CLEAN DEVELOPMENT MECHANISM

By

Muhammad Asif *

The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialised countries with a greenhouse gas reduction commitment, to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. A crucial feature of an approved CDM carbon project is that it has established that the planned reductions would not occur without the additional incentive provided by emission reductions credits, a concept known as "additionally".

The CDM allows net global greenhouse gas emissions to be reduced at a much lower global cost by financing emissions reduction projects in developing countries where costs are lower than in industrialized countries. However, critics argue that by allowing "business as usual" some projects emission reductions under the CDM are false or exaggerated, and in early 2007 the CDM was accused of paying □ 4.6 billion for projects that would have cost only □ 100 million if funded by development agencies.

The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the United Nations Framework Convention on Climate Change (UNFCCC).

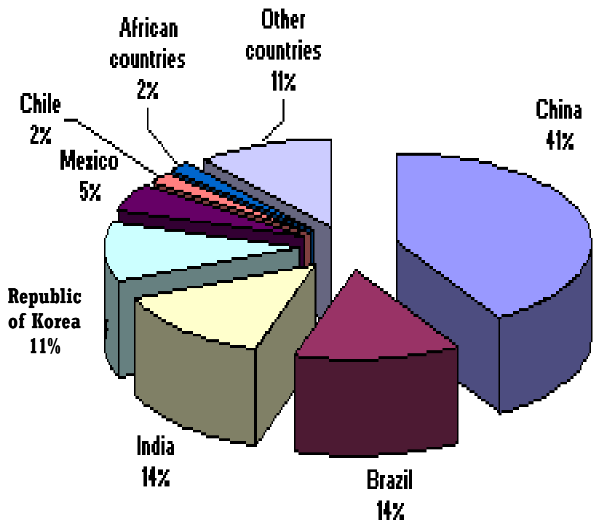

Figure 1 : Distribution of CDM Emission by Countries.

1-History and Purpose

The CDM was an important feature of the negotiations leading up to the Kyoto Protocol. Some governments desired flexibility in the way that emission reductions could be achieved and proposed international emissions trading as a way of achieving cost-effective emission reductions. At the time it was considered a controversial element and was opposed by environmental NGOs and, initially, by developing countries who felt that industrialised countries should put their own house in order first and feared the environmental integrity of the mechanism would be too hard to guarantee. Eventually, and largely on US insistence, the CDM and two other flexible mechanisms were written into the Kyoto Protocol.

The purpose of the CDM was defined under Article 12 of the Kyoto Protocol. Apart from helping countries comply with their emission reduction commitments, it must assist developing countries in achieving sustainable development, while also contributing to stabilization of greenhouse gas concentrations in the atmosphere.

To prevent industrialised countries from making unlimited use of CDM, Article 6.1 (d) has a provision that use of CDM be 'supplemental' to domestic actions to reduce emissions. This wording has led to a wide range of interpretations – the Netherlands for example aims to achieve half of their required emission reductions (from a BAU baseline) by CDM and Joint Implementation (JI)

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*Principal Chemist, Head of Chemical & Environment Section, Deputy Management Representative Environment, Kot Addu Power Company, Kot Addu.

The CDM gained momentum in 2005 after the entry into force of the Kyoto Protocol. Before the Protocol entered into force, investors considered this a key risk factor. The initial years of operation yielded fewer CDM credits than supporters had hoped for, as Parties did not provide sufficient funding to the EB (Executive Board). This left it understaffed.

2-CDM project process

·Outline of the project process.

An industrialised country that wishes to get credits from a CDM project must obtain the consent of the developing country hosting the project that it will contribute to sustainable development. Then, using methodologies approved by the CDM Executive Board (EB), the applicant (the industrialised country) must make the case that the carbon project would not have happened anyway (establishing additionality), and must establish a baseline estimating the future emissions in absence of the registered project. The case is then validated by a third party agency, called a Designated Operational Entity (DOE), to ensure the project results in real, measurable, and long-term emission reductions.

The EB then decides whether or not to register (approve) the project. If a project is registered and implemented, the EB issues credits, called Certified Emission Reductions (CERs, commonly known as carbon credits, where each unit is equivalent to the reduction of one metric tonne of CO_2e, e.g. CO_2 (or its equivalent), to project participants based on the monitored difference between the baseline and the actual emissions, verified by the DOE.

·Establishing additionality.

To avoid giving credits to projects that would have happened anyway ("freeriders"), rules have been specified to ensure additionality of the project, that is, to ensure the project reduces emissions more than would have occurred in the absence of the project. There are currently two rival interpretations of the additionality criterion:

1. What is often labelled ‘environmental additionality’ is that a project is additional if the emissions from the project are lower than the baseline. It generally looks at what would have happened without the project.

2. In the other interpretation, sometimes termed ‘project additionality’, the project must not have happened without the CDM.

A number of terms for different kinds of additionality have been discussed, leading to some confusion, particularly over the terms 'financial additionality' and 'investment additionality' which are sometimes used as synonyms. 'Investment additionality', however, was a concept discussed and ultimately rejected during negotiation of the Marrakech Accords.

Investment Additionality carried the idea that any project that surpasses a certain risk-adjusted profitability threshold would automatically be deemed non-additional. 'Financial additionality' is often defined as an economically non-viable project becoming viable as a direct result of CDM revenues.

Many investors argue that the environmental additionality interpretation would make the CDM simpler. Environmental NGOs have argued that this interpretation would open the CDM to free-riders, permitting developing countries to emit more CO_2 while failing to produce emission reductions in the CDM host countries.

It is never possible to establish with certainty what would have happened without the CDM or in absence of a particular project, which is one common objection to the CDM. Nevertheless, official guidelines have been designed to facilitate uniform assessment set by the CDM Executive Board for assessing additionality.

·Establishing a baseline

The amount of emission reduction, obviously, depends on the emissions that would have occurred without the project minus the emissions of the project. The construction of such a hypothetical scenario is known as the baseline of the project. The baseline may be estimated through reference to emissions from similar activities and technologies in the same country or other countries, or to actual emissions prior to project implementation. The partners involved in the project could have an interest in establishing a baseline with high emissions, which would yield a risk of awarding spurious credits. Independent third party verification is meant to ameliorate this potential problem.

3-Financial issues

With costs of emission reduction typically much lower in developing countries than in industrialised countries, industrialised countries can comply with their emission reduction targets at much lower cost by receiving credits for emissions reduced in developing countries as long as administration costs are low. However, many CDM projects have led to excessive profits.

The IPCC has projected GDP losses for OECD Europe with full use of CDM and Joint Implementation to between 0.13 % and 0.81 % of GDP versus 0.31 % to 1.50 % with only domestic action.

While there would always be some cheap domestic emission reductions available in Europe, the cost of switching from coal to gas could be in the order of □40-50 per tonne CO_2 equivalent. CERs from CDM projects were in 2006 traded on a forward basis for between □5 and □ 20 per tonne CO_2 equivalent.

The price depends on the distribution of risk between seller and buyer. The seller could get a very good price if it agrees to bear the risk that the project's baseline and monitoring methodology is rejected; that the host country rejects the project; that the CDM Executive Board rejects the project; that the project for some reason produces fewer credits than planned; or that the buyer doesn't get CERs at the agreed time if the international transaction log is not in place by then. These risks the seller can usually only take if it is a very reliable counterparty rated by international rating agencies.

4-Concerns

·Exclusion of forest conservation/avoided deforestation from the CDM

The first commitment period of the Kyoto Protocol excluded forest conservation/avoided deforestation from the CDM for a variety of political, practical and ethical reasons. However, carbon emissions from deforestation represent 18 % - 25 % of all emissions, and will account for more carbon emissions in the next five years than all emissions from all aircraft since the Wright Brothers until at least 2025.

This means that there have been growing calls for the inclusion of forests in CDM schemes for the second commitment period from a variety of sectors, under the leadership of the Coalition for Rainforest Nations, and brought together under the Forests New Declaration, which has been signed by over 300 NGOs, business leaders, and policy makers.

·The risk of false credits

As the CDM is an alternative to domestic emission reductions, the perfectly working CDM would produce no more and no less greenhouse gas emission reductions than without use of the CDM. However, it was recognized from the beginning that if projects that would have happened anyway are registered as CDM projects, then the net effect is an increase of global emissions as those "spurious" credits will be used to allow higher domestic emissions without reducing emissions in the developing country hosting the CDM project. Similarly, spurious credits may be awarded through overstated baselines, causing the same problem. Such a rejection is termed a "false positive".

On the other hand, if a project is rejected because the criteria are set too high, there will be missed opportunities for emission reductions. Such a rejection is termed a "false negative". For example, if it costs $75 to remove just one tonne from a domestic power station in a developed country, while the same money would reduce 37.5 tonnes of emissions through a genuinely additional CDM project in China, it is important that the validation process does not become so bureaucratic or onerous as to dissuade the more effective option. Some observers report that the CDM process is producing far more of these false negatives than false positives.

NGOs have criticized the inclusion of large hydropower projects, which they consider unsustainable, as CDM projects. Other concerns are the lack of renewable energy CDM projects and the inclusion of sinks as CDM projects.

Negotiators have not yet been able to agree on whether, or how, carbon capture and storage projects should be allowed under the CDM. They are also discussing how to reduce as much Hydrofluorocarbon (HFC) emissions as possible under the CDM without creating a perverse incentive to build more HCFC-22 production facilities just to get the revenues from selling CDM credits. If this were to happen, developing countries' obligations to stabilise (2016) and phase out (2040) HCFC-22 would be in jeopardy.

In response to concerns of unsustainable projects or spurious credits, the World Wide Fund for Nature and other NGOs devised a ‘Gold Standard’ methodology to certify projects that uses much stricter criteria than required, such as allowing only renewable energy projects.

The NGO CDM Watch argues that a majority of the CDM projects so far (2005) would have happened anyway, referring among other reasons to project activities completed before final approval as CDM projects, and arguing that these would be viable without the CDM financing, and, therefore, non-additional.

For example, a South African brick kiln was faced with a business decision; replace its depleted energy supply with coal from a new mine, or build a difficult but cleaner natural gas pipeline to another country. They chose to build the pipeline with SASOL. SASOL claimed the difference in GHG emissions as a CDM credit, comparing emissions from the pipeline to the contemplated coal mine. During its approval process, the validators noted that changing the supply from coal to gas met the CDM's 'additionality' criteria and was the least cost-effective option. However, there were unofficial reports that the fuel change was going to take place anyway, although this was later denied by the company's press office.

·Excessive payments for emission reductions.

In early 2007 an issue that had by then already been known for a while erupted in major media. A study published in Nature found that a major class of CDM project paid as much as 50 times more for the emission reductions than the costs alone would warrant, with the excessive profits ending up with the factories and the carbon traders.

The particular kind of CDM projects in question regard refrigerant-producing factories in countries (particularly China) that generate the powerful greenhouse gas HFC 23 as a by-product. By destroying the HFCs, the factories can earn CER credits. Destroying the HFCs requires a simple and relatively cheap piece of equipment called a scrubber; the author argues it would cost only □100 million to pay producers to capture and destroy HFC 23 compared with □4.6 billion in CDM credits.

While this is still cheaper than the typical cost of reducing emissions in industrialised countries, it is seen as a major loophole in the carbon trading system and undermines the tenet of emission trading being as a cost-effective tool for reducing emissions. Also, "HFC 23 emitters can earn almost twice as much from the CDM credits as they can from selling refrigerant gases – by any measure a major distortion of the market," writes the author.

In response, Halldor Thorgeirsson, Director of sustainable development mechanisms at the UNFCCC claims: "The idea of easy money is out of proportion." And he says the loophole is now closed and that new HFC 23 facilities will no longer be eligible for CDM credits.

5-Cdm Project To Date

Distribution of CDM emission reductions, by project type. As of 2nd November 2007,828 projects have been registered by the CDM Executive Board as CDM projects. These projects reduce greenhouse gas emissions by an estimated 171 million ton CO_2 equivalent per year. These are about 2,600 projects in the pipeline (most of which not yet registered) would until the end of 2012 produce over 2.5 billion tons CO_2 equivalent reductions.

For comparion: the current emissions of the EU-15 are about 4.2 billion ton CO_2 equivalent per year of the registered projects in the current pipeline, the majority of CERs have been from HFC destruction projects, a loophole in the CDM.

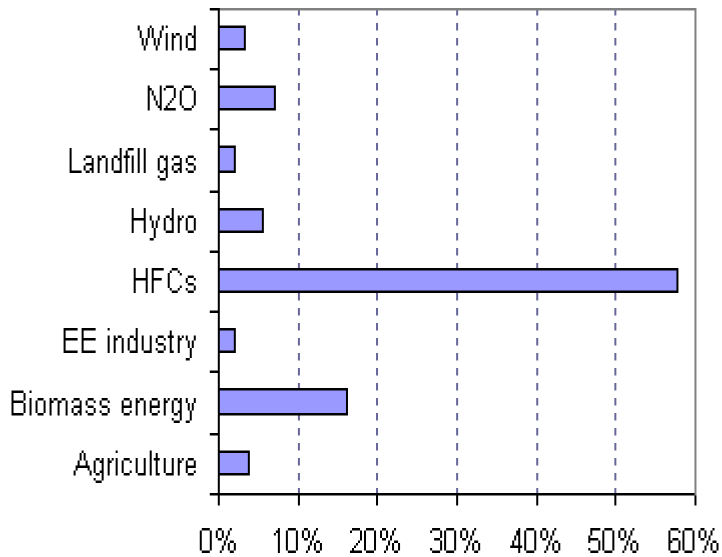


Figure 2 : Distribution of CDM Emission
by Project Type.

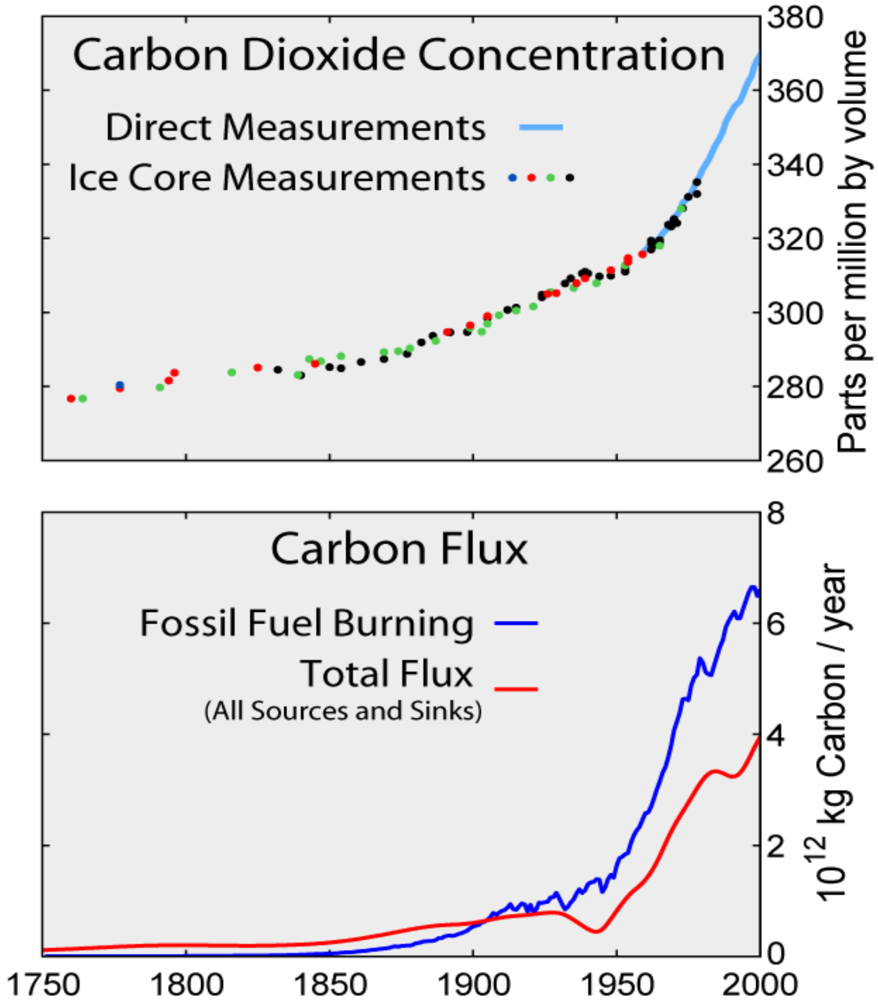
1- Greenhouse gas

Greenhouse gases are the gases present in the atmosphere which increase heat into space and, therefore, contribute to global temperatures through the greenhouse effect.

