Environmental accountability for a sustainable Earth

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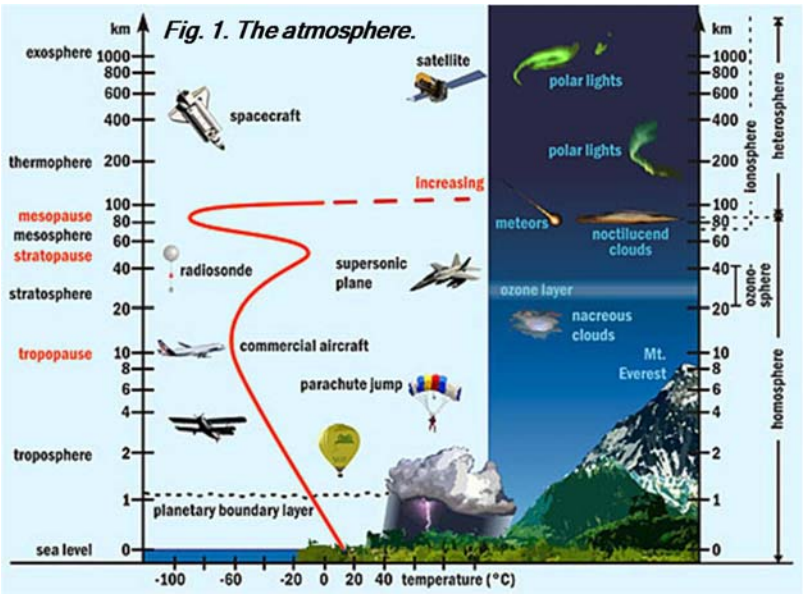
Abstract

In the present state of the world, the space age, human beings who are the trustees of the earth have a duty to bequeath a clean mother earth to nurture all living beings. We must rally and inspire a grand effort for earth, and an earth campaign that will eliminate poverty and pollution and bring new freedom, order and opportunity. Climate is changing due to human activity. Unless we act now, our children will inherit a hotter world, dirtier air and water, more severe floods and droughts and more wildfires. Potential increase of about 2.5 to 10 degrees Fahrenheit per year is observed. Air pollution affects everyone. Motor vehicle pollution has been substantially reduced with the help of advanced emission control technologies. A common approach to continuous improvement is needed to build a sustainable earth.

Keywords: Global warming, green house effect, climate change, thermal equilibrium, acid rain, carbon off-set, energy.

Introduction

Earth is the third planet from the sun. Earth is divided into several layers which have distinct chemicals and seismic properties. The inner core and crust are solid; the outer core and mantle layers are semi fluid. The core is composed mostly of iron and some lighter elements. Temperature at the center of the core may be as high as 7500°C, hotter than the surface of the sun (6000°C). The lower mantle is mostly silicon, magnesium and oxygen with some iron, calcium and aluminum. The upper mantle is olivine and pyroxene (iron magnesium silicate), aluminum and calcium. Taken as a whole, the earth's chemical composition is approximately 35% iron, 30% oxygen, 15% silicon, 13% magnesium, 3% nickel, 2% sulfur and 0.1% titanium. Earth's atmosphere shown in Fig.1 clearly identifies the troposphere (up to 10 km from the sea level), stratosphere (up to 50 km from the sea level), mesosphere (up to 90 km from the sea level) and above that is ionosphere, i.e.: thermosphere and exosphere (up to 1000 km). The troposphere to mesosphere is also called homosphere and the mesosphere to ionosphere is called heterosphere. Increased concentration of CO_2 in the atmosphere and reduced levels of ozone layer in the upper layers are concerns of today.



Energy balance & thermal equilibrium in the atmosphere

Short wave length (optical wave length) radiation from the sun reaches the top of the atmosphere. Clouds reflect 17% back into space. If the earth gets cloudier, more radiation will be reflected back and less will reach the surface. 8% is scattered backward by air molecules. 6% is directly reflected off the surface back into space. So the total reflectivity of the earth is 31%. This is technically known as an Albedo. During ice ages, the Albedo of the earth increases as more of its surface is reflective. What happens to the 69% of the incoming radiation that doesn't get reflection back: 19% gets observed directly by dust, ozone and water vapour in the atmosphere (stratosphere). Loss of stratospheric ozone is causing the stratosphere to cool with time, which, of course, greatly confusing the issue of global warming. 4% gets absorbed by clouds located in the lower part of the earth's atmosphere where weather happens (troposphere). The remaining 46% of the sun light reaches the surface. The earth wants to stay in thermal equilibrium (27°C), it must re-radiate the energy (Fig. 2).

