operate 24/7 throughout the year. On this basis, the values shown in these tables represent only global averages. In addition, figures for a given project, in a particular country, can go up to more than double that in the table, or down to half of that value.

Table (3) approximate prices of electricity generated by different methods in US$/ kWh

Gas	Coal	Biofuel	Tide	Geothermal	Nuclear	Offshore Wind	Onshore Wind	Rooftop Solar	Solar Thermal	Solar Cells
0.080	**0.120**	**0.071**	**0.065**	**0.080**	**0.180**	**0.065**	**0.123**	**0.200**	**0.240**	**0.128**
0.072	**0.110**	**0.100**	**0.050**	**0.120**	**0.113**	**0.060**	**0.150**	**0.223**	**0.128**	**0.080**

This table shows that generating electricity using natural gas, wind energy, or tidal energy are the most economical at the time being (2017-2018). However, the cost of electricity generated by solar cells, nuclear power, and geothermal energy have become close to that produced by coal, to the extent that it has made it an exclusive competition. This positive factor will help reduce future carbon emissions. This move away from coal may come regardless of countries' economic and environmental policies. In addition, electricity produced from burning oil has not been included in our current comparisons, for two reasons. The first is the lack of stability in world oil prices during the past decades. The second reason is that the share of oil as fuel in electricity power plants around the world is very low compared to those of coal and natural gas, and it does not exceed 5%. Most of the world's oil is consumed as fuel in transportation by cars, trucks, trains, ships and aircraft, which we will discuss in a future chapter. It appears from all of the above that clean energies in various forms, will impose themselves economically, in the coming decades, in one way or another. However, the speed at which this shift will take place will be affected by the economic and environmental policies of governments, especially the more industrialized ones. However, those policies are not expected to have a major impact on the outcome, which is the significant transition from fossil fuels to clean energy. These policies can only act to speed up or slow down this transition through the imposition of tax restrictions and exemptions helping one form of energy or another. It is clear that the competition of renewable energies of all kinds will be mainly with coal, which currently accounts for about 40% of the fuel used to generate electricity. In short, one can conclude that, over the last two decades, renewable energies have been able to find a place as an important contributor to the production of electricity around the world, and are likely to become more economically competitive in few years to come.

Future Forecasts

Highly developed countries adopt their economic, industrial, health, educational and human policies based on well drawn up plans for visions that will extend for decades to come. These plans are usually put after in-depth studies of the past and its evolution, the present and its realities, and then the prospects for the future. These plans usually have a margin of flexibility, through which takes into consideration both best and worse scenarios expected for each situation, and taking into account what surprises may occur. This helps decision makers perform the required adjustment to any particular plan, at any point in time. At present, electricity represents the backbone of human life, and it will remain so for an indefinite future. For this reason, predicting future quantities of electricity development in a country should be a key priority for the country's policies in particular, and the world in general.

It may be trivial to say that the world's electricity consumption will continue to rise for decades to come. The main reasons for this increase are two important facts. The first is that the world population at present is approximately 7.6 billion (billion = one thousand million). About 1.2 billion of these still do not have access to electricity. In addition, the world's population is expected to increase by 2.1 billion by 2050, to reach 9.7 billion. Given the very conservative assumption that per capita electricity consumption will remain constant, the world will have to supply electricity to a further 3.3 billion people by 2050. This alone will constitute an increase of 50% of the total current electricity capacity. The second fact relates to the current development in the use of electric vehicles, which will represent a transition from oil to electricity. This shift will add significantly to the required electricity. At present, it is difficult to predict the numbers and types of modes of transport that will switch from gasoline and diesel to electricity, but global oil prices will definitely play a crucial role in this transformation. Any rise in oil prices will accelerate this shift, while any major price drop will be a retarding factor. Nevertheless, it can be said that technologies for electric cars are now mature enough. This topic we will discuss in a coming chapter.

It seems clear that the world is moving towards a greater use of clean energies to generate electricity in the coming years. Whether or not the magnitude of this shift is enough to satisfy global warming enthusiasts will depend largely on fossil fuel prices and how close or divergent they are, either higher or lower than those of alternative energies are. The current situation indicates that the prices of these two groups of energies are close within a margin of not more than 20% at most.

Experts and scientific research centers predictions on the evolution of different sources of the world electricity generation for the years until 2040 are made through studying the patterns of development of these energies during the past years. Examples of such future predictions are presented in figures (42 and 43). Figure (42) is from an article in **cornerstone**, the official magazine of the global coal industry, written by ***Stephen Mills***, one of the IEA consultants. Figure (43) is published by International statistical center **statista**. Both figures present predictions for future prospects for this development in 2040 compared to 2015. The following points summarize the most prominent features of these expectations that can be inferred from these two figures:

1. The total need for electricity around the world will increase by up to 65% due to the increase in the world's population and the increase in the number of people who will have access to electricity.
2. Significant decrease in the use of oil in electricity generation, although it does not currently play an important role.
3. Increase of 10-15% in the use of coal in electricity generation
4. Equal shares of gas and renewable energies of various types in electricity generation in 2015. Renewable use will be 13% higher than that of gas in 2040.
5. Increase natural gas share in electricity generation by up to 25%.
6. Significant increases in both renewable energies and gas occur after 2015

All this means that most of the expected future increases in the need for electricity will be covered by renewable energy and gas primarily if there are no significant changes in oil, gas and coal prices.