Greenhouse gases are essential to maintaining the temperature of the Earth; without them the planet would be so cold as to be uninhabitable.

However, an excess of greenhouse gases can raise the temperature of a planet to lethal levels, as on Venus where the 96.5% carbon dioxide (CO_2) atmosphere results in surface temperatures of about 467 °C (872 °F). Greenhouse gases are produced by many natural and industrial processes, which currently result in CO_2 levels of 380 ppmv in the atmosphere.

Based on ice-core samples and records (see graphs) current levels of CO_2 are approximately 100 ppmv higher than during immediately pre-industrial times, when direct human influence was negligible.



·The "Greenhouse Effect"

Pattern of absorption bands created by greenhouse gases in the atmosphere and their effect on both solar radiation and upgoing thermal radiation

When sunlight reaches the surface of the Earth, some of it is absorbed and warms the surface. Because the Earth's surface is much cooler than the sun, it radiates energy at much longer wavelengths than the sun does, peaking in the infrared at about 10 µm. The atmosphere absorbs these longer wavelengths more effectively than it does the shorter wavelengths from the sun. The absorption of this longwave radiant energy warms the atmosphere; the atmosphere is also warmed by transfer of sensible and latent heat from the surface. Greenhouse gases also emit longwave radiation both upward to space and downward to the surface. The downward part of this longwave radiation emitted by the atmosphere is the "greenhouse effect". The term is a misnomer though, as this process is not the mechanism that warms greenhouses.

On earth, the most abundant greenhouse gases are, in order of relative abundance:

- water vapor
- carbon dioxide
- methane
- nitrous oxide
- ozone

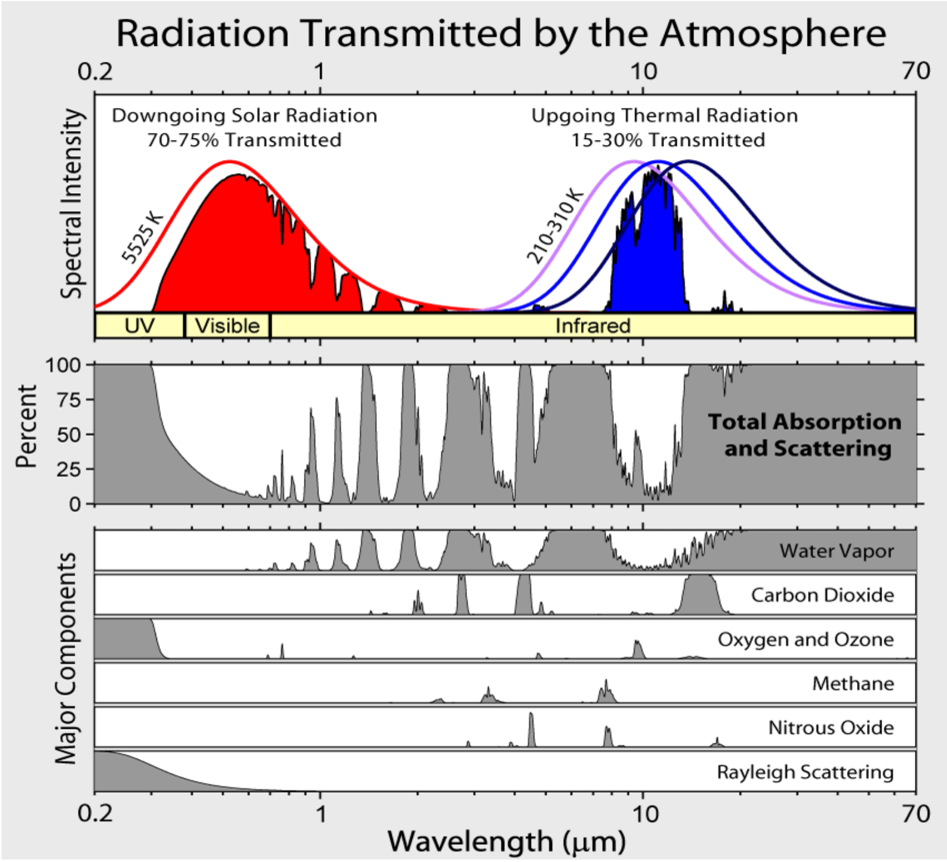
CFCs
The most powerful greenhouse gases are

- water vapor, which causes about 36% – 70% of the greenhouse effect on Earth. (Note clouds typically affect climate differently from other forms of atmospheric water.)
- carbon dioxide, which causes 9% – 26%
- methane, which causes 4% – 9%
- ozone, which causes 3% – 7%

It is not possible to state that a certain gas causes a certain percentage of the greenhouse effect, because the influences of the various gases are not additive. (The higher ends of the ranges quoted are for the gas alone; the lower ends, for the gas counting overlaps.)Other greenhouse gases include, but are not limited to, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons and chlorofluorocarbons

The major atmospheric constituents (nitrogen, N_2 and oxygen, O_2) are not greenhouse gases. This is because homonuclear diatomic molecules such as N_2 and O_2 neither absorb nor emit infrared radiation, as there is no net change in the dipole moment of these molecules when they vibrate. Molecular vibrations occur at energies that are of the same magnitude as the energy of the photons on infrared light. Heteronuclear diatomics such as CO or HCl absorb IR; however, these molecules are short-lived in the atmosphere owing to their reactivity and solubility. As a consequence they do not contribute significantly to the greenhouse effect.

Late 19th century scientists experimentally discovered that N_2 and O_2 did not absorb infrared radiation (called, at that time, "dark radiation") and that CO_2 and many other gases did absorb such radiation. It was recognized in the early 20th century that the known major greenhouse gases in the atmosphere caused the earth's temperature to be higher than it would have been without the greenhouse gases.



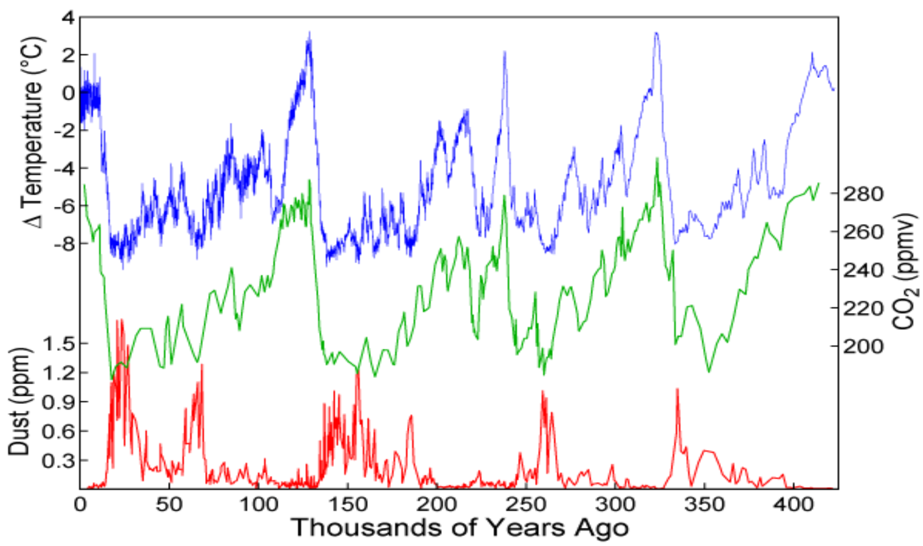
·Natural and anthropogenic.
Most greenhouse gases have both natural and anthropogenic sources. During the pre-industrial holocene, concentrations of these gases were roughly constant. Since the industrial revolution, concentrations of all the long-lived greenhouse gases have increased due to human actions.

Gas	Preindustrial Level	Current Level	Increase since 1750	Radiative forcing (Wm2)
Carbon dioxide	280 ppm	384ppm	104 ppm	1.46
Methane	700 ppb	1,745 ppb	1,045 ppb	0.48
Nitrous oxide	270 ppb	314 ppb	44 ppb	0.15
CFC-12	0	533 ppt	533 ppt	0.17

Ice cores provide evidence for variation in greenhouse gas concentrations over the past 800,000 years. Both CO_2 and CH_4 vary between glacial and interglacial phases, and concentrations of these gases correlate strongly with temperature. Before the ice core record, direct measurements do not exist. Various proxies and modelling suggests large variations; 500 Myr ago CO_2 levels were likely 10 times higher than now. Indeed higher CO_2 concentrations are thought to have prevailed throughout most of the Phanerozoic eon, with concentrations four to six times current concentrations during the Mesozoic era, and ten to fifteen times current concentrations during the early Palaeozoic era until the middle of the Devonian period, about 400 Mya. The spread of land plants is thought to have reduced CO_2 concentrations during the late Devonian, and plant activities as both sources and sinks of CO_2 have since been important in providing stabilising feedbacks.

Earlier still, a 200-million year period of intermittent, widespread glaciation extending close to the equator (Snowball Earth) appears to have been ended suddenly, about 550 Mya, by a colossal volcanic out gassing which raised the CO_2 concentration of the atmosphere abruptly to 12%, about 350 times modern levels, causing extreme greenhouse conditions and carbonate deposition as limestone at the rate of about 1mm per day.

This episode marked the close of the Precambrian eon, and was succeeded by the generally warmer conditions of the Phanerozoic, during which multicellular animal and plant life evolved. No volcanic carbon dioxide emission of comparable scale has occurred since. In the modern era, emissions to the atmosphere from volcanoes are only about 1% of emissions from human sources.



-Anthropogenic greenhouse gases

Since about 1750 human activity has increased the concentration of carbon dioxide and of some other important greenhouse gases. Natural sources of carbon dioxide are more than 20 times greater than sources due to human activity, but over periods longer than a few years natural sources are closely balanced by natural sinks such as weathering of continental rocks and photosynthesis of carbon compounds by plants and marine plankton. As a result of this balance, the atmospheric concentration of carbon dioxide remained between 260 and 280 parts per million for the 10,000 years between the end of the last glacial maximum and the start of the industrial era.

Some of the main sources of greenhouse gases due to human activity include:

•Burning of fossil fuels and deforestation leading to higher carbon dioxide concentrations. Deforestation (mainly in tropical areas) accounts for up to one-third of total anthropogenic CO_2 emissions.

•livestock enteric fermentation and manure management, paddy rice farming, land use and wetland changes, pipeline losses, and covered vented landfill emissions leading to higher methane atmospheric concentrations. Many of the newer style fully vented septic systems that enhance and target the fermentation process also are sources of atmospheric methane.

•Use of chlorofluorocarbons (CFCs) in refrigeration systems, and use of CFCs and halons in fire suppression systems and manufacturing processes.

•Agricultural activities, including the use of fertilizers, that lead to higher nitrous oxide concentrations.

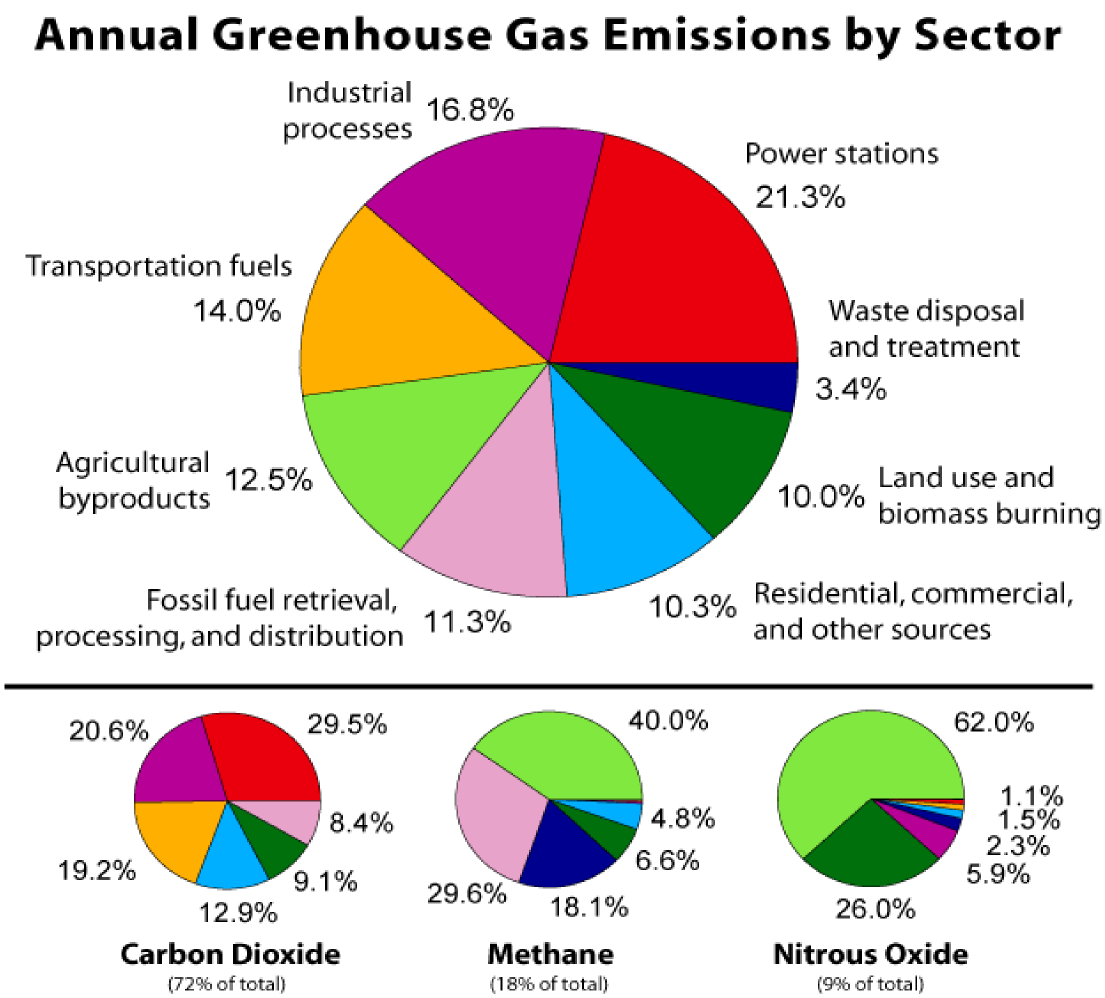
The seven sources of CO_2 from fossil fuel combustion are (with percentage contributions for 2000–2004):

1. Solid fuels (e.g. coal): 35%
2. Liquid fuels (e.g. gasoline): 36%
3. Gaseous fuels (e.g. natural gas): 20%
4. Flaring gas industrially and at wells: <1%
5. Cement production: 3%
6. Non-fuel hydrocarbons: <1%
7. The "international bunkers" of shipping and air transport not included in national inventories: 4%

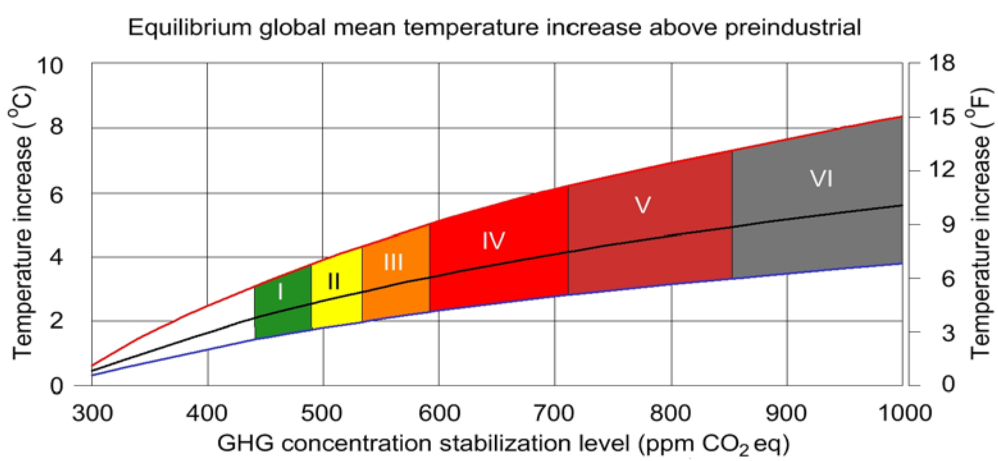
The U.S. EPA ranks the major greenhouse gas contributing end-user sectors in the following order: industrial, transportation, residential, commercial and agricultural. Major sources of an individual's GHG include home heating and cooling, electricity consumption, and transportation. Corresponding conservation measures are improving home building insulation, compact fluorescent lamps and choosing energy-efficient vehicles.