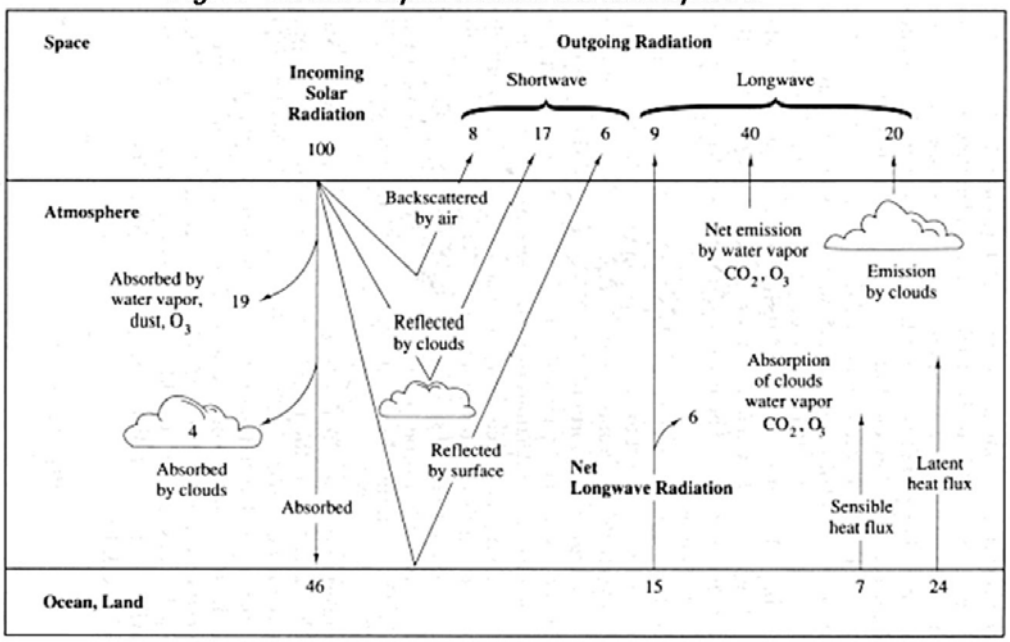
The wavelength of the emitted radiation is in the infrared. If it all went directly into space, the earth would be a significantly colder place than it is. This heat is later released to condensation. At a few meters below at the surface of the earth, the temperature is nearly constant because of this low heat flex. So clearly, if human activity increases the ability of the earth's atmosphere to absorb infrared radiation increases, this produces a net warming of the atmosphere over time. This is the enhanced green house effect.

Greenhouse effect

Greenhouse effect is one of earth's natural

processes to regulate the temperature of our planet. It is essential for life on earth and is unquestionably real. It is a result of heat absorption by greenhouse gases (carbon dioxide, methane, oxides of nitrogen and chloro fluro carbon-CFC) in the lower atmosphere and re-radiation downward of some of that heat. Without a natural greenhouse effect, the temperature of the earth would be about 0°F (-18°C) instead of it present 57°F (14°C). So, the concern is not with the fact that we have a greenhouse effect, but whether human activities are leading to an enhancement of the greenhouse effect by the emission of more and more greenhouse gases through fossil fuel combustion and deforestation. Carbon dioxide from combustion of coal, oil and gas concentration is increasing at a rate of 1.9 ppm/year since 2000. The pre-industrial level of CO_2 was about 280 ppm and the current level is about 380 ppm. IPCC projects the growth range from 490 ppm to 1260 ppm by the end of 21st century.

Fig. 2. Thermal equilibrium in the atmosphere.