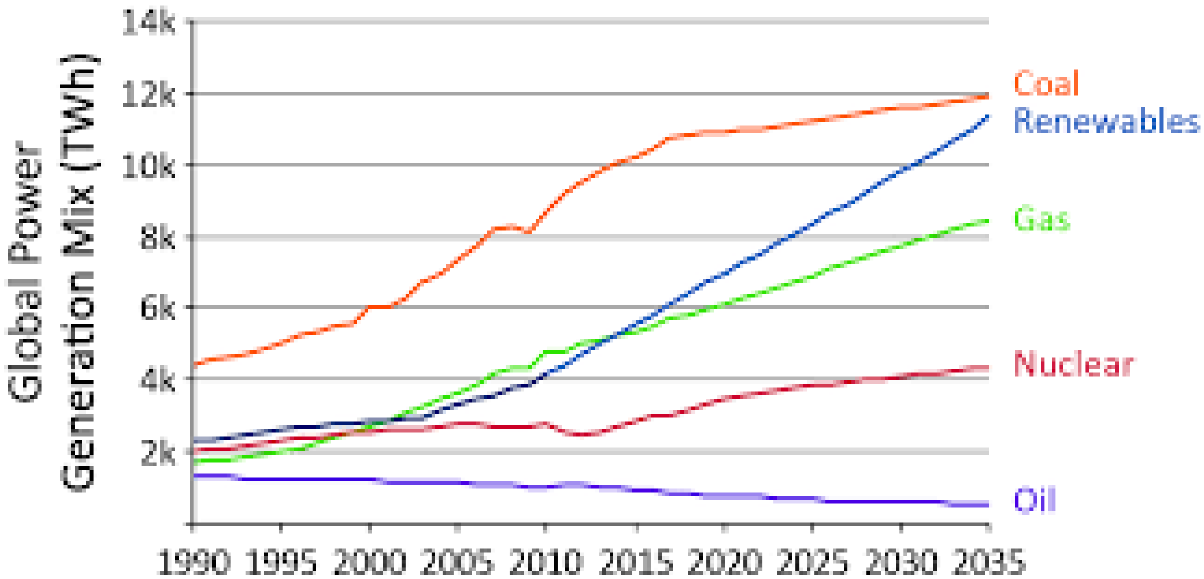

Figure (42) developments of past and future electricity generation map (Stephen Mill – cornerstone journal)

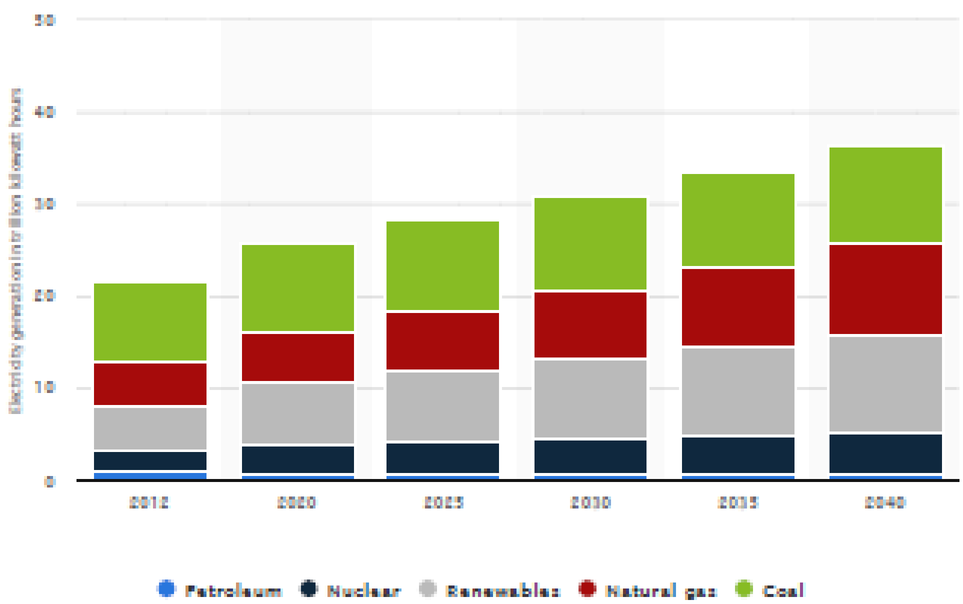

Figure (43) Forecast of world electricity generation map (statistica publications)

Homes Solar Electricity Systems

Prices of homes solar units of all sizes have decreased significantly over the past decades. These prices are expected to fall further in the coming years due to lower solar cell prices and energy storage batteries. This will make the use of these units, whether connected to the electrical grid or those operating independently, as in remote areas, accessible to many parts of the world. Many world countries have difficulties in meeting their population electricity demands. This is particularly true in North and Subsahan Africa, some Middle East countries and the Indian continent. This resulted in either living without electricity all together in the poorest rural areas, or resorting to the use of local diesel generators to make up for the electricity shortage in urban areas. This forces citizens to pay two bills for electricity, one for the inadequate national grid and another for the supplementary supply. The use of solar home units can be just the ideal solution to this problem. Most these regions are characterized by horizontal expansion, which provide enough empty area or rooftop needed to install solar panels. In many cases, the available area is not less than 100 square meters. With currently available solar cell efficiencies, such area can produce daily average of 1-5 kW of electric power round the clock. The prevailing price for such complete unit including batteries, inverter and installation is in the range 2000 – 3000 US$. Units of this type will repay their initial price within 5 – 7 years by the electricity they generate.

The deployment of these units, especially in countries with electricity shortages, will not require significant financial investments by governments, which can do much to encourage their citizens to achieve self-sufficiency in electricity through some legislation on customs, taxes and import duties.

Banks and financial institutions, and traders can also play a key role in the provision of loans and financial facilities, through the installment of the basic amounts of the prices of these units. There is an important role for universities, scientific and educational institutions, and the media in all their forms to spread the culture of economic and environmental benefits associated with the use of solar energy on the household scale. This will benefit individuals and society, and is in the interest of the State at the same time.

Chapter Ten
Oil and its Carbon Emissions

Where Does the World Oil Go?

The world burns about 100 million barrels of oil a day. This is responsible for 36% of global carbon emissions. However, oil is not an important part of the fuel used in electricity generation, and its consumption in this field is only 3-5%. The transportation sector accounts for nearly two-thirds of world oil consumption, while the rest is used to produce petrochemicals, home heating and other industries. Cars consumed more than 51% of the world's oil produced in 2016, while aviation fuel, ships and trains accounted for 13% of world oil consumption for the same year. It can thus be said that any action to reduce carbon emissions must necessarily reduce the consumption of cars in one way or another.

The invention of a car powered by the four-stroke internal combustion engine was one of the most important track changing discoveries in the history of man on this earth. This invention simply changed the way of life, in a way that will last long in the near and medium future. Therefore, some knowledge of the history of the car, its reality and future prospects are an important part in understanding the role of the car in carbon emissions and climate change.