Carbon dioxide, methane, nitrous oxide and three groups of fluorinated gases (sulfur hexafluoride, HFCs, and PFCs) are the major greenhouse gases and the subject of the Kyoto Protocol, which came into force in 2005.

Although CFCs are greenhouse gases, they are regulated by the Montreal Protocol, which was motivated by CFCs' contribution to ozone depletion rather than by their contribution to global warming. Note that ozone depletion has only a minor role in greenhouse warming though the two processes often are confused in the media.



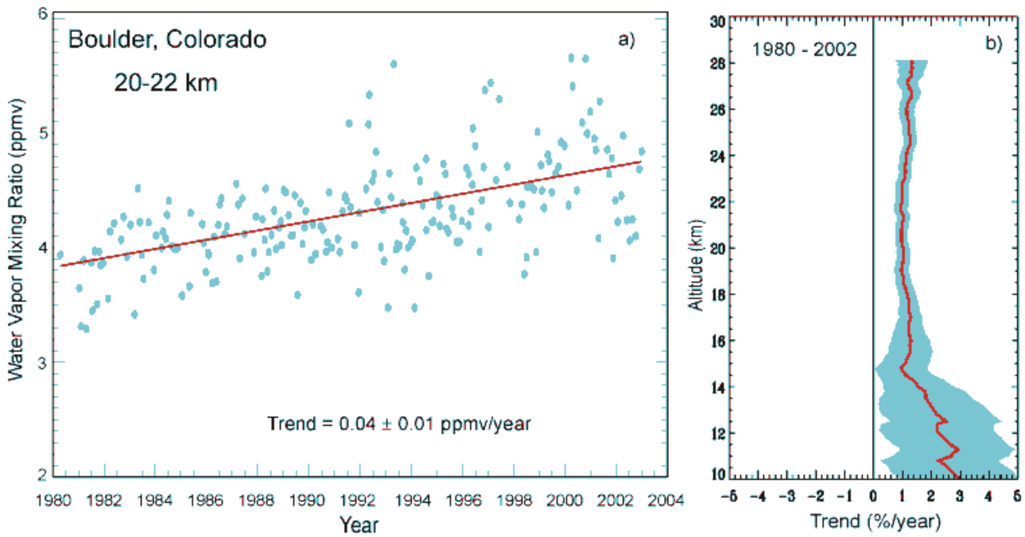
Global anthropogenic greenhouse gas emissions broken down into 8 different sectors for the year 2000.



-The role of water vapor
Increasing water vapor at Boulder, Colorado.

Water vapor is a naturally occurring greenhouse gas and accounts for the largest percentage of the greenhouse effect, between 36% and 66%. Water vapor concentrations fluctuate regionally, but human activity does not directly affect water vapor concentrations except at local scales (for example, near irrigated fields).

The Clausius-Clapeyron relation establishes that warmer air can hold more water vapor per unit volume. Current state-of-the-art climate models predict that increasing water vapor concentrations in warmer air will amplify the greenhouse effect created by anthropogenic greenhouse gases while maintaining nearly constant relative humidity. Thus water vapor acts as a positive feedback to the forcing provided by greenhouse gases such as CO_2.



·Greenhouse gas emissions

Measurements from Antarctic ice cores show that just before industrial emissions started, atmospheric CO_2 levels were about 280 parts per million by volume (ppm; the units µ L / L are occasionally used and are identical to parts per million by volume). From the same ice cores it appears that CO_2 concentrations stayed between 260 and 280 ppm during the preceding 10,000 years. Studies using evidence from stomata of fossilized leaves suggest greater variability, with CO_2 levels above 300 ppm during the period 7,000–10,000 years ago, though others have argued that these findings more likely reflect calibration/contamination problems rather than actual CO_2 variability.

Since the beginning of the Industrial Revolution, the concentrations of many of the greenhouse gases have increased. The concentration of CO_2 has increased by about 100 ppm (i.e., from 280 ppm to 380 ppm). The first 50 ppm increase took place in about 200 years, from the start of the Industrial Revolution to around 1973; the next 50 ppm increase took place in about 33 years, from 1973 to 2006. Many observations are available online in a variety of Atmospheric Chemistry Observational Databases. The greenhouse gases with the largest radiative forcing are

Relevant to radiative forcing				
Gas	**Current (1998) Amount by volume**	**Increase over pre-industrial (1750)**	**Percentage increase**	**Radiative forcing (W/m²)**
Carbon dioxide	365 ppm {383 ppm(2007.01)}	87 ppm {105 ppm(2007.01)}	31% {37.77%(2007.01)}	1.46 {~1.532 (2007.01)}
Methane	1,745 ppb	1,045 ppb	150%	0.48
Nitrous oxide	314 ppb	44 ppb	16%	0.15

Global anthropogenic Carbon emissions 1751–2004.

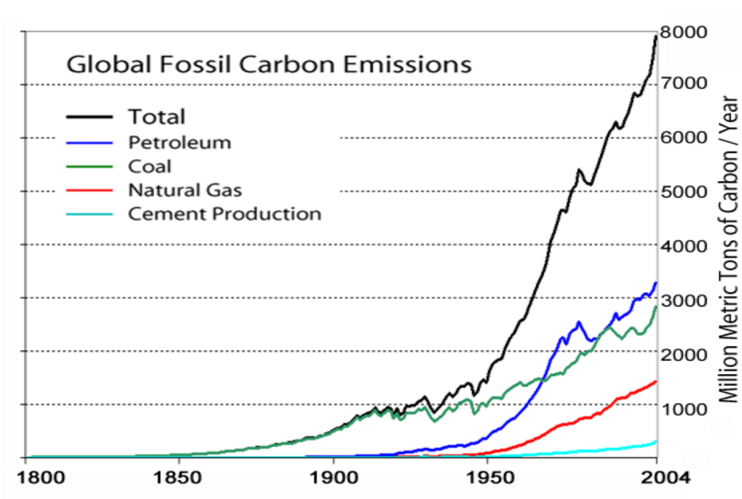
Relevant to both radiative forcing and ozone depletion; all of the following have no natural sources and hence zero amounts pre-industrial		
Gas	**Current (1998) Amount by volume**	**Radiative forcing (W/m^2)**
CFC-11	268 ppt	0.07
CFC-12	533 ppt	0.17
CFC-113	84 ppt	0.03
Carbon tetrachloride	102 ppt	0.01
HCFC-22	69 ppt	0.03

·Recent rates of change and emission
Greenhouse gas intensity in 2000 including land-use change

The sharp acceleration in CO_2 emissions since 2000 of >3% y–1 (>2 ppm y–1) from 1.1% y–1 during the 1990s is attributable to the lapse of formerly declining trends in carbon intensity of both developing and developed nations. Although over 3/4 of cumulative anthropogenic CO_2 is still attributable to the developed world, China was responsible for most of global growth in emissions during this period. Localised plummeting emissions associated with the collapse of the Soviet Union have been followed by slow emissions growth in this region due to more efficient energy use, made necessary by the increasing proportion of it that is exported.In comparison, methane has not increased appreciably, and N_2O by 0.25% y–1.

·Asia
Atmospheric levels of the main greenhouse gas have set another new peak in a sign of the industrial rise of Asian economies led by China. Over the 2000-2010 interval China is expected to increase its carbon emissions by 600 MT, largely because of the rapid construction of old-fashioned power plants in poorer internal provinces.

·United States
The United States emitted 16.3% more GHG in 2005 than it did in 1990. According to a preliminary estimate by the Netherlands Environmental Assessment Agency, the largest national producer of CO_2 emissions since 2006 has been China with an estimated annual production of about 6200 megatonnes. It is followed by the United States with about 5,800 megatonnes. Relative to 2005, China's fossil CO_2 emissions increased in 2006 by 8.7%, while in the USA, comparable CO_2 emissions decreased in 2006 by 1.4%. The agency notes that its estimates do not include some CO_2 sources of uncertain magnitude. Although these tonnages are small compared to the CO_2 in the Earth's atmosphere, they are significantly larger than pre-industrial levels.



·Removal from the atmosphere and global warming potential
Aside from water vapor, which has a residence time of days, most greenhouse gases take many years to leave the atmosphere. Although it is not easy to know with precision how long it takes greenhouse gases to leave the atmosphere, there are estimates for the principal greenhouse gases.

Greenhouse gases can be removed from the atmosphere by various processes:

- As a consequence of a physical change (condensation and precipitation remove water vapor from the atmosphere).
- As a consequence of chemical reactions within the atmosphere. This is the case for methane. It is oxidized by reaction with naturally occurring hydroxyl radical, OH· and degraded to CO_2 and water vapor at the end of a chain of reactions (the contribution of the CO_2 from the oxidation of methane is not included in the methane Global warming potential). This also includes solution and solid phase chemistry occurring in atmospheric aerosols.
- As a consequence of a physical interchange at the interface between the atmosphere and the other compartments of the planet. An example is the mixing of atmospheric gases into the oceans at the boundary layer.
- As a consequence of a chemical change at the interface between the atmosphere and the other compartments of the planet. This is the case for CO_2, which is reduced by photosynthesis of plants, and which, after dissolving in the oceans, reacts to form carbonic acid and bicarbonate and carbonate ions as a consequence of a photochemical change. Halocarbons are dissociated by UV light releasing Cl· and F· as free radicals in the stratosphere with harmful effects on ozone (halocarbons are generally too stable to disappear by chemical reaction in the atmosphere).
- As a consequence of dissociative ionization caused by high energy cosmic rays or lightning discharges, which break molecular bonds. For example, lightning forms N anions from N_2 which then react with O_2 to form NO_2.

Per capita responsibility for current anthropogenic atmospheric CO

·Atmospheric lifetime
The parameter atmospheric lifetime describes how long it takes to restore the system to equilibrium following an increase in the concentration of a greenhouse gas in the atmosphere. Individual molecules may be exchanged with sinks such as the soil, the oceans, vegetation and other biological systems, reducing the excess to background concentrations, and the average time taken to achieve this is the mean lifetime.

The atmospheric lifetime of CO_2 is often incorrectly stated to be only a few years because that is the average time for any CO_2 molecule to stay in the atmosphere before being removed by mixing into the ocean, uptake by photosynthesis, or other processes.

However, this ignores the balancing fluxes of CO_2 into the atmosphere from the other reservoirs. It is the net concentration changes of the various greenhouse gases by all sources and sinks that determines atmospheric lifetime, not just the removal processes.

Examples of the atmospheric lifetime and GWP (Global Warming Potential) for several greenhouse gases include:

- **CO_2** has a variable atmospheric lifetime, and cannot be specified precisely.Recent work indicates that recovery from a large input of atmospheric CO_2 from burning fossil fuels will result in an effective lifetime of tens of thousands of years.Carbon dioxide is defined to have a GWP of 1 over all time periods.
- **Methane** has an atmospheric lifetime of 12 ± 3 years and a GWP of 62 over 20 years, 23 over 100 years and 7 over 500 years. The decrease in GWP associated with longer times is associated with the fact that the methane is degraded to water and CO_2 by chemical reactions in the atmosphere.

- **Nitrous oxide** has an atmospheric lifetime of 120 years and a GWP of 296 over 100 years.
- **CFC-**12 has an atmospheric lifetime of 100 years and a GWP of 10600 over 100 years.
- **HCFC-22** has an atmospheric lifetime of 12.1 years and a GWP of 1700 over 100 years.
- **Tetrafluoromethane** has an atmospheric lifetime of 50,000 years and a GWP of 5700 over 100 years.
- **Sulfur hexafluoride** has an atmospheric lifetime of 3,200 years and a GWP of 22000 over 100 years.

·Airborne fraction

Airborne fraction (AF) is the proportion of a GHG emission (usually CO_2) remaining in the atmosphere after a specified time. Canadell (2007) define the annual AF as the ratio of the atmospheric CO_2 increase in a given year to that year's total emissions, and calculate that of the average 9.1 PgC y-1 of total anthropogenic emissions from 2000 to 2006, the AF was 0.45. For CO_2 the AF over the last 50 years (1956-2006) has been increasing at 0.25±0.21%/year.

·Global warming potential

The global warming potential (GWP) depends on both the efficiency of the molecule as a greenhouse gas and its atmospheric lifetime. GWP is measured relative to the same mass of CO_2 and evaluated for a specific timescale. Thus, if a molecule has a high GWP on a short time scale (say 20 years) but has only a short lifetime, it will have a large GWP on a 20 year scale but a small one on a 100 year scale. Conversely, if a molecule has a longer atmospheric lifetime than CO_2 its GWP will increase with time.

·Related Effects

Carbon monoxide has an indirect radioactive effect by elevating concentrations of methane and tropospheric ozone through scavenging of atmospheric constituents that would otherwise destroy them. Carbon monoxide is created when carbon-containing fuels are burned incompletely. Through natural processes in the atmosphere, it is eventually oxidized to carbon dioxide. Carbon monoxide has an atmospheric lifetime of only a few months and as a consequence is spatially more variable than longer-lived gases.

Another potentially important indirect effect comes from methane, which in addition to its direct radioactive impact also contributes to ozone formation. Shindell et al (2005) argue that the contribution to climate change from methane is at least double previous.