Global warming

Carbon dioxide and other air pollution that is collected in the atmosphere, like a thick blanket, trap the sun's heat and cause the planet to warm up. Coal-burning power plants are the largest U.S. source of carbon dioxide pollution–they produce 2.5 billion tons every year. Automobiles, the second largest source, create nearly 1.5 billion tons of CO_2 annually. Technologies exist today to make cars that run cleaner and burn less gas, modernize power plants and generate electricity from non-polluting sources, and cut our electricity. Global warming is already causing damage in many parts of the US. Of course, the impacts of global warming are not limited to the US in 2003; extreme heat waves caused more than 20,000 deaths in Europe and more than 1,500 deaths in India. And in what scientist regard as an alarming sign of events to come, the area of the Arctic's perennial polar ice cap is declining at the rate of 9% per decade. Global warming doesn't create hurricanes, but it does make them stronger and more dangerous. Because the ocean is getting warmer, tropical storms can pick up more energy and become more powerful. So global warming could turn say a category 3 storm into a much more dangerous category 4 storm. In fact, scientists have found that the destructive potential of hurricanes has greatly increased along with ocean temperature over the past 35 years. Global warming is a complex phenomenon, and its full-scale impacts are hard to predict far in advance.

Climate change

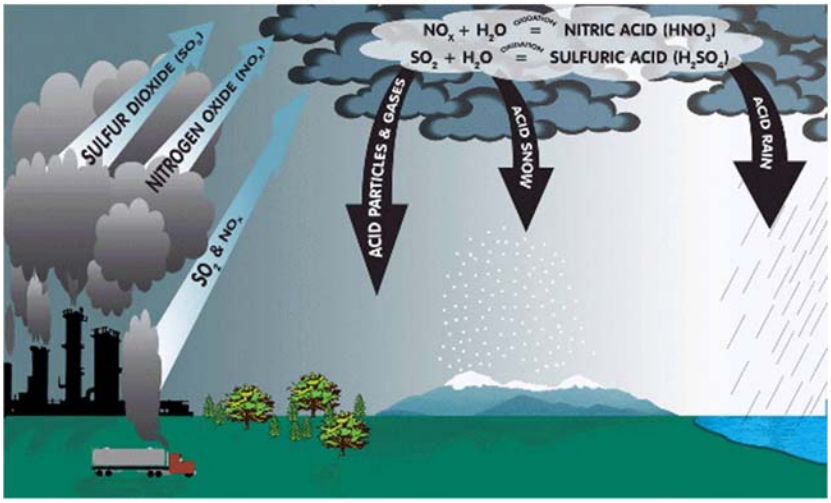
Global climate models describe how the atmosphere, the oceans, the land, living things, ice and energy from the sun. Other models take in to account of many factors of the atmosphere, biosphere, giosphere, hydrosphere and cryosphere to model the entire earth system. Burning materials releases CO_2 and other GHG into the atmosphere. Climate change is a serious threat to everywhere. The warming of our climate system is directly linked to human activity. Slowing or even reversing the existing trend of global warming is the defining challenge of our ages. Warming of the climate system is unequivocal. Increasing global air and ocean temperatures, rising global average sea level, reduction of snow and ice are changes we are facing today. Globally the area. Rate of global average sea level has risen from 1.8 mm/year to 3.1 mm/year from 1961 to 1993. The reasons for sea level rise have been due to thermal expansion, melting glaciers,ice caps and the polar ice sheets. Projected sea level rise at the end of 21st century will be 18 to 59 cm.

Acid rain

Acid rain also called acid precipitation or acid deposition, acid rain is precipitation containing harmful amounts of nitric and sulfuric acids formed primarily by sulfur dioxide and nitrogen oxides released into the atmosphere when fossil fuels are burned. It can be wet precipitation (rain, snow or fog) or dry precipitation (absorbed gaseous & particulate matter, aerosol particles or dust). Acid rain (Fig. 3) has a pH below 5.6. Normal rain has a pH of about 5.6, which is slightly acidic. The term pH is a measure of acidity or alkalinity and ranges

from 0 to 14. A pH measurement of 7 is regarded as neutral. Measurements below 7 indicate increased acidity, while those above indicate increased alkalinity.

Fig. 3. Acid rain.