The Car is a Cart without Horses

Man invented the circular wheel about 6500 years ago. These wheels were used as platforms for the manufacture of pottery. The Sumerians developed it after nearly a thousand years later in the construction of the wagons, which horses had been pulling ever since. No one knows if the horses would prefer to pull these wagons or to carry a person riding their backs.

The famous artist ***Leonardo da Vinci*** was the first to put a design on paper for a wagon that did not need horses to pull. It was a three-wheeled wooden cart driven by two giant helical springs similar the springs of the clock. These springs store energy when they are winded up, then release it to rotate the wheels of the cart. Da Vinci is not believed to have actually built this machine. The idea of replacing horses with motorized mechanical devices started since the beginning of the industrial revolution and the discovery of the power of steam. It is believed that French inventor ***Nicholas Cugnot*** built the first steam-powered vehicle in 1769. It was a slow, three-wheeled vehicle used to carry a military gun.

Steam-powered cars became operational by 1850. These vehicles continued work for many years, and were used for many purposes. However, this situation did not last long after the invention of the internal combustion engines and their development by 1900.

The invention the steam engine by ***James Watt*** was the basis for the start of the industrial revolution, in the middle of the nineteenth century. However, that engine's ultimate fate of losing the battle against the internal combustion engine was theoretically settled even before this happened in practice. The reason for this loss lies within one fundamental principles related to an important law in physics. This law is called the ***Second Law of the Thermodynamic.*** It states that no engine can convert heat into mechanical work with efficiency grater than that of a ***Carnot*** engine.

Carnot Cycle and the Second Law of Thermodynamics

The French scientist ***Sadi Carnot*** reached a simple mathematical formula that determines the maximum theoretical efficiency of any thermal engine in 1824. This formula expresses the maximum efficiency in terms of the high and the low temperatures of the gas that drives the engine. The formula states that the maximum efficiency is equal to the difference between the high temperature to which the gad is heated and the low temperature to which the gas is cooled, divided by the high temperature (all *measured in absolute degrees = Celsius+ 273*). Since the difference between the two temperatures is always less than the high one, the denominator in this formula is always grater than the numerator. The efficiency is thus always less than 100%. Increasing efficiency on this basis requires one of two things. First is increasing the high temperature of the working gas to be as large as possible. Second is reducing the low temperature of the working gas to be as small as possible.

Since it is more difficult to reduce the low temperature, it makes sense to work to increase the high temperature. It is very difficult to reach steam at temperatures greater than 500 degrees Celsius, because this brings the steam to very high pressure. Increasing pressure results many problems, related to the thickness of pipes and boiler walls to be able to withstand the high pressure and heat. Typical steam temperatures in steam locomotives are about 200 ° C. Inserting this value into Carnot formula, and assuming the ambient temperature of about 20 ºC to be low one, we can obtain the efficiency as:

$$\varepsilon = \frac{(200+273)-(20+273}{(200+273)} \approx 0.38 = 38\%$$

This represents the maximum ideal achievable efficiency. In practice, this efficiency is impossible to reach because of losses related to mechanical frictions and heat escape. Consequently, most steam engines are considered good enough if they can achieve efficiencies of about 30%.

Internal combustion engines on the other hand have overcome this problem because the high combustion temperatures of burnt fuel gases in their cylinders that may reach up to 2500 ° C. This makes these engines operate with much higher efficiencies than steam engines. The cooling water inside the engine cools the cylinders quickly. To demonstrate this, let us assume that the low temperature is that of the engine cooling water, which is about 90 degrees Celsius. Inserting the value of 2500 ºC for the high temperature, we obtain the efficiency as:

$$\varepsilon = \frac{(2500 = 273)-(90+273)}{(2500+273)} \approx 087 = 87\%$$

This is much bigger than that for steam engines. This superiority in efficiency was the main reason for the loss of the steam-engined car the competition against the internal combustion engined car. The latter gained the right to be legitimate mother for all cars at present.

The Motor Car

Opinions differ on the name of the first person who built a car driven by an internal combustion engine. Studies show that Austrian inventor

Siegfried Marcus built the first such car in 1870 but did not register it as a patent, although he had registered patents for a large number of his other inventions. The second car, made by Marcos was discovered in 1950 hidden behind a wall at the Vienna Museum and was still in good condition. The concealment of that car was because the German Nazi authorities had removed Marcus's name from all the documents concerning inventors' names and their inventions, because he was of Jewish origin. On this basis, the German Nazi authorities regarded ***Carl Benz*** as the first person to build a car with an internal combustion engine in 1885. Sales of Benz cars started two years later**. Mercedes-Benz** still produces cars today.

At 4 am on June 4, 1896, on the other side of the Atlantic, ***Henry Ford*** took to the streets of Detroit, riding a small beast with four bicycle wheels and a two-cylinder internal combustion engine, powered by ethanol. ***Nikolaus Otto*** had previously invented this engine in 1876. At that hour of dawn, Ford just finished assembling and installing all parts of that little monster in a workshop by the side pf his house. The engine made noise, which disturbed the sleepers, in buildings on the two sides of the street. That noise represented the announcement of the birth of a horseless cart on America's roads and christening it as the legitimate grandmother of all vehicles running on liquid fuel to this day.

Ford's invention of the motor vehicle was not a new thing in itself, but his most important invention was the idea of the assembly conveyor belt. This enabled him to mass produce large numbers of identical cars, making them affordable to more people by 1901. Luck also served Ford and his car over that period, during which oil discoveries began to increase. These discoveries, in turn, led to the availability of liquid gasoline fuel at a cheap price. That primitive car has evolved over 120 years since that date. Ones that are more suitable replaced the bike tires. The original two-speed manual transmissions changed to three, four … seven or eight speed ones, many of which became automatic. The number of engine cylinders has increased from two to four, six, eight, twelve or more. The speeds increased from 40 km to more than 250 km/h. Air conditioning, amenities, belts, and air bags for accident safety became integral parts of cars. Cameras, sensors, and driver directing screens are becoming important also. The engine went through many modifications and addition that increase fuel efficiency, and reduce the toxic products of combustion. Nevertheless, the four-stroke internal combustion engine has remained steadfast, with no change in the basis in its way of operation, and its burning of fuel to this day when the car has become an integral part of modern life.