HYDEL POWER GENERATION – A LOW CARBON ENERGY PROSPECT FOR PROSPEROUS PAKISTAN

By

Dr. Allah Bakhsh Sufi[1], A. Dastgir[2] and Zahid-ul-Haq[3]

ABSTRACT

The global electricity industry is still dominated by big fossil fuel-fired utilities. They account for 67% of all electricity generation worldwide. It is expected that big coal or gas power plants will still provide half of all new generating capacity coming on line by 2030. The worldwide share of the total hydel power generation is 19% of the total bulk. The share of hydel power in power generation contribution of Pakistan is 33% with installed capacity of 6595 MW of hydel energy. We will still have to explore many horizons to exploit the hydel potential of approx. 41722 MW. The share of thermal power in Pakistan is 65% which is slightly less than world percentage. It is known fact that thermal powers plant emissions are responsible for a considerable amount of nitrogen oxide, sulphur dioxide and carbon dioxide emissions globally. The energy from fossil fuels is costly and rising fuel costs and climate worries are making government to boost an environmental friendly policy. The renewable energy resources can avoid or reduce these carbon emissions, as well as reduce thermal pollution waste, noise and adverse land use impacts. In renewable energy sources, solar, wind, biomass and traditional hydel energy are included. To combat global warming and other problems associated with fossil fuels we must switch to renewable energy resources. All renewable energy technologies are not appropriate to all applications or locations. As far as Pakistan is concerned, wind energy Production is limited along sparsely populated coastal areas: solar energy systems are not cost-effective; biomass fuels are controversial because of food crises. The best option for Pakistan is to kick start a habit of low CO_2 emission through environment friendly hydel power production to its maximum sustainable generation. This cost effective energy production is the order of the day. We need to exploit our vistas of small hydro, micro hydro, low-head hydro, pumped storage hydro, run-of-the-river and major Dams hydro units to fulfill approx. 43000 MW energy needs for Pakistan in 2018. To reduce CO_2 emissions to take stock of the future environmental degradation, and to get rid of load shedding, it is the only viable sustainable and judicious option to the country.

INTRODUCTION

It is hard to fight the tendency to make a problem go away by pretending it is not there or perhaps, accommodating to a bad situation rather than trying to change it. Those who knew of limit to our natural reserves of oil and gas had long warned that there would be an end to the era of abundant, cheap energy. The concept of energy crisis is rather forty year old. The amounts of oil, gas, coal and uranium are in the earth are finite. Furthermore, in recent past, the gap between aspirations and possibilities is worsened by the prospect of an absolute limit to the use and environmental costs of energy and resources. Burning oil and gas, like coal, inevitably produces carbon dioxide, which is vented to the atmosphere. For the past 73 years, we have known that the burning of fossil fuels over the past century has increased the amount of CO_2 the air. Other aspects of the earth's environment are changing for the worse, many people assume – in response to all of the production, refining, transport, deforestation and burning of fossil fuels. These changes are mainly global in nature like CO_2 production. In the century and half since 1850, human activities have increased the amount of CO_2 in the atmosphere of the earth from 290 ppm or less to more than to present 380 ppm. Perhaps a major total increase has come within the past decade. By the year "2020" if present trends remain continued, the amount of CO_2 in atmosphere could approach to alarming level – until recently the increase was commonly attributed to the burning of fossil fuels. Now there is evidence that it may be due in

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. Chief Engineer (Water Resources Planning), Planning Division, WAPDA.
2. Research Officer (Ecology), WAPDA Environmental Cell.
3. Director, WAPDA Environmental Cell, WAPDA.

equal degree to another source i.e. the worldwide destruction of forests i.e. the unprecedented cutting of forest in Indonesia and Brazil has put them in top ten culprits of CO_2 contribution on global level.

Although CO_2 is only a trace gas in the atmosphere of the earth; present at a concentration of about 0.038% by volume, it plays a possibly critical role in controlling climate of the earth because it absorbs radiant energy in infrared wavelengths. The energy trapped in this way has a large potential for altering the world climate substantially. The human activities that are increasing the carbon dioxide content of the atmosphere promise to bring a drastic warming of the climate which is already evident.

The most obvious corrective action would be a major reduction in the consumption of fossil fuels.

The atmosphere holds at present about 765 x 10^{15} grams of carbon in the form of CO_2 release worldwide by the combustion of fossil fuels is about 7 x 10^{15} grams of carbon per year. Human activities add 5.4 billion tones of CO_2 into atmosphere in each year. The amount of CO_2 added in 1975 in atmosphere was 5 x 10^{15} grams per year, out of which 3.3 x 10^{15} grams add to the carbon contents of the atmosphere while 1.7x 10^{15} grams of fossil fuel carbon is removed by some terrestrial and oceanic processes. Fossil fuels are the major contributors but all in all 13 x 10^{15} grams carbon per year is released into atmosphere from all sources and only 3.3 x 10^{15} grams per year accumulates into the atmosphere. The major source of accumulation is fossil fuels even if they are not the major source of contribution (Table-1).

TABLE-1: Review of Air Pollution from Fossil Fuels

Global Climate Change	**Fossil fuel responsible for effect noted**
- Carbon dioxide (CO_2)	Coal burning produces more CO_2 than petroleum, which produces more than natural gas.
- Methane (CH_4)	Methane primarily arises from coal and petroleum recovery and natural gas pipeline leaks.
Acid Deposition	
Sulfur dioxide (SO_2)	SO_2 is emitted is especially high amounts by coal-burning facilities, and to lessen extents by burning oil and natural gas.
Nitrogen oxide (NO_2)	NO_2 forms a reaction between nitrogen and oxygen during high temperature combustion. In urban areas motor vehicles are major source of NO_2 power plants are also important.
Carbon monoxide CO	CO is product of incomplete combustion (due to lack of O_2). In urban areas upto 90% is from gasoline combustion.
Ozone (O_3)	O_3 is not emitted as O_3 but forms from other pollutants. Motor vehicles are major source of NO_x and VOC_x which lead to O_3.
Presentation	Coal burning is a source of particulates so is oil burning. ▪ Metals are emitted as particulates (except element mercury). ▪ The particulate carbon soot, results from incomplete combustion.
VOCs Hydrocarbons	Hydrocarbons are major volatile organic compounds VOC, emitted from gasoline burning.
Eutrophication	
Nitrogen oxide (NO_2)	Fertilizer is the source of fixed nitrogen but motor vehicles contribute increasing amounts.

Ultimately fossil fuels contribution adds more towards global warming than any other single factor. The potential associated with a steady increase in CO_2 content of the atmosphere (Table-2)

TABLE-2: Increasing Concentration of Atmospheric Greenhouse Gases

Parameter	Historic Level	Current Level	Warming Potential Compared to CO_2	Lifetime in Year
Carbon dioxide (CO_2)	280 ppm	380 ppm	1	5-200
Methane (CH_4)	700 ppb	1720 ppb	23	12
Nitrous oxide (N_2O)	275 ppb	314 ppb	300	114
Chlorofluorocarbons (CFCs) and related chemicals.	0	PPt level	4000-8000	**Lifetime in Year** Day & Week 5-100
Perfluoromethane PFM	40 ppt	80 ppt	5700	50,000
Sulfur hexafluoride (SF_6)	0.01 ppt	3 ppt	22000	3200

Is looming large presently and doubtless it is bearing heavily on such decisions as whether to accelerate the development of power plants based on renewable energy sources instead of those based on coal, gas and oil. Whether, to preserve forest areas instead of encroaching on them. There is also no aspect of national and international policy that has remained unaffected by the prospect of global climate change. CO_2 until now, which was an apparently innocuous trace gas into the atmosphere, is moving rapidly towards a central role as a major threat to the present world order.

The energy sector is a lifeline for any economy. The provision of environment friendly energy source is order of the day. Coal burning, electric power plants are major CO_2 sources in many countries from USA to China to India. The coal, the major culprit is abundant and cheap when compare with oil and natural gas, provides over 80% of China's and 50% of USA's electricity. The overall electricity consumption may grow an additional 76% by 2020, as compared with 1997 worldwide. This is especially likely to happen in Asia where coal already provides 80% of the energy and also in Central and South America. The Nuclear power generates about 18% of the electricity worldwide and 11% of the need of OECD countries (Figure-3). In USA and France the foregoing figures are 15% and 80% respectively. The wind and solar energy productions are contributing less than 0.5% worldwide, while biomass burning is adding a small amount of CO_2 into the atmosphere. The energy consumption doubled during 1970 to 1997. It is projected to rise another 60% between 1997 and 2020 (Figure-2). The energy use is projected to grow with special rapidity by 120% in developing countries and it clearly shows that not more than 6% of the energy will come from renewable energy sources in developed countries such as from solar or wind, while in the third world developing countries it will be even far less than that. When major energy growth will occur the only most reliable source still to be exploited to its maximum for developing South Asian countries will be hydel power. A dam appears to have many advantages. It generates little air pollution and depletes few non renewable resources. It generates needed electricity and it is expected to prevent floods. It is further expected to produce more lentic aquaculture ichthyofauna and finally is used to provide irrigation water. There are concerns over large dams for electricity generation but implementation can follow after studying all pros and cons in a prior environmental impact assessment and by providing mitigation measures in case if electricity generation is a priority then by seeking to run-of-the-river and small hydro projects. Pakistan needs to exploit its hydel generation potential to maximum for viable future economic development in the country.

DISCUSSION

The use of fossil fuels has been rising at the rate of 2-3 % per year, with no end in sight. Yet, at the same time we are rethinking our energy future on the basis of availability of resources and managing our demands. We need to consider Environmental Factors looming large on the horizon, primarily climate change. Note again that all fossil fuels are carbon based compounds and non can be burned without releasing carbon dioxide (CO_2) as a by product. Of the three fossil fuels: coal, oil & natural gas – Coal produces the most & natural gas produces least Carbon dioxide. As Carbon dioxide is a greenhouse gas, the increasing atmosphere concentration of Carbon dioxide is likely to bring about major changes in global climate. This threat of climate change – and mounting evidence indicates that it is already occurring – is likely to force a curtailment of fossil fuel consumption long before limited resources do. Therefore, fossil fuel contributions to global warming are probably the most compelling reason to reduce energy demand through conservation and to examine non-fossil fuel alternatives. Further more, fossil fuel use incur real costs for society, some of these costs; such as those related to exploration & construction of generating plants are “direct effects”. While there are many indirect affects including; environmental & human health problem. Although the potential impacts of global warming are still poorly understood, they are thought to induce effects on crop yields, water supply, redistribution of populations and impacts of altered weather patterns on hurricanes, typhoons & similar phenomenon.

Then we come to the other alternative i.e. renewable energy sources. Renewable resources are of most environmental friendly but they have their own drawbacks i.e. in solar energy, photovoltaic solar penal have made significant improvement but they are still 5 to 10 years away from achieving economic parity with fossil fuels – at least at current rates of development. Wind energy the most mature renewable technology, is growing fast, but researchers need to find a way to store electricity when the breeze is not blowing. The great bio-fuel scam – in which Government support for corn ethanol choked US market with a fuel that simply add to other problems such as deforestation and food price hikes.

Renewable sources offer a way to supplement, or replace much of our reliance on traditional thermal generating technologies. But these sources also differ in several important ways from conventional energy sources. For example wind, solar and tidal power provides only intermittent, not continuous, generation of electricity as discussed above.

The world has long been astoundingly wasteful about energy use, but for years, that mattered little because power and fuel were so cheap and demand was not so high but with oil now over US$126.00 per barrel that moment may have arrived for world. The answer is an “efficiency surge” i.e. crash improvements that can help offset the steady increase in energy prices and so buy time for the development of Carbon free alternatives. But presently, there is so much water pouring out of the bucket that it is insane to put more water into it.

The future of renewable energy sources will partly depend on the ability of utilities to fore cast and control intermittent sources, to store energy at peak generating period and retrieve it when and where it is needed, and to maintain a consistently high quality flow of electricity to consumer.

There are some success stories in world regarding Carbon dioxide emissions. It is telling story between 1990 to 2005 Germany’s total greenhouse gases emissions declined 18%, in the same period those of US went 16% up. But Germany’s impressive performance has been less about innovation than that about implementations i.e. it has become world leader in solar power. In three years 4 Lacs households in small businesses have installed 3 thousand MW of solar generating capacity. Then come Japan and Spain. These are fragmentary success stories. A lot is to be desired further in the matter. We are still in infancy as far as exploitation of global renewable energy resources are concerned.

There is an energy source which has a technology backed with at least century of experience. This energy source is hydel energy. By taking advantage of the water cycle, we have tapped into one of nature's engine to create useful form of energy. In fact humans have been using the energy in moving water since thousand of years. Today the exploitation of the movement of the water to generate electricity is known as hyroelectric power, is the largest source of renewable power worldwide. On earth water hydrologic cycle provides an enormous opportunity to harness the useful energy.

Keeping in view, all pros and cons, the hydropower is a horizon yet to be explored in many part of the world. The hydropower produces no greenhouse gases leading to atmospheric pollution. Their impact on environment can be mitigated to bare minimum with preliminary environmental impact assessment studies and by ultimately suggesting appropriate mitigation measures. The large dam projects are being pursued in Canada (the largest at, James Bay at Quebec, China, India and many other developing countries including Pakistan). The mitigation measures include i.e. construction of a dam on a site where damage to indigenous ichthyofauna is less drastic (being an oligotrophic site); such as Diamer Basha in Pakistan. By constructing fish ladders etc. the USA and other developed countries except Canada and Russia have reached at their total hydropower potential exploitation. The USA and other developed countries will not advocate the hydropower development projects. They are already at their exploitation peaks. It is in the interest of Pakistan, India, China and Canada to develop this energy source. This hydroelectric power contributes about 19% of the world's electricity. It does not produce CO_2 and other harmful emissions compared to fossil fuels. It is less expensive than energy generated by fossil fuels. Small scale / micro hydropower systems can be introduced in remote areas on small streams without the construction of dams which renders them further environment friendly.

The total technically exploitable potential for hydropower is 15 trillion kw power hour, equal to half of projected global electricity use in 2030. Out of which only about 19% have been developed so far. The main areas for future development include Soviet Union, South Asia, and South America.

The hydel power provides one fifth of the world's electricity second only to the fossil fuels. Worldwide hydel power capacity is 776 gigawatt (GW); with 12% in USA, 9% in Canada and 8% in Brazil. The China's 3 Gorges Dam, poised to become the largest hydroelectric project in the world with 18.2 GW capacity will bestow China ahead Brazil.

Globally the hydroelectric capacity has more than doubled since 1970. Another 10 GW is under construction. In future the installed capacity of small hydro will increase from 48 GW today to 55 GW by 2010, with the largest increase will be coming from China, with plants to develop further 10000 MW in next decade. In USA the hydroelectric installed capacity is 95 GW, which is 10% of the total power generation of that country. Presently more than 90 GW worldwide pump storage capacity is available. In run-of-the-river system, you can only generate power according to the flow intensity in river but the hydro plants with dams can be used according to the energy requirements, if it is priority utilization. It is once again reiterated that for viable economic and environmental improvements and the reduction in CO_2 emissions, renewable energy sources in general and hydropower in particular are very important instead of their drawbacks.

PAKISTAN'S SCENARIO

The single renewable energy source which Pakistan possesses in abundance is hydropower, most environment friendly and cheapest source of energy. Its potential is approximately 42,000 MW. The acute shortage of energy in Pakistan is clear like daylight. The load-shedding is the outcome of this deprivation, which is devastating for economy. Installed capacity of power generation in Pakistan is 19560 MW; out of which, 65% is thermal and 33% hydroelectric while 2.4% is nuclear. The installation of IPP thermal plants in the recent past to tackle energy crisis has not only created atmospheric pollution but also price hike of electricity in Pakistan. At the time of independence, Pakistan had only an installed capacity of 10.7 MW. When WAPDA was created in 1959, the hydel power generation in Pakistan was 119 MW. In 1980 system capacity enhanced to 3000 MW. Presently the capacity stands at 19560 MW, which includes 12473 MW (65%) thermal, 6595 MW (33% hydel, Table-3) and 462 MW (2.4 % nuclear). Pakistan is bestowed with economically exploitable hydropower potential of approx 40000 MW. We in Pakistan are

TABLE-3: Existing Hydel Power Stations in Pakistan

Sr. No.	Name of Project	Installed Capacity (MW)
1.	Diamer Basha	4500*
2.	Tarbela	3478
3.	Ghazi Barotha	1450
4.	Mangla	1000
5.	WARSAK	240
6.	Chashma	184
7.	Malakand	19.6
8.	Daragi	20
9.	Rasul	22
10.	Shadiwal	13.5
11.	Chichoki Malian	13.2
12.	Nandipur	13.8
13.	Kurram Gari	4
14.	Reshun	2.8
15.	Renala	1.1
16.	Chitral	1
17.	Jagran-I	30.4
18.	Kathai	1.6
19.	Kundal Shahi	2
20.	Leepa	1.6
21.	Northern Area Projects	94
22.	Small/Micro Hydel Stations	3
	Total:	6595

*(Design Completed)

opting for environmentally hazardous fossil fuels power plants rather than taking advantage of eternally available gift of God. 16 potential hydropower sites in Upper Indus Basin reach are identified with an installed capacity of 13981 MW (Table-4). As far as tributaries of main rivers are concerned, they have 17 favorable potential sites with 1020 MW capacity for an annual energy production of 5100 GWh. The identified low-head hydropower potential is

TABLE-4: Upper Indus Basin Potential of Hydropower Schemes

Rank	Scheme	River	Power (MW)
1.	Dasu	Indus	3700
2.	Bunji	Indus	4710
3.	Thakot	Indus	1043
4.	Patan	Indus	1172
5.	Rakhiot	Indus	670
6.	Yulbo	Indus	710
7.	Kalangai	Swat	256
8.	Kohala	Jhelum	740
9.	Munda	Swat	740
10.	Karot	Jhelum	240

approx 1080 MW and an annual energy production of 640 GWh. The potential of the run-of-the-river projects at Indus is 20000 MWt. The potential of the tributaries of Indus and Jhelum is 8000 MWt. The scenario of indigenous fossil fuels is bleak i.e. projected lifespan of the existing natural gas and oil is just 15 & 9 years respectively.

Domestic coal reserves can only be exploited at great financial and environmental costs. 70% of the oil needs of Pakistan are met through exports. The rising prices of oil are rendering it as least likely source of thermal power generation. While hydroelectricity is very cheap i.e. the generation cost of hydroelectricity in 2002-03 was Rs.0.50/- kilowatt per capita, energy consumption for Pakistan is 320 kwh and this only caters for 60% of population while 40% will have no access to electricity. So, ultimately only viable and foreseeable solution to Pakistan energy crisis in hydropower which is cheap, environment friendly and renewable source of energy, is waiting to be explored. The annual demand in energy increase has risen to 10% in 2007 as compared to projected at 7.7%/annum in vision 2025.

Eight No. hydropower units with a capacity of 716 MW with run-of-the-river system were to kick start in 2006-07. They never materialized. The development of small hydro units has rather a niche in critics of reservoirs. It needs further exploitation. We must forthwith embark on harnessing hydel potential, instead of experimenting in costly and unexplored renewable energy resources and imitating and competing India in nuclear energy. We should tread on a way followed by China, by developing hydel energy capacity.

CONCLUSION & RECOMMENDATIONS

The development of hydropower in a country has a direct relationship with CO_2 emission reduction along with sustainable socioeconomic development and eradication of poverty and ultimately minimizing environmental degradation. The humanity today faces these challenges with more stark realities than ever before. Hydropower is closely linked to both water management and renewable energy production so has a unique role to play in contributing towards sustainable development with low carbon economy.

Hydropower projects are robust, highly efficient, long-term investments with life spans of 100 years or even more, in sharp contrast to the other alternative renewable energy sources which are unpredictable, intermittent and less localized. Hydropower is proven and well advanced technology based on more than a century of experience. That is why Government of Pakistan should formulate a very emphatic policy to develop hydropower in Pakistan on war-footing. This will kick start a habit of low carbon energy goal for nation’s glorious future.

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RE-UTILIZATION OF SOLID WASTE CARBON SAVES ECONOMY

By

Muhammad Khalid Iqbal, Tahira Shafiq, Khursheed Ahmad*

ABSTRACT :
Today the world is facing the greatest challenge of Climate change. The greenhouse gas emissions from municipal solid waste produced by anthropogenic activity are the major contributing factor to climate change. Solid waste management is a problem of major relevance for all societies. To cope with such a problem is becoming a quite hard task, owing to the increasing awareness of environmental issues by population and authorities. In order to control this problem, present study was conducted. The annual municipal solid waste collected from Lahore contained an average 87.31 % organic matter, 3.89% stone, 1 .46% wood, 1.58% polythene, 2.97%paper, 2.05% straw and 0.92% cloth. The proximate analysis of organic matter indicated average 2.0%protein, 9.1% ash, 76.6%moisture, 9.2% fat and 3.1% fiber. In this study organic waste of fruit and vegetable was composted in a laboratory scale composter. Before composting the concentration of carbon lies between 28.0 to 33.5 % and nitrogen 1.20 to 1.29 %. But after composting C range 19 to 26.5 % and N 1.9 to 2.3 %. The C/N before composting was 23 to 27 and after composting it was 9 to 15. Reduction in pollution threat to environment due to huge piling of organic waste is an extra benefit.

INTRODUCTION

The issue of solid waste management has been with us for as long as mankind has existed – it was probably felt by the first cave dwellers, and will probably always exist if not as a problem, as a management challenge. Indeed, waste management is increasingly couched in terms of resource management and sustainable solutions

Aerobic decomposition(composting) is a potential treatment technique for municipal solid waste (MSW) and yard waste. Recently, composting has gained a lot of interest particularly in developing countries. European legislation (Directive 99/31/EC) dictates that biodegradable components should be gradually diverted from landfills, necessitating the use of alternative MSW treatment techniques, such as composting.

Solids hydrolysis has been suggested as the rate-limiting step during anerobic decomposition of MSW (as long as near optimal conditions are maintained fractionated initial solid organic carbon into three groups, namely readily hydrolysable, moderately hydrolysable and slowly hydrolysable carbon and used to describe the amounts of methane and carbon dioxide emitted from solid waste landfills.[(1)]

Pakistan is an agriculture country with most of its revenues derived from sale of agriculture products. The per hector yield in Pakistan is considered to be one of the lowest in the world and the main reason for this is the imbalance in use of fertilizers which in turn is mainly due to inappropriate knowledge. The government of Pakistan is determined to develop this very important sector of our economy through increased productivity. Additionally GOP has also shown its interest in providing support to initiatives in the alternate fertilizer sector

By using five times of compost, we can save one bag of urea, one bag of super phosphate and one bag of sulfate of potash. Similarly, 15kg of natural gas used in the manufacture of urea can be saved for fuel in recycling organic waste, we saved many resources for example by recycling one tons of paper, 175 pounds of sulfur, 350 pounds of lime stone, 60000 gallons of water, 900 pounds of steam and 225 kilowatt hours of electricity [(2)]. The objective of this study was to calculate the readily, moderately and slowly hydrolysable solid carbon fractions, and their corresponding hydrolysis rate constants, for six biodegradable solid waste components under aerobic conditions.

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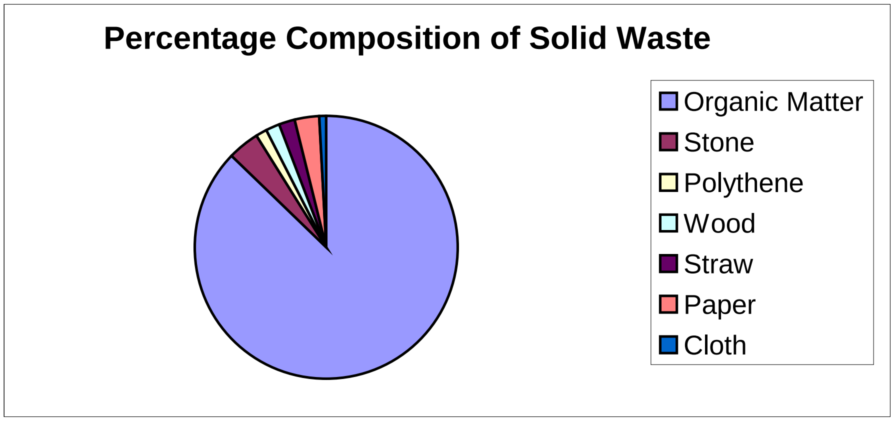
*CEPS PCSIR Laboratory Lahore, NCBE Lahore.

RESULTS AND DISCUSSION

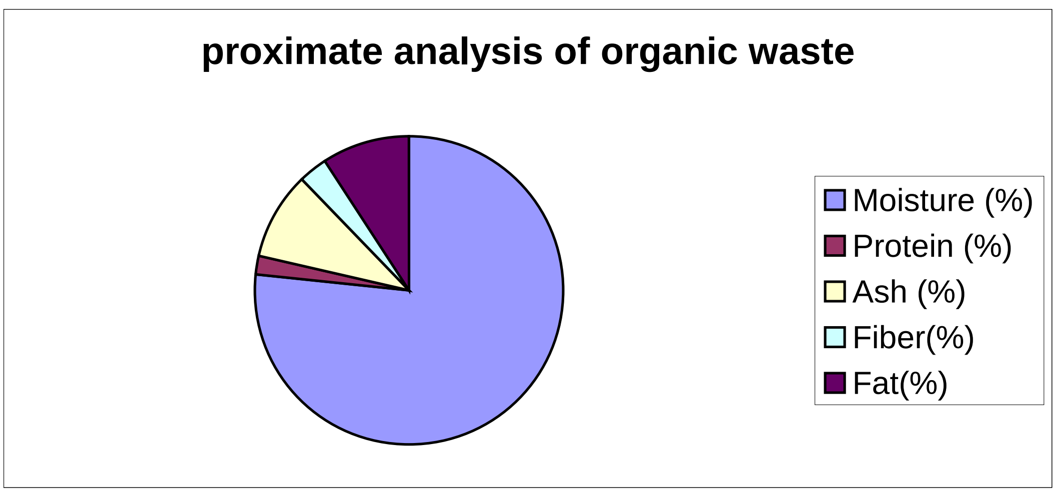
Data regarding the composition of municipal solid waste collected from different localities of Lahore has been shown in Fig. 1. Municipal solid waste consist of organic matter, stone,

Fig -1



polythene, wood, straw, paper and cloth. Organic matter was averaged 87.31% in different seasons of study. Matter beside organic matter average percentage of stone, polythene, wood, straw, paper and cloth were 3.89%, 1.58%, 1.46%, 2.05%, 2.97%, 0.92% respectively. Stone and papers were available in almost all samples whereas wood ; cloth and polythene were available in few samples. The decomposable material was in maximum concentration as compared with the indecomposable material. The proximate analysis of organic matter contains

Fig-2



different concentration of moisture, protein, ash, fiber, and fat. Moisture concentration was maximum, which ranges from 68.9% to 83%, whereas protein 0.3% to 3.2%, ash 5% to 13%, fiber 1.1% to 5.9% and fat 6% to 12.4% respectively. The availability of the maximum concentration of moisture in solid waste leads to the recycling of organic matter make compost product, which is beneficial for our economical and environmental system. Major concern of bio solids and municipal solid waste compost users are the physical and chemical safety of the end products. Physical contamination, usually visible, can be removed through screening and separation strategies before or after composting.(3). In our study, we observed changes in the chemical composition of solid waste before and after the composting in different batches. Before composting the concentration of carbon lies between 28.0% to 33.5% and nitrogen 1.20% to 1.29 %. But after composting C ranges 19% to 26.5 % and N 1.9% to 2.3%. The C/N before composting was 23 to 27 and after composting it was 9 to 15. The C/N decreased after composting due to the utilization of C and N by microbes. The same results were observed by other works.(4) On the other hand the concentration of P, K, Fe was ranged as 0.14% to 0.18%, 1.12% to 1.16% and 440 to 451mg/kg before composting and after composting these values were as 0.26% to 0.30%, 1.58% to 1.64%, and 675 to 684mg/kg respectively. From the observations indicating that easily biodegradable carbon was exhausted and the compost at maturity reached[5]. The bio maturity of our compost was accessed, which indicate that compost reach full maturity after 30 days. For instance, continuous decrease of C/N ratio and increase of CEC indicates that composting mixture becomes bio stabilized after 30 days of composting. [6].

Table: Composition of compost

Parameters	Before composting	After composting
C (%)	28.0-33.5	19-26.5
N (%)	1.20-1.29	1.9-2.3
P (%)	0.14-0.18	0.26-0.30
K (%)	1.12-1.16	1.58-1.64
Fe (Iron) (mg/kg)	440-451	675-684
C/N	23-27	9-15

MATERIALS AND METHODS

Municipal solid waste was collected from different localities of Lahore. The sampling was done by batch method to make composite sample. During sampling every precautionary measures were adopted and samples were labelled properly .The samples were segregated according to their contents to determine the percentage of organic and inorganic components. Un-decomposeable pieces of bones, stones and polythene bags were removed and material was crushed to extract moisture. After extraction the material was oven dried at $60C^0$ for 24 hours. The dried material was ground to finer particles with the help of mechanical grinder to increase the surface area. The oven dried ground material was transferred into lab scale prepared mechanical composter. Composting was done under controlled temperature and aeration. Moisture level (40%v/w of compost) and temperature $30\text{-}70C^o$ were maintained during composting. In the composter, oxygen inlet was available to aerate the process of decomposition. In the centre of the composter the temperature rose to $55C^0$ after 3 days, rising to a peak of $71C^0$ after 10 days and slowly fell to below $65C^0$ after 30 days, at this point the compost was turned Composted material was analyzed to determine C, N,P,K and Fe. Total Nitrogen of compost material was done with macro kjeldhal's apparatus by Ginning and Hibbard's method of sulphuric acid digestion and distillation of ammonia into 4% boric acid[7]. Available phosphorous in composted material was calculated by Olsen's extraction method[8]. Fe was determined by atomic absorption spectrophotometer (UV-VIS-200) and K by flame photometer (Jenway model PFP-7). The chemical analysis was performed on dried bases. Carbon contents was estimated after ashing the material at $550C^o$ using equation

% C = 100-%ash/1.8 [9]. The proximate analysis of each sample was done by AOAC Method[10].

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LOW-CARBON ECONOMY: A PAKISTANI PERSPECTIVE

By

Muhammad Daniel Saeed Pirzada*

Abstract
The likely impact of global climate change has been discussed. There is a growing consensus that greenhouse gases are major contributors towards global warming and consequent climate change. International efforts are afoot to reduce the emission of carbon dioxide and other greenhouse gases.

The economic and social situations, on the other hand, demand a large-scale expansion of the power sector. Keeping in view the national resource situation and the worsening air quality, careful planning is required to not only address the energy needs but also be compatible with the theme of low-carbon economy for a sustainable development.

The Climate Change
According to an estimate the cost of natural calamities during 2007 was around $30 billion, double the figure for the year 2006[1]. Climate change is considered the most likely reason for the increase in large-scale disasters. The worst catastrophes in terms of loss of life occurred in developing countries (over 11,000 people died in Asia). In terms of loss of property the Kyrill storm alone (occurred in Europe) caused $5.8 billion damages. There is overwhelming scientific evidence that climate change is a serious global threat. There is a need therefore to intensify measures to combat climate change.