The number of cars on the world's roads currently stands at about 1.2 billion cars, an average of one car for every six people. The number of people per car varies from one country to another. While approaching one car per person in the United States, it averages about two cars per three people in Europe, and a car for every two people in most Middle Eastern countries, down to less than one car for every twenty people in some poor African countries. Nearly half of the world's total crude oil production per day burns, pumping about 22 million tones of carbon dioxide into the atmosphere every day. This represents an average of 18 kg of carbon dioxide per car per day. These high carbon emissions have made the car one of the important enemies of environmental protection and global warming advocates. However, pressures towards finding a substitute to the internal combustion engine is dictated by the economic considerations of higher oil prices on the one hand, and the health issues caused by air pollution in large cities on the other, more significantly than claims, protests and demonstrations on the issue of global warming.

Figure (44) Top, Siegfried Marcus car found hidden behind a museum wall. Middle, Henry Ford original car. Bottom, Ford first production model

A Divorced Ex Making a Comeback

The traditional car that has served people sincerely, for more than a hundred years, has found it self exposed for the first time, to a strong competition from its old great rival, the electric car. This happened for the first time after the world oil crisis, which led to high fuel prices, in the seventies of the last century. Some may be surprised to learn that the birth of the electric car preceded the birth of gasoline-powered cars by over 40 years. The invention of the first electric direct current motor by British scientist ***William Sturgeon*** in 1832 represented the first step in building the first electric car in the same way the invention of the internal combustion engine made in building the first conventional car.

Scottish chemist ***Robert Davidson*** used the electric motor to build the first electric car in 1837. Davidson used the non-rechargeable galvanic batteries, made up of copper, zinc and sulfuric acid, to operate that first car. Davidson also built the first electric locomotive, named **Kelvani**, following the name of the battery inventor in 1841. The weight of that locomotive was seven tons, and it ran about two and a half kilometers, at a speed of six and a half kilometers per hour on the railway, between Edinburgh and Glasgow, carrying a weight of six tons. The locomotive was not very successful due to inefficient batteries and was left to meet its fate at the hands of railway workers who destroyed it, believing it could threaten their jobs if it happened to replace their beloved steam locomotives.

The invention of the lead battery by French physicist ***Gaston Planté*** in 1851, and its later development in 1891 by another French scientist, ***Camille Alphonse Faure***, gave a powerful boost to the electric car and its spread. The actual commercial production of these vehicles began in Germany, Britain and France during the years 1888 - 1896 and in the United States during the years 1890 - 1891. The last ten years of the 19th century represented the golden age of electric cars. Electric taxis roamed the streets of London, Berlin, Paris, New York and other major cities. These vehicles were suitable for short urban commuting within cities, but not for long journeys, due to limited battery charging capacities. The electric cars had a social imprint that reflected the social position and nature of its users. These cars, for example, have become popular with women in Britain because of their ease of driving, as there is no transmission change box or clutch, no need to check water or oil, and no manual handle engine start. This made them become women's favorite vehicles. This led some manufacturers to disguise their reality by making their front appearance similar to that of gasoline cars through the installation of what looks like a water cooler at the front. In the United States, electric cars were large, heavy, fitted with leather seats and other comforts, reflecting a high economic and social standard for their owners, the majority of whom had electricity at home to charge batteries. Sales of electric vehicles in the United States peaked in 1910, after the introduction of battery replacement stations. Electric cars were equipped with a mechanism that facilitate the replacement of discharged batteries with charged ones, quickly and easily at those stations, instead of waiting for batteries to be recharged. The electric car was characterized by being quiet compared to gasoline ones. They also did not need the manual handle start up of the engine, as was the case in gasoline cars.

The success of the electric car did not last long, as it began to lose competition with the gasoline car on more than one front. The first was the development of highways between cities. The gasoline car was more suitable because it could travel such long distances without the need to refuel. In addition, the speed of the gasoline car, replacing the manual start of the engine with an electric motor starter, and the addition of the silencer to the exhaust pipe in the gasoline car were all factors that greatly increased its popularity. All this led to declines in sales of electric cars, and limiting their use on short distances only. For example, electric milk floats remained in use for the distribution of milk and dairy products in Britain throughout the twentieth century. All this forced most electric cars production plants to halt production altogether during the second decade of the twentieth century.

It must be said here that the main reason for the almost disappearance of the electric vehicle is inherited in its batteries. All of these vehicles used lead-acid batteries. These are characterized by being heavy, expensive, limited charging capacity, and a relatively short life. Most of these batteries lose much of their capacity after about 50 repeated discharges and recharges cycles, after which their replacement becomes necessary. On the other hand, large oil discoveries in many parts of the world have led to the availability of cheap fuel for internal combustion engines. These two reasons were able to bring a state of almost null interest in electric cars for decades between 1920 and 1970.

Research and studies on electric cars have received some attention from some companies after the invention of nickel-cadmium batteries. These are lighter, and with more capacity, and durability than those of lead batteries. However, this interest did not exceed the research stage and few experimental models, which never reached the actual production stage.

Low fuel prices were one of the main reasons for the disappearance of the electric vehicle. This necessarily means that increasing those prices can help bring back some attention to the electric vehicle and that is what happened during the 1970s, after oil prices began to rise. Another important factor that came in support of the electric car was the large increase in air pollution in large cities, which led to striking deterioration of public health. This resulted in material and humans health damages, which forced governments to put laws and strict legislation to limit various pollutants emitted from cars exhausts. These restrictions and legislation have forced cars manufactures to make significant efforts to reduce emissions by improving engines designs to eliminate the need to add lead compounds to gasoline and introduce additional new equipment to reduce or absorb polluting gases such as nitrogen oxides and carbon monoxide. All this led to an increase in car prices. Even so, the main problem in the electric car, the batteries have remained unresolved, making most car companies do not pay it much attention, betting instead on the possibility of grudgingly making emissions specifications match environmental legislation. In many cases, those manufacturers suffered heavy fines, or the withdrawal of large numbers of already sold cars from the market, when they failed to match the environmental specifications.

The interest in the electric vehicle received support from another world that is far away from the automotive one. This was the world of communications, whose massive development at the end of the 20th century and the beginning of this century spreaded like wildfire. There are currently about 5 billion mobile communication devices around the world. This means that 63% of the world's populations now own these devices, at the very least. This would not have happened if manufacturers had not put the money and effort to research in lithium-ion batteries with their high storage capacity, lightweight, and durability that are hundreds of times superior to those of lead batteries. Research on Lithium-Ion batteries began in 1973 and commercial production of the first generation began in 1991. Efforts are continuing to improve their performance and reduce their costs. It is noteworthy that the prices of these batteries have decreased by 80%, during the six years 2010 – 2016. This was due to efforts by some car manufacturers in adopting development and production of these batteries for using them in their electric vehicles.

The return of the electric car began at a little bit slow pace when Tesla Motors announced the delivery of its first production of these cars to customers in 2008. Their car could travel 320 kilometers before it needed to recharge its batteries. Sales reached 2,450 cars in 30 countries around the world by the end of 2012. Most other global car manufacturers like GM, Mitsubishi, Toyota, Peugeot, Citroen, Nissan, Mercedes, and others started producing their own models of electric cars. The total number of electric cars sold worldwide was half a million in 2014, and reached two millions in 2016. Approximately 46% of these cars were sold in the United States.

Figure (45) shows the evolution of the number of electric vehicles on the roads in different countries around the world, which reached two millions in 2016, according to the International Energy Organization (IEA).

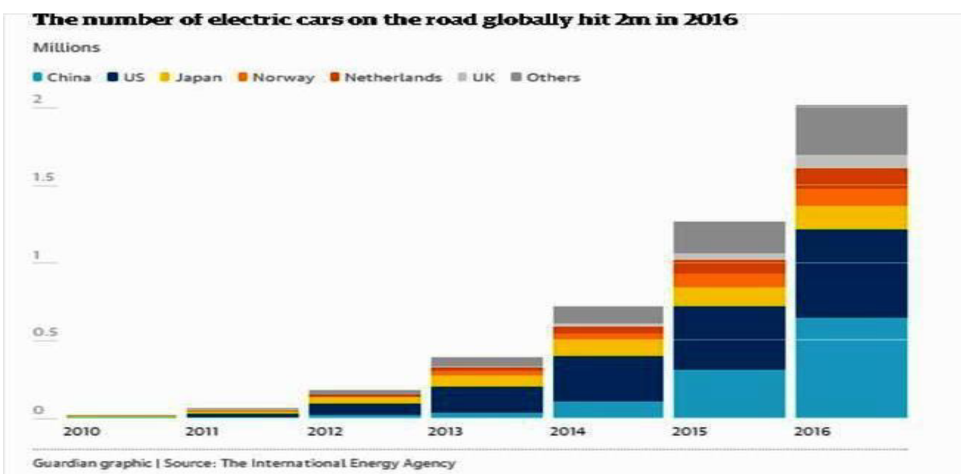

Figure (45) development of numbers of electric cars in different world regions between 2010 – 2016 (IEA publications)

Future of the Electric Vehicle

Despite the rapid increase in the number of electric vehicles in the last five years, which is approaching 8% per year, the number of these cars, which currently exceeds two million cars, represents hardly more than two cars out of every thousand. These figures show that unless significant technological developments or a significant increase in oil prices make the electric car an attractive economic alternative, the current increase rates cannot result in completely abandoning the conventional car before 2100. Even so, some European countries have plans to make their roads free of conventional cars by 2050. These countries intend to achieve this goal through more stringent air pollution legislation, taxes and credit facilities to encourage their citizens to switch to electric cars. Also noted, that China has recorded higher sales of electric cars than other countries in recent years.

It is also worth noting that the current electric cars rely on their work on lithium batteries. This will necessarily increase global demand for Lithium metal. Australia, Chile, Argentina, China, Zimbabwe, Portugal and Brazil are among the major producers of the metal. However, there is some concern that current and projected lithium sources will be able to meet all future requirements for this material if demand continues to be increased by the electronics and automotive industries.

Cars and Global Warming

It should be said here that switching from a conventional cars to their electric counterpart electric ones would have little impact on atmospheric carbon dioxide emissions. This is for the simple reason that the electricity that drives these cars is mostly generated by burning coal and gas. On this basis, any effective action to reduce carbon emissions must be through the use of renewable energies in generating electricity. However, the electric car plays an important role in reducing other polluting gases such as nitrogen oxides, sulfur oxides, carbon monoxide and black carbon.

The role the electric vehicle will play as far as carbon emissions are concerned remains unclear. A major shift to electric vehicles will surly result in less demand for oil on one hand and increased need for electricity. Weak oil demand will result cheaper prices, which will help conventional cars markets and slow down growth of electric cars one. Increased electricity demand by caused by added electric vehicles will result in more need for coal and gas unless these additional needs are covered from renewable energy sources. It is thus conceivable to say that a major world shift to electric vehicles may cause a backfire effect on global carbon emission if the increased electricity needs are met by burning more coal.

Chapter Eleven

Cement and its Carbon Emissions

Cement and Carbon Dioxide

Cement represents the material most widely used by humans. Even so, some of us would be surprised to know that cement production involves a hidden contribution to global carbon emissions apart from that resulting from burning fuels in cement furnaces during the production process. Everyone knows that the process of the cement industry involves heating the raw materials consisting of gravel, sand and limestone to temperatures as high as 1500 degrees Celsius using oil or gas at some stage. This produces carbon dioxide in well-known quantities. Another hidden fact is that carbon emissions from the industry account significantly more that resulting from burning fuels. The fact is that total carbon emissions from cement industry account for 5% of total global emissions, which far more than that resulting from burning of oil or gas in the industry's furnaces. This is what we will see in the following lines, but it is useful before doing so to take a brief overview of the history and manufacture of cement.