The effect of climate change and global warming on the world economy has recently been studied and evaluated in great detail. Sir Nicholas Stern, the renowned economist, led the compilation of famous, Stern Review on the Economics of Climate Change[2]. Stern states, "our actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century." The climate change is going to affect all the countries. The poorest countries, being most vulnerable, will bear the main brunt.

Greenhouse Gases: Not All That's Green Is Good
There is a growing consensus among the environmentalists that rising concentrations of greenhouse gases in the atmosphere are contributing to the already visible signs of climate change. Human activities, especially burning of fossil fuels, are the main contributors to the atmospheric build-up of CO_2 and other greenhouse gases. As greenhouse gases are retained by the atmosphere for longer periods, it is anticipated that their atmospheric concentrations will continue to rise for several decades. Consequently, the average global temperatures will keep increasing[3]. The list of greenhouse gases in earth's environment in order of relative abundance is headed by water vapour, carbon dioxide, methane, nitrous oxide and chlorofluorocarbons (CFCs).

Both natural processes and human activities generate greenhouse gases. The industrial revolution resulted in an increase in the anthropogenic share in the overall concentrations of all the long-lived greenhouse gases. Apart from water vapours the change in concentrations of greenhouse gases in all cases has been due to human activities on the planet. Table 1, compares the relative change in concentration and 'radiative forcing' of different greenhouse gases[4].

*Pakistan Institute of Nuclear Sciences & Technology P. O. Nilore, Islamabad

Table- 1
Change in concentration and radioactive forcing of common greenhouse gases

Gas	**Pre-industrial Level**	**Current Level**	**Increase since 1750**	**Radiative forcing (Wm^2)**
Carbon dioxide	280 ppm	384ppm	104 ppm	1.46
Methane	700 ppb	1,745 ppb	1,045 ppb	0.48
Nitrous oxide	270 ppb	314 ppb	44 ppb	0.15
CFC-12	0	533 ppt	533 ppt	0.17

Radiative forcing, a measure of change in net irradiance at the tropopause, is used as an index of a factor's influence as a potential climate change mechanism. "Net irradiance" is the difference between the incoming radiation energy and the outgoing radiation energy and is measured in Watts per square meter. An exceptionally high value of radiative forcing for CO_2 reveals its potential effect on global warming.

According to a recently published study of the trends in atmospheric concentration of greenhouse gases from 1990-2004, methane and nitrous oxide emissions decreased by 10 percent and 2 percent, respectively[5]. This decline has been attributed to changes in policy, agricultural practices and improved emission-control technologies. For the same period the carbon dioxide emissions increased by 20 percent. In the future, too, greenhouse gas emissions are expected to rise. Use of newer, cleaner technologies and everyday choices in commuting, housing, energy use and recycling can help curb this growth.

How this rise in greenhouse gas emissions is going to affect us is not certain. Simulations predict a rise between 1.5ºC and 5.9º C by 2100. The large range of the estimates reflects our uncertainty. The likely consequences in the foreseeable future include persistent sea-level rise and associated increase in the occurrence of extreme storm surges[6]. In some areas changing rainfall patterns, inundation, and spread of infectious diseases will increase the risks of famine and high mortality.

Low-Carbon Economy (LCE)

Avoiding catastrophic climate change requires major reductions in the emissions of greenhouse gases. However, sustainable low emissions are achievable only through significant market adjustments. The existing economies will need to undergo a major transformation to ensure emission levels (especially for carbon dioxide) compatible with this objective. A common term for this philosophy is Low-Carbon Economy (LCE).

The LCE requires an integration of efforts over all sectors of economy – from power generation and manufacturing to agriculture and transportation. This is to say all sectors of economy need to switch to energy efficient and material efficient processes and practices. The strategies proposed in this regard depend primarily on nuclear power and concepts like carbon capture and storage (CCS). The latter concept focuses on capturing carbon dioxide from large point sources such as fossil fuel power plants and storing it rather than releasing it into the atmosphere. Due to its high cost and inefficiency, so far no large-scale power plant is operating with a full carbon capture and storage[7]. Similarly, there are safety and spent-nuclear-fuel storage concerns over nuclear power. Because of these and other issues many scientists have proposed that renewable energy should be the main basis of an LCE[8]. Other proposals in this regard include a carbon tax and emissions trading.

Carbon Tax

The carbon tax, as the name suggests, is a charge on fossil fuel consumption based on their carbon content. When burnt, the carbon in these fuels becomes carbon dioxide, the chief greenhouse gas. The primary purpose of introducing a carbon tax is to lower the greenhouse-gas emissions. The tax can prove an incentive for greater use of renewable energy resources, energy conservation, switch from private to public transportation and use of compact fluorescent lamps (CFLs). As carbon tax sets a definite price on fossil fuel consumption (or carbon dioxide emissions), some improvement is guaranteed[9]. It also makes renewable energy resources cost-competitive with cheaper fossil fuels and the money raised by the tax can help subsidise environmental programmes.

Emissions Trading

Emissions trading or cap-and-trade is an incentive approach for achieving desirable reductions in the emission of pollutants. The 'cap' or upper limit on the amount of a pollutant emitted can be set by a central authority (a government or international body). Businesses are issued emission permits and are required to hold an equivalent number of *allowances* (or *credits*), which represent the right to emit a specific amount of a pollutant. The total amount of allowances and credits cannot exceed the 'cap'. Businesses needing to increase their emissions must buy credits from those who pollute less. This transfer of allowances is referred to as 'trade'[10]. In effect, the buyer is paying a charge for polluting while the seller is being rewarded for having cut emissions by more than the standard. In theory, those who can easily reduce emissions cheaply will do so, achieving the pollution reduction at the lowest possible cost to the society.

Many experts believe that carbon trading is the best approach. It can be cheaper for existing industries because the 'cap' is determined in proportion to current emission levels. In addition, most of the money in the system is spent on environmental activities, and the investment directed at sustainable projects that earn credits in the developing world. However, the emissions trade has intrinsic problems of complexity, monitoring, enforcement, and consensus on initial allocation methods.

A major step forward in tackling the problem of global warming was the adoption of Kyoto Protocol at the third Conference of the Parties to the UNFCCC (COP 3) in Kyoto, Japan, on December 11, 1997[11]. The protocol aspires to achieve "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

Pakistan

Pakistan has an estimated population of 162,508,000 as of February 2008. The country, thus, has the world's sixth largest population -- placing it above Russia but below Brazil. Because of the high growth rate, Pakistan is expected to surpass Brazil in population by the year 2020. Pakistan had an economic growth rate of 7 percent per annum for four consecutive years up to 2007. The economy has transformed from an agricultural base to a strong service base. The gross domestic product is estimated to be US $ 475.4 billion so that the per capita income (PCI) stands at $ 2,942[12].

Energy scene

The fossil-fuel-burning electricity-generating sector is a major contributor of GHGs. A critical analysis of present and future energy demand and its resources is therefore imperative.

Like any other economy, the main drivers of growth in energy demand are growth in population and economic development. In addition, electricity is still not available to a significant segment of Pakistan's population. The people aspire for a better quality of life – including greater access to clean energy. This makes Pakistan a severely energy-thirsty nation. The present per capita energy consumption is merely one sixth of the global per capita use, the gap between peak demand and supply of electric power is 3,000 MW and widening. Figure 1 shows the electricity generation mix for the country.

Electricity Generation Mix

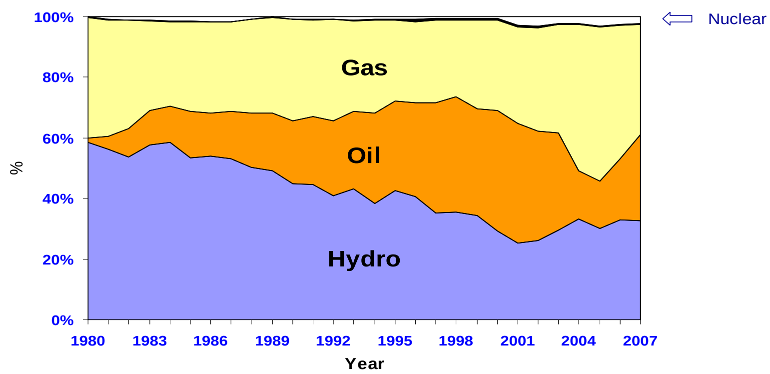

Figure 1: Electricity Generation Mix of Pakistan

Nuclear energy, along with renewable energy sources such as solar, wind and hydro is a cleaner source of energy[13]. Nuclear energy provides an attractive option with the potential for large-scale expansion. A steady growth of nuclear energy facilities therefore provides a way for avoiding increasing GHGs emissions by the electricity sector. As such, the nuclear energy appears to have a vital role in a sustainable low carbon economy. In spite of key developments in the nuclear power generation technology, issues like safety, and non-proliferation tough hurdles to the expansion of nuclear power generation, especially in the Third World countries. In this field technical cooperation by developed countries has been minimal and receding.

Pakistan is a nuclear-weapon state and has made major strides in the area of nuclear fuel cycle. Yet, the country's heavy manufacture sector is in its infancy. In addition to the political will and financial commitment to a capital-intensive nuclear power programme, like other developing countries, Pakistan faces the issues of global concerns for safety and proliferation. These have been impeding financing and bilateral nuclear trade/cooperation agreements. Pakistan has installed a small power plant with help from China and another is in the pipeline. But apparently for the next two decades the share of nuclear generation in the national power production is likely to remain nominal (Figure 2).

Primary Energy Mix
(% Shares)

	Coal	Oil	Gas	Hydro	Nuclear
2007	7.0	28.8	50.4	12.7	1.0
2010	6.1	34.5	48.9	9.9	0.6
2015	5.2	22.6	60.7	8.8	2.6
2020	5.4	50.6	28.4	12.5	3.1
2025	17.2	45.5	21.8	11.2	4.3
2030	31.4	42.4	12.2	9.7	4.3

Figure 2: Future Generation Mix of Pakistan

Pakistan has a substantial hydro-power potential, but on account of the way large dams politics has played out its exploitation in the near future remains rather uncertain. Pakistan also plans to install in the next three years wind turbines to generate 400 to 500 megawatt electricity. But the wind energy contribution remains minor, uncertain and uneconomical. In the near term the thrust remains for the import of gas from neighbouring countries[14].

Pakistan also has huge reserves of coal[15]. In terms of exploiting national resources, coal-fired power plants will be the logical choice. Together with gas-fired plants these power generation technologies are primary sources of GHGs. The problem of control and reduction of GHSs will therefore get more severe with the installation of every new power unit.

Health Issues

Even though we are far from bridging the demand-supply gap in the power sector, the mismanagement, lawlessness and thoughtlessness in environment management has started having an impact on national health. Air pollution affects body's respiratory and cardiovascular systems. Many studies have established aggravated asthma, bronchitis, emphysema, lung and heart diseases, and respiratory allergies as a direct cause of air pollution.

According to the WHO the number of deaths per year attributed to outdoor pollution is 28,700. The impact of air pollution is measured by an index that combines the time lived with a disability and the time lost due to premature mortality – the Disability Adjusted Life Year (DALY). The estimated outdoor DALY value for Pakistan is 2.3[16]. This places Pakistan among the top 10 on the pollution-impact list.

Vehicular emissions are a significant source of air pollution. These include oxides of carbon, nitrogen and sulphur. In addition to the harmful gases, the diesel-driven vehicles emit very fine particulates (>2.5 microns) that can penetrate the deeper recesses of human lungs causing respiratory problems. The fact that the pollutants are emitted at ground level in close proximity to the people aggravates the problem. At high concentrations, these pollutants cause severe health problems and degrade the quality of life.

A Strategy for Clean Air

Two approaches namely, *End-of-Pipe treatment* and *Cleaner Production* are applied to combating pollution. The end-of-pipe systems *i.e.* treatment of wastes is a traditional means for reduction of pollution. Cleaner production, on the other hand, is a preventive, case-specific environmental protection initiative. It is intended to minimise waste and emissions through source reduction strategies[17]. The process re-engineering helps to reduce or suggest better options in use of materials and energy, and to avoid generation of pollutants. In Pakistan, at present, end-of-pipe approach holds sway. There is a need to introduce and implement the pro-active attitude of the cleaner production with regard to environmental problems as an efficient solution to the problem, saving resources and increasing economic efficiency of industries.

Recently, there have been some efforts in the country in this regards that include an agreement aimed at utilising municipal solid waste to generate fuel. The EcoSecurities, will purchase the greenhouse gas (GHG) emission reductions that the project achieves[18].

Conclusions

1. On one hand, the country is facing a severe energy crisis, and is forced apparently to accept quick solutions irrespective of the cost; on the other, we need to address the global greenhouse gas (GHG) emission reduction challenge. This helps us reach the conclusion that Pakistan should integrate adaptation to climate change into its future planning and investment. Farsightedness, planning and teamwork will be the instruments to turn the tide against the carriers of calamity and catastrophe.

2. First, there is the need to promote energy conservation and efficiency in residential and industrial buildings. The national vehicle fleet is doubling every five to seven years. Well-

designed mass public transport systems will be needed in major cities to curb this trend. This will require substantial investment but the benefits will be large, including reduced oil consumption and pollution levels.

3. There is a need to create awareness about pollution and environment-related damages.

4. Pakistan needs to generate national consensus on use of water resources for power generation. We need to explore our renewable energy potential. In terms of long-term planning we must embark on a Solar Energy programme.

5. There is a need to build long-term scenarios at the national level towards a low-carbon economy.

6. We should try to benefit from the emission trading policies and economic incentives for emission reductions for developing countries provided under the Kyoto protocol.

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ISOTOPIC AND CHEMICAL CHARACTERIZATION OF COAL FROM SELECTIVE AREAS OF PAKISTAN

By

A. Mashiatullah, T. Javed, R. M. Qureshi, Z. Shah*, Z. Latif and Habib-ur- Rehman**

ABSTRACT

Environmental pollution has become a worldwide concern as it may adversely affect human health. This is created by the man himself as a result of indiscriminate release of toxic substances into the environment from various socio-economic development activities. The large-scale use of fossil fuels is the main cause of man-made climate changes. Combustion of these fossil fuels is considered to be the largest contributing factor to the release of greenhouse gases into the atmosphere, water pollution and accumulation of solid waste. The power generation sector accounts for a major proportion of these emissions and the upward trend is set to continue in future. In this regard, the categorization of fossil fuel such as coal is extremely necessary for pollution purposes. The stable isotope and chemical techniques are applied for the characterization of coal in selective areas of Pakistan. The stable carbon isotope ratio ($\delta^{13}C$) and toxic/trace elements concentration of coal of selective areas of Pakistan have been determined. The carbon Isotope compositions of major coal lie in the range of -26.7 per mill to -23.9 per mill PDB. The Katha-pale, Lakhra and Cherat show very consistent isotopic composition around -24.9 $\pm$ 0.2 per mill PDB. The Markarwal and Sharigh coals have comparable isotopic values and are 0.5 per mill enriched in $\delta^{13}C$ than the Katha-pale, Lakhra and cherate coals. No systematic isotope effects are found in the process of qualification from peat to Tertiary lignites and sub-bituminous coal. The observed variations in the carbon isotope composition of coal obtained from Sharigh coal field and the Sor-range /Degari Coal field in Balochistan are attributed to the deposition environments. Significant concentration of toxic elements such as S, Cd, Cr, Cu, Mn, Ni, and Pb are found in these samples. Use of this coal for domestic/ bricks kilns and in combustion chambers of thermal power plants and industrial and energy sector may cause a significant environmental pollution as well as health problems.