History of Cement

The need for adhesives to the building components such as stone and brick has emerged since the beginning of the human era by the construction of buildings. Mud was the first adhesive used for this purpose. Ancient

Egyptians discovered how to make plaster, and used it in construction. Plaster was made by heating the alabaster (gypsum) stone, which is mostly crystallized calcium sulphate $CaSO_4$ combined with water molecules, needed for its crystallization resulting in $CaSO_4.2(H_2O)$. The process of heating makes the alabaster loses its crystallization water molecules. Heated alabaster is then fine milled to produce plaster. Plaster becomes a soft adhesive, which hardens during a certain period when mixed with water. After re-combining with water, to re-crystallize and become inactive solid again.

The Romans discovered that the mixing of limestone powder with volcanic ash and water produced a cement adhesive that could harden under water. This material was called ***pozzolanic***, relative to the area where volcanic ash existed in Italy. The Romans used this material mainly to build port piers. The written works of Roman architects contain many details about the manufacture and use of this material.

Nature inspired the British engineer ***Joseph Aspdin*** with the idea of producing volcanic ash, which was not available in England, for the simple reason that there are no volcanoes there. Aspdin speculated that volcanic ash is nothing but only earthy material, which has been subjected to severe heat, and has acquired certain active properties. On this basis, Aspen heated a mixture of limestone, clay and crushed iron scraps to form a substance called ***Portland cement*** because of the similarity of the hardened cement color with the stone in the Portland area. The cement was patented in 1824 and the same name is still used today.

Manufacturing of Cement

Cement is currently manufactured with a wide range of specifications in terms of hardness, hardening time, underwater hardening properties, response to temperatures, and other variables, which do not concern us much here. In general, cement production involves burning a crushed mixture of limestone, sand, clay and gravel with the addition of other materials such as iron in rotating furnaces under a temperature of more than 1500 ° C. The high temperature results in the production a mixture of chemically active oxides of calcium, silicon, Iron, and aluminum. The mixture is afterward cooled and re-grinded. These oxides although chemically active, they do not react with each other when they are dry. However, they react immediately in the presence water, which works as an additional chemical to form highly complex very stable compounds.

Cement and Carbon Emissions

The most important part of the cement manufacturing, as far as carbon emissions are concerned, is the limestone, chemically known as calcium carbonate ($CaCO3$). Limestone is a very mechanically rigid substance, as we know it, but it decomposes at high temperatures to carbon dioxide ($CO2$) and calcium oxide (CaO), which is called lime. It is one of the most chemically active substances in cement. It is important to note that the reason behind the need to continue spraying concrete with water for several days is to provide it with the water needed to complete chemical reactions and to ensure that it does not dry. Chemical reactions halt when calcium oxide absorbs carbon dioxide from the atmosphere and converts back to limestone, which cannot react with other cement components. In such a case, the concrete loses much of its hardness. The most important thing to note here is that the process of heating limestone releases large quantities of carbon dioxide in addition to those coming from burning fuel to heat up the furnaces. In all, the production of one ton of cement generates another ton of carbon dioxide, which is released into the atmosphere. It is a fact that has made the cement industry contributes an important 5% of the global carbon dioxide emission.

Cement industries around the world are facing major challenges not only with carbon emissions but also with the industry's overall environmental impact. One of the most important of these is the major changes in landscape resulting from extraction of raw materials such as stone, clay and sand. High air pollution from dust, and metals produced by furnaces in the industry are becoming a major concern. Most countries have established significant determinants on such emissions. These determinants forced the cement industry to invest more money and research efforts to address these problems. Most current studies are directed towards the recycling of concrete resulting from the demolition of old buildings and its use as raw materials in the production of new cement. There are also studies related to reducing the amount of limestone as a raw material feed, by replacing it with other materials or by adding new raw materials that reduce the amount of carbon dioxide produced. The results of most of these studies are still considered industrial secrets, but it is unlikely that any new type of cement, or those developed from existing cement, will succeed if it does not have the same strength, rigidity, and hardening properties similar to those of current cement.

Chapter Twelve

Adventurous but Not So Crazy Ideas

The previous pages presented a number of issues related to technologies, procedures, and methods currently in place or which can be implemented in the near future, in order to reduce carbon emissions. It may be useful to write few more lines about a number of ideas, and experiments that are still in their early stages, some of which at least may one day be able to contribute in reducing dependence on fossil fuels, and reduce carbon emissions.

- **Desertec Industrial Initiative:** Most renewable energies are characterized by geographical variations beside their temporal ones. Thus, it does make good sense to try to harness those energies from places where they are abundant, and transport them to areas where they are in high demand. This summarizes in few words what ***Desertec Industrial Initiative*** is all about. Desertec is a large project created as a limited liability company under the same name in Germany in 2003. The main interest here is harnessing sustainable power from sites where renewable sources of energy are more abundant and transferring it through high-voltage direct current transmission to consumption centers. Although this interest covers all types of renewable energies, special emphasis are put on solar energy from Saharan, sub-Saharan Africa and the Middle East where sunshine is most available. Electric energy generated is transported to Europe via high voltage direct current (DC) cables. Both mirrors steam generation and photovoltaic cells type's power stations are planned. It is anticipated that such projects will be able to cover about 15% of Europe electricity demands by the year 2050 beside those of home countries where power is generated. The latter is expected to rise sharply in coming years due to improved life quality and population increases.

One of the obstacles facing such projects is related to the amounts of water needed to clean dust from surfaces of mirrors and solar panels. One of the solutions for this problem being explored is covering mirrors and solar panels by a nanotechtological thin film, which repels dust and bacteria away from these surfaces.

Other problems are of types that are more political. These are mostly related to government's instabilities in Saharan and Sub-Saharan countries and regional conflicts between them.