1. INTRODUCTION:

Coal is a fossil fuel formed in ecosystems where plant remains were preserved by water and mud from oxidization and biodegradation, thus sequestering atmospheric carbon.. It is composed primarily of carbon along with assorted other elements, including sulfur. It is the largest single source of fuel for the generation of electricity world-wide, as well as the largest world-wide source of carbon dioxide emissions, which, according to the IPCC are responsible for causing climate change and global warming. Coal is slightly ahead of petroleum and about double that of natural gas. The continued depletion of conventional petroleum resources, i.e., oil and natural gas is renewing energy sector interest in fossil fuels derived from humic sources. Extraction of coal is an obvious alternative.

The rapid growth in population (3.1 % per year) has led to a considerable rise in the demand of energy consumption for the development of industrial and commercial sectors in Pakistan. At present Pakistan is exploiting five sources of commercial energy namely: hydro, nuclear, oil, gas and coal. The former four sources do not have enough potential to cope with the country's increasing demand of energy. The only potential fossil fuel available in Pakistan which can practically meet this requirement is coal [Butt, 1980]. There has been a growing interest in the use of coal for energy production. Pakistan has large reserves of coal out of which proven reserves are nearly 748 million metric tons [Talpur et.al., 1987]. The estimated reserves are about 1,178 million metric tons. Recently, some coal power plants are being installed along the coastal areas of Karachi.

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*Isotope Application Division, PINSTECH, Islamabad, Pakistan
** Mineral Exploration Centre, Peshawar

The vast deposits of coal in Pakistan are classified as highly volatile to sub-bituminous with high ash and sulphur contents. The coal deposits of Pakistan are relatively younger in age and fall into the poor grade - low rank category which has restricted their use for industrial purposes. Ahmed et.al. [1986] has emphasized the need for obtaining more reliable data on the geology of coalfields in terms of petrographic studies as well as standardization of procedures for the collection, storage and versatile analysis of coal available in Pakistan in order to boost its utilization.

Carbon, stable isotope variations can be large between different coals. These differences can often be recognized in their bulk $\delta^{13}C$ values. Isotope signatures of coals can be diagnostic of several factors, including deposit age, type, maturity and generation history. This new application of stable isotopes, at the maceral and compound levels, have great potential to improve the interpretative precision over conventional whole coal or bulk techniques.

In this paper, the carbon isotope technique is described as a fast method to study: a) relationship between isotope effects which may occur during the process of coalification and the maturity attained by Tertiary coals in Pakistan, and b) the possible existence of biotope and age effects during the Tertiary regime. Some toxic/trace elements of environmental concern are also determined and discussed for two coal samples collected from Makarwal coalfield.

2. PRESENT INVESTIGATIONS:

2.1. Coal Sampling and Preservation:

Fifty four coal samples ranging were obtained from seven coalfields namely : Makarwal, Katha-Pale, Cherat, Sharigh, Sor-range, Degari, and Lakhra through Pakistan Mineral Development Corporation and Geological Survey of Pakistan. These were collected as "channel samples" or "run of mine" (ROM) samples from the top, middle and bottom of some coal seams. Coal samples were broken into small pieces using mortar and pestal and were crushed in a Whiley grinding mill. Powdered samples were sieved through 60 mesh size. The sieved samples were dried at 50^oC and preserved in plastic bottles placed in a desiccator. Three SARM (South African Reference Materials) coal standards namely SARM-18, SARM-19 and SARM-20 (particle size : <106 micron) were purchased from South African Bureau of Standards, Pretoria, Republic of South Africa.

2.2. Experimental:

A. Stable Carbon Isotope Analysis:

For stable carbon isotope analysis on mass spectrometer, the organically bound carbon in coal was converted to CO2 using the sample preparation system as shown in Fig. 1. About 15 - 20 mg moisture-free powdered coal sample was placed in a porcelain boat (8cm x 1cm x 0.8cm) and introduced into the quartz portion of the vacuum system. After preliminary evacuation (10-2 torr), high purity oxygen was filled in the combustion part of the line at pressure slightly less than one atmosphere. The sample boat was externally heated with a gas burner (˜600°C). The evolved CO/CO2 were then circulated in the line with the help of a magnetically driven circulation pump. During this circulation, CO_2 gas and moisture was condensed in a trap held at liquid nitrogen temperature (-196^oC). The CO gas was converted to CO_2 while passing over the heated copper gauze (900^oC) in the presence of oxygen. After 5 minutes of circulation, all CO was converted to CO_2 and collected totally in the CO_2 trap. The temperature of this trap was then raised to -80^oC with the help of liquid nitrogen-freon mixture in order to transfer the CO_2 in a suitable sample collector for mass spectrometric analysis. The stable carbon isotope data is expressed as δ ‰ (delta per mil) values relative to the international carbonate standard **PDB**. The reproducibility of $\delta^{13}C$ measurements was better than 0.1 ‰.

Figure-1: Carbon isotope variation of various coalfields in Pakistan (Fm = Formation, ROM = Run of Mine)

$\delta^{13}C$ ‰ (PDB) -27 -26 -25 -24 -23 -22 -21	Coal Field	Sample Type
	Cherat (Hangu Fm)	ROM/3
	Makarwal (Hangu Fm)	ROM/2
	Katha/(Patala Fm) Salt Range	Channel/3
	Lakhra (Lakhra Fm)	Channel/3
	SOR-Range (Ghazij Fm)	ROM/11
	Degari (Ghazij Fm)	ROM/13
	Sharigh (Ghazi Fm)	ROM/9

B. Chemical Analysis:

Standards: The coal standard reference materials namely SARM-18, 19 and 20 were heated at 50°C till a constant mass was obtained. Each standard (˜5g) was pelletized in a stainless steel mould of 35mm diameter at 30 kN for 20 seconds, using a Press Herzog Model HTP 40 (FRG).

Samples : Two samples obtained from the Makarwal coalfield were baked and pelletized as per procedure reported for standard. Minor difference remained in the size fraction of the sample and standard, the later containing much smaller particle size.

XRFS Procedure : The measurements were carried out in vacuum using a wavelength dispersive X-ray Fluorescence Quantometer model 8420, Applied Research Laboratories, Switzerland. The standards and samples were bombarded with primary X-rays from Rhodium anode X-ray tube operated at 50mA and 50kV. Samples were rotated during XRFS measurements to avoid any inhomogeneities present in the sample. The intensities of the analyte lines were related to concentrations using calibration curves drawn with the help of SARM standards. Multivariable regression (MVR) analysis was carried out on the intensities and concentrations of standards. This MVR calculation provided mathematical algorithms to compute the base curve polynomials simultaneously. The first degree based polynomial coefficients (A0 & A1) were calculated by computer using multitask system (MTS) software programme.

TABLE -1: XRFS elemental analyses of two coal samples from Makarwal (Sample type: ROM, Lumshiwal cross-section)

Elements	Sample - A	Sample - B
Al (%)	0.96	1.31
S (%)	7.41	5.53
K (%)	0.0682	0.113
Ca (%)	0.114	2.63
Ti (%)	0.89	0.426
Fe(%)	1.85	3.92
Cr(μg/g)	79.5	96
Co(μg/g)	6.65	6.11
Ni(μg/g)	18.4	18.73
Cu(μg/g)	23.24	7.36
Zn(μg/g)	17	1.17
V (μg/g)	72.34	58
Cd(μg/g)	38	24
Pb(μg/g)	23.78	22.48
U (μg/g)	9	-

The relationship : Ci = Ao + Ai Ii was used to correlate concentration (Ci) with intensity (Ii). The calibration curves are linear over the entire concentration range. These calibration curves were then used to evaluate XRFS measurements on same standards treated as "test samples" and the two coal samples collected from Makarwal Collieries, Punjab. The precision was expressed as one sigma value of replicate (three or five measurements). The accuracy was given in % deviation (±) as difference in measured and certified values expressed as percent of certified concentration.

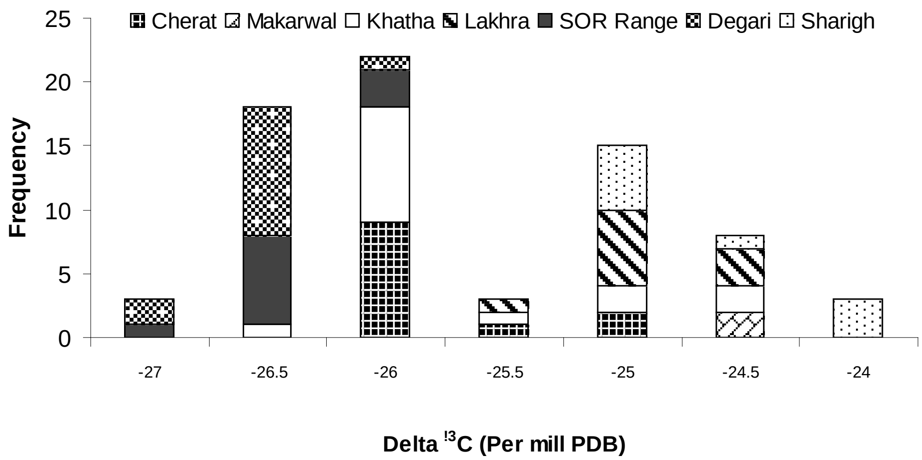
3. RESULTS AND DISCUSSIONS:

3.1. Stable Carbon Isotope Characterization:

Several investigators, including Wickman (1952, 1953); Redding (1978); Schwartzkopf and Schoell (1985) have demonstrated that the variation of carbon isotope ratios in coals is limited to a range of about 5%0 between s13Corg -22 ‰ and -27 ‰ .The stable carbon isotope composition of seven coalfields is shown in Figure-1. The δ^{13}C values fall in a very narrow range: -26.7 ‰ to -23.9 ‰. Three of the seven coalfields namely, Katha-Pale, Lakhra and Cherat show a very consistent isotopic composition around -24.9 ± 0.2 ‰. The Makarwal and Sharigh coals have comparable carbon isotopic values and are 0.5 ‰enriched in δ^{13}C than the Katha-Pale, Lakhra and Cherat coals. These values are in good agreement with those reported for Tertiary lignitic coals in Australia [Jeffery et.al., 1955]. Degari and Sor-Range coals have identical values (-26.2 ‰) and are depleted by about 1 to 1.5 ‰ than the rest of the coalfields.

Figure-2 shows the carbon isotope frequency histograms for seven coalfields. Notable is the fact that the carbon isotopic composition of all lignitic coals is comparable to that normally found for the starting material i.e. peat (δ^{13}C ~ -25 ‰). Coalification i.e. transition of peat (initial stage) through lignite (intermediate stage) to bituminous coal and anthracite, is activated by decomposition of plant debris through biochemical processes and later with increasing burial geochemical reactions. These reactions cause depletion in the C, H, O and N contents of the altering peat. These elements are given off in the form of water, CO_2 and CH_4, higher hydrocarbons and nitrogen. Because hydrogen and oxygen that split off during this reaction are bonded to the carbon which is removed from the residual molecule through splitting of C - C bond, one might expect carbon isotope effects to occur during the process of coalification. However, these effects have been reported to be very small [Jeffery, et.al., 1955].

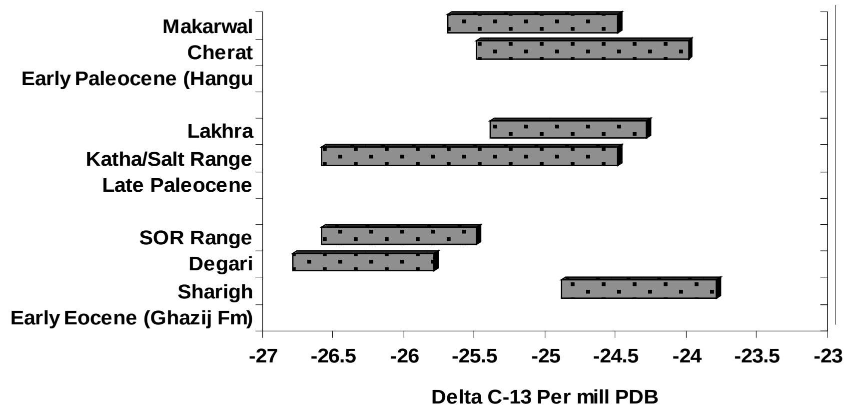
Figure-2: Carbon isotope frequency histogram of coal samples



The observed variations in the stable carbon isotope composition of coal may then be discussed in view of the type of photosynthetic cycle for assimilation of environmental CO_2 in plants responsible for peat formation. For example, plants following the Calvin or C3 cycle of carbon fixation have a $\delta^{13}C$ variations around -27 ± 5 ‰. Those following the Hatch-Slack or C4 cycle have variations around -13 ± 4 ‰. The CAM (Crassulacean Acid Metabolism) plants show a large spread around -17 ‰. The terrestrial wood has variations around -25 ± 5 ‰. Thus, the observed range of d13C values between -23.9 ‰ to -26.7 ‰ (Fig. 3) indicate that Tertiary coals have been formed from burial of plants which mainly represent the Calvin Cycle of photosynthesis.

Significant carbon isotope difference is observed between Sharigh coals and the isotopically identical Degari and Sor-Range coals. The former is 1.8 ‰enriched in $\delta^{13}C$ than the later two coalfields. All the three coalfields pertain to the Eocene age. The vegetation responsible for peat formation grew under deltaic to fluviatile conditions (Ahmed et.al., 1986). The isotopic differences in these coalfields which are widely separated may be explained from the existence of different plant-biotope or the depositional environments. Thus, the Sharigh coal may be expected to form from C3 plants which were either isotopically heavier than the C3 plants grown at Degari and Sor-Range fields at the time of peat formation. Another and rather more promising explanation for this difference may be the possibility that with similar plant biotope, the Degari/Sor-Range coal was formed in deltaic to fluviatile / terrestrial environments whereas the Sharigh coal was formed in marine / estuarine environments in which the plants assimilated marine bicarbonate ion or the CO_2 produced from hydrolysis of bicarbonate ion. A better determination of spatial trends of $\delta^{13}C$ at these coalfields is required to validate the second hypothesis. Figure-3 shows a fairly constant distribution of carbon isotope composition on the geological time scale. This suggests that during the Tertiary regime, the carbon isotope composition of the carbon dioxide source of the plant material and that of the atmosphere did not occur. These observations are in agreement with those of Craig [1953] who found no time or spatial distribution in the analysis of a number of individual samples ranging through the upper Paleozoic and Tertiary.

Figure-3: Variation of Carbon Isotopic composition of coal in tertiary period



3.2. Chemical Characterization:

Two coal samples from Makarwal area were analyzed for same elements using SARM reference coal standards for calibration. The results of XRFS analyses are recorded in Table-1. The amount of Al, S, K, V, Cr, Co, Ni, Cd, Ba and Pb in both the samples is of the same order of magnitude whereas Ca, Ti, Cu and U are more in Sample-A than in Sample-B. However, the concentrations of Fe, Mn, and Zn are higher in Sample-B. From environmental point of view, the percentage of S around 5 - 7 % is noteworthy in these coal samples. These values are in agreement with previously reported results [Ahmed et.al., 1986]. The qualitative XRD analysis on these samples indicates that sulphur is present in the form of pyrite. Moreover, the toxic elements like Cr, Cd and Pb are present at µg/g level. The concentration of Cr is > 80 µg/g and Cd is <39 µg/g and of Pb is around 20 µg/g.