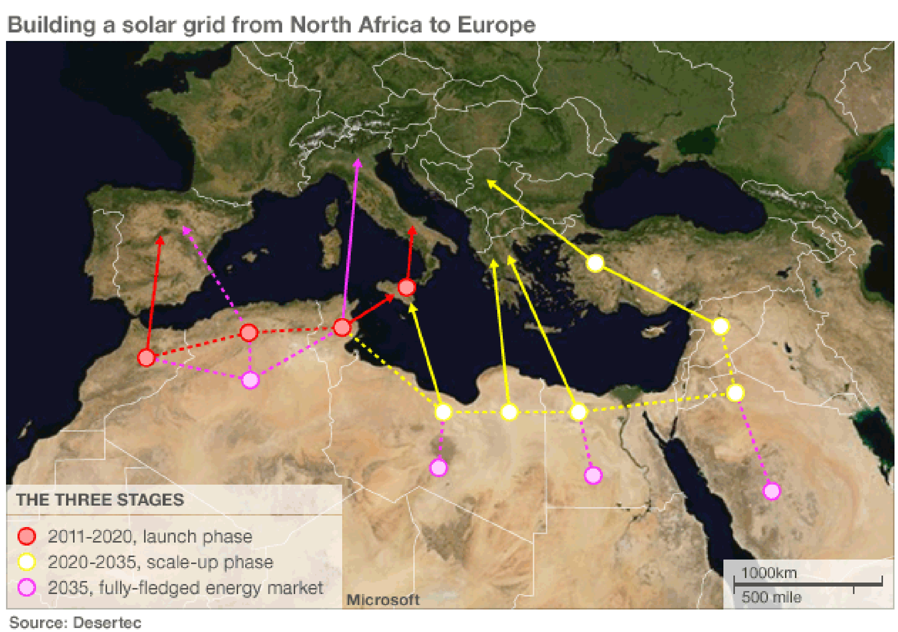

Figure (45) Map diagram of Desertec Industrial Initiative

http://peakenergy.blogspot.com/2011/12/harnessing-desert-sun-to-power-europe.html

- **Battery Banks:** Renewable energies storage still represents a bottleneck hindering the optimum exploitation of these energies. The development of Lithium-Ion batteries represented a large step forward in this respect. However, large-scale battery storage units are just beginning to emerge. One good example in this direction is the so far world largest battery bank unit built by **Tesla** in the state of South Australia for contracted value of 50 million US$. The contracted building time was 100 days. Interestingly, Tesla declared that it would give the installation to the Australian Government free, if it were not completed within the 100 days period. However, Tesla did indeed commission the project after only two months. This installation official name is ***Hornsdale Energy Reserve***. It is a 129-megawatt.hours Lithium-Ion battery pack, intended to operate in conjunction with a nearby wind farm as an electricity reservoir for times when power demand peaks or when winds are insufficient to generate enough electricity. The basic building unit of this battery bank is ***Samsung 21700*** individual small batteries of Approximate Dimensions: **70.15mm** height x **21.1mm** width, Weight: 69g. The battery bank covers approximately one hectare of land. No details on how many such small units were used to assemble the battery bank. However, using both electric capacity and overall cost calculation, the author rough estimates this number in the range of 8 - 10 millions. This battery bank can supply the grid to provide stability and prevent load-shedding blackouts while other generators are started in the event of sudden drops in wind or other network issues. This service has reduced the cost of grid services to the Australian Energy Market Operator by 90%. Other similar such projects with higher storage capacities are underway either in the planning or construction stages worldwide.

- **Nuclear fusion reactors:** These are nuclear reactor using energy released in fusion reactions of Deuterium and Tritium hydrogen isotopes. Research began on such reactors in the 1950s, but it has not yet reached a stage where they can actually produce energy. However, countries such as the United States, Russia and the European Union still allocate billions of dollars a year in their budgets for research and development of experimental reactors to achieve this goal.
- **Solar Glass**: This is a translucent glass, which is much similar to normal window glass, but with embedded solar cells that generate electricity. This will make it possible for apartments in high-rise buildings, which do not have large spaces, to install solar energy systems for this purpose. This glass exploits the invisible part of the solar spectrum for this purpose, while allowing visible light to pass through it normally. According to ***Richard Lunt***, a professor of chemical engineering, this glass can save 40% of the electricity needs in the United States.
- **Highways that charge electric vehicles batteries:** In April 2018, Sweden launched the first part of a highway where electric vehicles can charge their batteries as they travel without the need to stop. The charging mechanism depends on the presence of a metal rail connected to an electrical source. This rail is 5 cm below highway level and the vehicle can be electrically connected by dropping an electric-powered lever that electrically connects to the rail. The length of the part of the highway that was provided with this track was about two kilometers long. This highway consists of sections connected to

the source of electricity; the length of each section is 50 meters. Sweden has drawn up plans to equip its entire highway network with a total length of about half a million kilometers with such facility. The main objective of this system is to reduce the size of batteries in cars, because the car will be able to recharge batteries at short intervals, which will reduce the prices of electric cars and encourages their acquisition. The system is part of Sweden's efforts to reduce dependence on fossil fuels in the transport sector by 70% by 2030

- **Solar Highways**: These are highways and streets paved with solar panels covered with glass or transparent asphalt, which have strong mechanical properties, enabling cars and means of transport to drive on them, without casing damage. France, the Netherlands and China are currently building prototypes of these highways, about one kilometer long. They are also being furnished as intelligent roads, including computer processors, with which the various street areas communicate with one another and with the traveling vehicles. These streets are furnished with traffic lights, consisting of colored economic lamps, replacing the paints used in traffic signals, in addition to lighting the streets at night. Some experts raised concerns regarding solar highways. These concerns involve driving safety issues related to road visibility and reduced breaking friction in addition to anticipated high costs.
- **Evacuated Tube Trains (Hyperloop)**: Air resistance and friction of wheels, along the road or rail, are the most important factors limiting the speed of transportation and increase fuel consumption. These two obstacles were thought to be avoided by making air isolated vans with inside atmospheric pressure glide inside large, almost air evacuated

tubes. These vehicles float on an airbag, at very high speeds of up to 1200 kilometers per hour. This is much higher than the speed of commercial aircraft, which does not exceed 850 kilometers per hour. The idea first appeared in 2012 and quickly became the nucleus of an ambitious project to build a 560-kilometer line connecting Los Angeles and San Francisco to cover the distance in 35 minutes, at speeds of up to 1,200 kilometers per hour. There are plans to connect other US cities in this way. Another project of the same type is being planned in India to travel the 350-kilometer distance between the cities of Jinni and Benklur in half an hour. There is a similar plan in Europe to connect the 500-kilometer distance between the cities of Helsinki and Stockholm with a hyperloop line that passes under the Baltic Sea to cover the distance in 30 minutes. In addition, the United Arab Emirates has a 140-kilometer project linking the cities of Dubai and Abu Dhabi to travel that distance in just 12 minutes. According to press reports recently, Saudi Arabia is considering building a project of this kind as well.

- **Solar energy from space:** The most important hindrance to the evolution of solar energy is that it is available only in the daytime, and this availability is at the mercy of the weather. The idea of placing solar panels in space orbits around the globe, which allows them to be exposed day and night and not affected by clouds, was conceived in 1970's. Such solar panels can generate continuous electricity. The idea here is to convert this electricity to electromagnetic radiations (microwave waves) or concentrated laser beams, and transmit them wirelessly to earth, to be re-converted into electricity. This idea gained interest recently. Scientists from the United States, China, Japan, India and the United Kingdom have made progress in building technologies to send energy from space to earth. The Japanese intend to conduct the first test of such a project in 2018 by setting up a small pilot space station, with a capacity of a few kilowatts in a low earth orbit. This is to be followed by another experiment in which a 100 kW experimental station will be put into low orbit also in 2021. If these experiments are successful, Japan intends to send a 200 MW power plant to a fixed orbit by 2028. If everything goes well, Japan will put a large 1000-megawatt plant in fixed orbit around the earth each year starting in 2037.

- **Collecting Body Heat:** This may seem a bit strange, but a number of cities around the world have already begun experimenting with the accumulation of heat from human bodies in crowded subway stations by collecting hot air and using it to heat homes and nearby offices. There are currently 500 apartments, near Islengton London Underground Station, which are heated by hot air from the station. There is also a shopping mall in the United States Minnesota that uses heat from the shoppers' bodies to heat the center resulting in no need for central heating, despite the coolness of Minnesota weather.

What has been presented above represents only few ideas and innovations that governments and private enterprises take seriously, through the investments of efforts and funds to study their potentials. There are dozens, or even hundreds of other ideas, that the human mind conceives every day. These have not been addressed here; either because they do not represent a large source of energy, or that they have not yet received attention from government, companies and institutions. The human mind is daily devoid of ideas and inventions that may seem insane at the time, to emerge years later, becoming part of human life. Perhaps these ideas and inventions, which are the juice of the human mind, represent the last weapon of nature in its battle to restore the balance of the planet that the same human mind has caused it to perturb.

Appendix I

Useful Internet Websites

Facts about Earth and its Atmosphere

https://www.nationalgeographic.com/science/space/solar-system/earth/

http://nineplanets.org/earth.html

https://www.nasa.gov/topics/earth/index.html

https://space-facts.com/earth/

History of Climate Change

https://en.wikipedia.org/wiki/History_of_climate_change_science

https://skepticalscience.com/history-climate-science.html

Carbon Dioxide by Fuel Type

https://www.eia.gov/tools/faqs/faq.php?id=73&t=11

Atmospheric Carbon Dioxide Concentrations

https://www.co2.earth/monthly-co2

https://www.skepticalscience.com/print.php?r=77

https://en.wikipedia.org/wiki/Carbon_dioxide_in_Earth%27s_atmosphere

IPCC

https://www.ucsusa.org/global-warming/science-and-impacts/science/ipcc-backgrounder.html#.WrJ5PNR96XZ

Historical Variations of world Temperatures, Sea Levels and Carbon Dioxide

http://www.johnenglander.net/chart-of-420000-year-history-temperature-co2-sea-level/

Ice Core Measurements

https://www.scientificamerican.com/article/ice-core-data-help-solve/

http://www.talkorigins.org/faqs/icecores.html

World Temperatures

https://en.wikipedia.org/wiki/Global_temperature_record

NOAA Publications

https://www.ncdc.noaa.gov/news/picture-climate-how-we-can-learn-corals

Global Warming Skeptics

http://notrickszone.com/2017/09/28/update-the-2017-explosion-of-non-hockey-stick-graphs-continues/#sthash.KqZUTR8t.dpbs

The Hockey Stick Curve

https://en.wikipedia.org/wiki/Hockey_stick_graph

IPCC Reports and Publications

http://www.ipcc.ch/ipccreports/tar/wg1/index.php?idp=5

http://euanmearns.com/the-temperature-forecasting-record-of-the-ipcc/

Warm Temperatures in the middle Ages

https://en.wikipedia.org/wiki/Medieval_Warm_Period

Little Ice age

https://en.wikipedia.org/wiki/Little_Ice_Age

Climategate Investigations

https://www.scientificamerican.com/article/climategate-scientist-cleared-in-inquiry-again/

World Forests

https://en.reset.org/knowledge/forests-our-green-lungs

http://www.fao.org/news/story/en/item/326911/icode/

https://www.mnn.com/earth-matters/wilderness-resources/stories/more-trees-than-there-were-100-years-ago-its-true

http://dailycaller.com/2016/03/01/chart-of-the-day-this-chart-on-us-forest-growth-good-news-or-bad-news-for-enviros/

World Climate Summits

https://en.wikipedia.org/wiki/Earth_Summit

https://en.wikipedia.org/wiki/United_Nations_Framework_Convention_on_Climate_Change

https://en.wikipedia.org/wiki/United_Nations_Climate_Change_conference

https://ec.europa.eu/clima/policies/strategies/progress/kyoto_2_en

http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php

http://www.climatechangenews.com/2015/02/16/kyoto-protocol-10-years-of-the-worlds-first-climate-change-treaty/

World Countries Carbon Emissions

https://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions_per_capita

https://www.statista.com/statistics/270508/co2-emissions-per-capita-by-country/

http://edgar.jrc.ec.europa.eu/overview.php?v=CO2andGHG1970-2016&dst=CO2gdp

Countries Commitments to Paris Agreement

http://climateactiontracker.org/countries/russianfederation.html

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