The measured elemental concentrations in Makarwal coal are also compared with the NBS-Coal standards namely: SRM-1632 and SRM-1633 [Nadkarni, 1980] and with NBS-1635, KY # 9ASTM and IL # 6-ASTM [Lindahl, 1981]. The concentrations of Ti and U in Sample-A are in agreement with the best values of their concentrations reported for NBS coal standards, SRM-1633 and of Cu in SRM-1632. The concentrations of Al and U in Sample-B are in the same order of magnitude as the best value reported for these elements in SRM-1632 and of Cr in SRM-1633. Moreover, the concentration of Co, Ni and Pb in both Makarwal samples are similar to those reported for SRM-1632 and SRM-1633 coal standards. The concentration of Fe in Sample-B and of Ti in Sample-A are similar to their respective amounts analyzed in high Ca coal [Nadkarni, 1980]. Our value for Cu in Sample-B is comparable with those reported in KY # 9ASTM and in IL # 6ASTM and of Mn with NBS-1635 coal standard. The concentration of Zn in Sample-A is similar to that determined in NBS-1635 and in Eastern ASTM Coal [Lindahl, 1981].

4. CONCLUSIONS:

Carbon Isotope Variations : The $\delta^{13}C$ values of sampled Tertiary coals in Pakistan fall within a narrow range. Their mean stable carbon isotopic compositions close to the mean isotopic values of peat suggest that the coals are of lignitic grade. However, the range of carbon isotopic composition and the existence of any changes during the process of coalification in each coalfield can further be validated upon a detailed comparison of a large number of coal samples.

Paleo-vegetation : The observed range of variations in the carbon isotope composition of coal from various coalfields in Pakistan is indicative of C3 type of vegetation / plants responsible for the formation of Tertiary coals.

Depositional Environments : It is speculated that the plants responsible for peat formation at Sharigh coalfield grew under marine/deltaic environments and thus used in addition to environmental CO_2, the carbon of marine bicarbonate ion / CO_2 produced from hydrolysis of bicarbonates. The Degari and Sor-Range coalfields were formed under deltaic to fluviatile / terrestrial environments.

Paleo-environments : No systematic carbon isotope changes are observed during the Tertiary regime thereby indicating consistent carbon isotope composition of atmospheric CO_2 during this period.

Environmental Pollution and Engineering Concerns : Based on the elemental and mineralogical analyses, it is observed that the Makarwal coal matrix contains significant contents of toxic materials such as Pb, Mn, Cd, Cr and sulphur as pyrite. Thus, the use of this coal for thermal power plants may require significant purification processes for the safety of thermal power plants and to exclude possibilities of acid rain in surrounding environments from pyritic sulphur as it is between 5 - 7 percent in this coal.

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ENERCON AND LOW CARBON ECONOMY

By

Asif Masood*

ABSTRACT

A low Carbon Economy (LCE) is a popular term that refers to an economy which has a minimal output of Green House Gases (GHG's) emission into biosphere, but specifically refers to the Green House Gas (Carbon dioxide CO_2). The latest study evolving the scientific and public opinion has come to the conclusion that there is an un–reasonable accumulation of GHG's (especially CO_2) in the atmosphere. The aim of Low Carbon Economy (LCE) is to integrate all aspects of itself from its manufacturing, agriculture, transportation and power generation around technologies that produce energy and material with little GHG's emission, thus around populations, buildings, machines and devices which use those energies & material efficiently and dispose or recycle its waste to have minimal output of Green House Gases (GHG's).

LOW CARBON ECONOMY (LCE) IN TRANSPORT SECTOR

Ambient air quality in major cities of Pakistan is constantly deteriorating due to urbanization and industrialization as well as growing commercial and transportation activities. The un-desirable carbon emissions from motorized vehicles in Pakistan is approximately 5 million plus and increasing @ 6% annually. The air pollution problem in major cities gets aggravated due to continued use of aged vehicles with worn out engines, poor maintenance, over loading and adulteration of fuel.

INTRODUCTION

The increasing concentration of Green House Gases (GHG's) is warming the earth's atmosphere. The phenomenon is called climate change or global warming. This is among the most pervasive threats to the life. It has dynamic impacts on functioning & structure of eco-system which reduces the productivity and has negative impact on the species and their habits, it also adversely affects water availability, food security, human health & well being. The climate change threatens economic development and has considerable negative effects on various socio-economic sector of society.

CLEAN DEVELOPMENT MECHANISM (CDM)

United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 at Earth Summit in Rio de Janeiro. It aims at stabilization of GHG's concentration in the atmosphere at a level that would prevent dangerous human-induced interference with the natural climate system. UNFCCC was signed by 154 states including Pakistan and entered into force on 21st March 1994. Kyoto Protocol was adopted under the UNFCCC in 1997 to mitigate climate change effects by legally binding the developed countries to reduce their combined GHG emissions by at least 5.2% below 1990 levels during the first commitment period (2008 to 2012).

Among the various mechanisms, the Clean Development Mechanism (CDM) was introduced under the Protocol specifically for developing countries to achieve their sustainable development goals, while at the same time mitigating climate change. CDM allows the developed countries to acquire Certified Emission Reductions (CERs) resulting from project activities implemented in the developing countries. CDM is a great opportunity for developing countries, which can generate additional revenue from sales of CERs, along with other sustainable development and environmental benefits.

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*Chief Technical Officer ENERCON / ECF

LOW CARBON EMISSIONS

Most of the automobiles exhaust carbon dioxide (CO_2) and water vapors (H_2O). CO_2 is the most important anthropogenic green house gas and increases in carbon dioxide concentration primarily due to fossil fuels.

TRANSPORT

The amount of road cargo and automobiles traffic is increasing. The increase is the consequence of a higher number of vehicles and increased average number of Kilometers driven. The number of passenger's kilometers in public road transport is decreasing. The number of vehicles on the road has increased rapidly in the past decade only due to introduction of leasing and car financing companies in all cities of Pakistan. Transport account for rapidly growing percentage of overall GHG emissions. Theoretically transport is very attractive sector in terms of mitigation, individual projects might be to large scale for Clean Development Mechanism (CDM) which include road to rail modality shift, replacement of 2 strokes by 4 stroke engines and vehicles using green fuel like CNG.

MITIGATION OPTIONS

Mitigation of GHG's emissions in transport sector can be achieved through a combination of following measures.

- There is need to introduce attractive transportation options that include fuel efficient automobiles/devices to control carbon emissions and increase the fuel economy.
- Efficient and affordable public transport, mini cars and 4 stroke engines in two wheelers. In addition to this, policies should address externalities caused by vehicles and force drivers to face full social cost of their use through permits and fees to enter cities, parking fees, road tolls and in general, raise public awareness.
- The government should also attempt to make available to the user an alternative to fossil fuels by creating Cycling culture, linking Rails and Bus services and rewarding car sharing programs.

There are number of options available to mitigate the Green House Gases (GHG's) to reduce the carbon emissions for Clean Development Mechanism (CDM), like introducing Battery Operated Vehicles (BOV's), Mass Rapid Transport System (MRT's), CNG Buses, CNG Cars and efficient devices for fuel efficiency to control carbon emissions.

STRENGTHENING THE INSTITUTION OF MOTOR VEHICLE EXAMINATION (MVE's)

The comprehensive plan for inspection and certification of vehicles will be introduced by ENERCON to strengthening the institution of Motor Vehicle Examiner's (MVE's). As a part of this phase ENERCON will establish a model inspection and certification centers using project fund or with donor support. The center will standardize inspection procedures and provide training and support to MVE's in private sector and concerned police staff. The formation of advisory board at district level has been recommended to ensure proper check & balance on the working of MVE's and private inspection facilities.

INSPECTION SYSTEM OBJECTIVES OF MOTOR VEHICLE

The motor vehicle inspection system is normally to strengthen and streamline the following objectives:

- Enhance awareness of motor vehicle safety.
- To reduce the carbon emissions from environment.
- Reduce road traffic accidents.
- Conduct carbon emissions inspection based on National Environmental Quality Standards (NEQS).

FINDING AND ANALYSIS

Transport pollution causing health hazards and smoke emitting vehicles are identified as source of Hydro carbons, Carbon dioxide (CO_2), Carbon mono-oxide, Sulpher and Nitrogen oxide. Thus, it is imperative to have effective and comprehensive motor vehicle inspection system, in order to improve low carbon economy & environment conditions and enhance public health and safety. Some of the findings are as follows:

- Existing vehicles inspection system can be improved by involving private sector.
- Private investment can be achieved by only practical demonstration.
- Motor vehicles ordinance 1965 and motor vehicles Rule 1969 has not been implemented in true spirit in the country.
- No specific arrangements exist for coordinating motor vehicle inspection or certification.

FUEL EFFICIENCY IN ROAD TRANSPORT SECTOR (FERTS) PROJECT

ENERCON has set up computerized tune-up centers through out the country, where through tuning of engines & by good house keeping of vehicles, 10% fuel can be saved and noxious exhaust emissions can be reduced by 60% thus, reducing air pollution and Green House Gases (GHG's). By introducing Fuel Efficiency in Road Transport Sector (FERTS) only 14% of total vehicles population was covered from this project. There is dire need to establish more tune-up centers to improve quality of repair & maintenance of vehicles.

MODEL INSPECTION CENTER

In later, 90's Hydrocarbon Development Institute of Pakistan (HDIP) had established a model CNG station. This station has facilitated and expedited the process of setting up CNG stations in private sectors. The experience can be replicated to facilitate private sector investment in modern vehicle inspection in Pakistan to improve inspection practices, it also improves the quality of maintenance and repair along with cleaner and healthier environment. The objectives are:

- To demonstrate economic feasibility of setting up similar stations by private sector in the country.
- To facilitate investment in modern maintenance and repair shops.
- To establish government / Private sector partnership at district level.
- To provide technical support to prospective investors on the sources and functions of inspection equipment.
- To demonstrate benefits of an improved inspection system.

LOW CARBON FUELS

Transportation accounts for at least 40% of Pakistan's Annual Green House Gases emissions, mostly Pakistan relies on petroleum based fuels for 85% of its transportation needs. The government requires adopting the measures to introduce low carbon fuels; the Low Carbon Fuels (LCF) will produce 10% reduction in GHG's emissions from production and use of fuels in vehicles.

GREEN VEHICLES

Green vehicles are considered to be more Environmental Friendly than traditional petroleum internal combustion engine vehicles. The conventional vehicles can also become greener by mixing renewable fuels. Typical gasoline cars can handle up to 15% ethanol. Diesel powered vehicles can completely be converted to Bio-Diesel.

BIO-DIESEL

Bio-Diesel is an environmental friendly, biodegradable fuel derived from renewable and non-depleting resources. It is defined as fatty acids derived from vegetable oils or animal's fats. It can be used in pure form as well as a blend with regular diesel. Regular diesel mixed with 20% Bio-Diesel is called B20.

SOURCES

1. Non – Edible oil seeds
    - Pongamia Pinnata (Sukh Chane)
    - Jatropha (Jamal Ghota)
    - Castor Bean (Hernoli, Arind)
2. Waste Vegetable Oil
3. Animal Fats
4. Edible Oil Seeds
    - Soybean
    - Sunflower
    - Canola
    - Mustard

APPLICATIONS

- No modification in existing Diesel Engines is required for employment of up to 20% blend of Bio-Diesel (B20).
- Electricity can be produced through generator running on 100% Bio-Diesel in remote areas.
- Agricultural machinery.
- Industrial engines.

BENEFITS OF BIO-DIESEL

- It decreases country's dependence on imported Diesel oil.
- Bio-Diesel is renewable source of energy.
- The exhaust emissions from Bio-Diesel are lower than regular Diesel fuel. Bio-Diesel provides substantial reductions in carbon monoxide, unburned hydrocarbons and particulate emissions.
- Bio-Diesel contributes less to global warming when compared to Diesel oil.
- Bio-Diesel has excellent lubricating properties. Even when added 1 to 2%, it can convert fuel with poor lubricant properties (such as modern ultra-low-sulfur Diesel) into an acceptable fuel.

BIO-DIESEL PRODUCTION

- Extraction of oil from seeds through oil expeller or seed press.
- Vegetable oil chemically reacts with an alcohol in presence of a catalyst (sodium or potassium hydroxide).
- This produces Bio-Diesel and Glycerol as by product.

ETHANOL

Ethanol is extracted from molasses, which is a by product of sugar industry. Mixing of ethyl alcohol in petrol by 30% can run motors without requiring alteration in engines. Pakistan has been a leading exporter of molasses from 1998 to 2004, but now local industry finds itself at a cross road, deciding whether to keep exporting molasses in the raw form or extract industrial alcohol from it to earn three time more foreign exchange. It is confirmed that molasses could be used effectively to produce petrol, ethanol fuel which is renewable and more efficient.

BENEFITS OF ETHANOL

- It reduces country's dependence on imported oils.
- Ethanol is renewable and more efficient.
- Ethanol or industrial alcohol is also used to manufacture medicines.
- It reduces the carbon emissions and is more environment friendly.
- It will increase the rate of foreign exchange three times from its exports.

PRODUCTION OF ETHANOL

Ethanol is recovered from molasses and is estimated at 240 to 270 liters per tones depending on its quality. Processing entire 2 million tones of molasses that Pakistan produces approximately 500 million liters (0.4 million tones) of Ethyl alcohol can be extracted which can bring $160 million if exported at an average of $400 per tones and most importantly can produce additional 160,000 tones of fuel by mixing 10% of Ethanol in petrol without loosing additional dollar on import.

REASONS FOR FAILURE IN PAKISTAN

Pakistan has potential to expand its Ethanol production using its vast sugar cane resources, but many challenges lie ahead. Soaring crude oil prices give strong incentives to investors to seek cheap alternative forms of energy, as Ethanol. Pakistan has great potential to produce Ethanol to satisfy its energy need, but there are many hurdles:

- Pakistan sugar market is heavily regulated, making it difficult to forecast local cane derived ethanol prices.
- Policy would have to be laid down to give strong incentives for Biofuel investments to take-off.
- There is no policy to promote the blend of Ethanol with petrol.
- Pakistan has 80 sugar mills but only few of them can extract industrial alcohol or Ethanol.

ADVANTAGES OF GREEN VEHICLES USE

Vehicle emissions contribute to increasing concentration of gases that are leading to climate change. The principal Green House Gases (GHG's) associated with road transport are Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O). The transport sector is the fastest growing source of Green House Gases (GHG's).

RECOMMENDATIONS

The following is recommended in order to achieve low carbon economy:

- Increased focus on fuel efficient vehicles, shapes and configurations specially hybrid engine vehicles.
- More alternative and fuel efficient vehicles to be introduced (Less than 1300cc).
- Driver training for more fuel efficiency.
- Low carbon Bio fuels cellulosic (Bio-Diesel, Ethanol, Bio-Butanol)
- Less international trade of physical objects, despite more overall trade.
- Promote use of blended fuel with attractive fuel price.

CONCLUSION

It is a dire need to globally implement Low Carbon Economy (LCE) to avoid catastrophic climate change and as a precursor to an ideal Zero-Carbon Economy, with the continuing research and development in the world, new inventions may come up to fight the harmful emissions polluting the atmosphere, but in the end it is mankind itself which has created this monster. To kill it or reduce its magnitude, joint & consistent efforts from each member of the mankind are necessary, essential and inescapable. No one can get away on the pretext of ignorance because, "IGNORANCE IS SIN".

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