Carbon off-set

Carbon offsetting is the act of mitigating GHG emissions. A well known example is the purchasing of offsets to compensate for the GHG emissions from personal air travel. The idea of paying for emissions reductions elsewhere instead of reducing ones own emission is known as emissions trading. Carbon offsets refer to voluntary acts by individuals or companies that are arranged by commercial or non- profit carbon-offset providers. Tree planting was a mainstay of carbon offsetting. Renewable energy, energy conservation and methane capture have now become popular. Offsets may be cheaper or more convenient alternatives to reducing fuel consumption. This can produce higher carbon sequestration rates because the level of carbon in such land is comparatively low. Trees provide other benefits in addition to capturing CO_2, such as providing organics mal habitants, providing renewable resources, such as building materials and preventing soil erosion. Tree sequesters carbon through photosynthesis, converting CO_2 and water into molecular oxygen and plant organic matter, such as carbohydrate. Hence, forests that grow in area or density and thus increase in organic biomass will reduce atmospheric CO_2 level. In 2001 assessment, IPCC estimated the potential of mitigation on the order of 100Gt CO_2 eq by 2050 mainly by trees.

Environment

Environment is not "out there", it is the air we breathe, the water we drink and the places we live, work and play. There are many opportunities, including technological options, to reduce near-term emissions, but barriers to their deployment exist and cost estimates vary greatly. Local, regional and global environmental issues are inextricably linked and affect sustainable development-climate change, loss of biodiversity; stratospheric ozone depletion, desertification, freshwater availability and air quality are all inter-linked. Unless we, all humans on Earth become truly ecologically and socially sustainable, only a few of us (in person or in our progeny) can hope to survive the current crises that humanity is facing.

Environmental pollution

Environmental pollution is a very big challenge we are faced with today. It threatens the health of human beings and other living things on our planet. It can be particularly harmful to people with existing lung or heart disease, the elderly and the very young. Levels, extent and duration of exposure, age, individual susceptibility and other factors play a significant role in determining whether or not someone will experience pollution-related health problems. Air pollutants-called "air toxics"-are known or suspected to cause cancer or other serious health effects, such as damage to respiratory or nervous systems. Air toxics include metals, particles, and certain vapours from fuels and other sources. World Health Organization (WHO) estimated about 800,000 people die per year due to fine particle matter inhalation. A benefit of $ 175B is expected at the cost of $ 11B. Air pollution has many sources. Some sources are obvious-like industrial smokestacks, chemical plants, automobiles, trucks, and buses. Others are not so obvious-like gasoline stations; dry-cleaners; outboard motors; lawn, garden, farm, and construction equipment engines; certain paints; and various household products.

Agriculture

Agricultural lands occupy about 40 to 50% of the earth's land surface. Agriculture accounted for an estimated emission of 5.1 to 6.1 GtCO_2-eq/yr. About 10 to 12% of total global anthropogenic emissions of GHGs. CH_4 contributes 3.3 Gt CO_2-eq/yr and N_2O contributes 2.8 Gt CO_2-eq/yr. Agricultural CH_4 and N_2O emissions have increased by nearly 17% from 1990 to 2005, an average emission increase of about 60 Mt CO_2-eq/yr. A variety of options exists for mitigation of GHG emissions in agriculture improved agronomic practices, nutrient use tillage, residue management, restoration of organic soils are the most prominent option. Many mitigation opportunities can be implemented by technological improvements. Current initiatives suggest that synergy between climate change policies; sustainable development and improvements of environmental quality will likely lead the way forward to realize the mitigation potential in agriculture.

Waste management

Post-consumer waste contributes less than 5% GHG emissions (1300 Mt CO_2-eq/yr). The largest source is landfill methane (CH_4) followed by waste water CH_4 and N_2O in addition to minor emission of N_2O result from incineration of waste containing fossil carbon. A range of

environmentally effective technologies are available to mitigate GHGs in this sector.

Energy

Energy conservation and efficiency go a long way preserving our planet's rich natural resources and promoting a healthy environment. We all can play a vital role to reduce demand, cut energy cost, and protect our precious natural resources. Combustion of fossil fuel continues to dominate a global energy market that is striving to meet the ever-increasing demand for heat, electricity and transport fuels. Green house gas emissions from fossil fuels have increased despite greater deployment of low-and zero-carbon technologies. Global dependents on fossil fuels has led to the release of over 1100 Gt CO_2 in to the atmosphere since the mid of 19th century. 70% of the total GHG emissions are from fossil fuel combustion for heat supply, electricity generation and transport. Comprehensive renewable energy promotion approach should be lounged wherever needed. Future investment in R&D should determine,

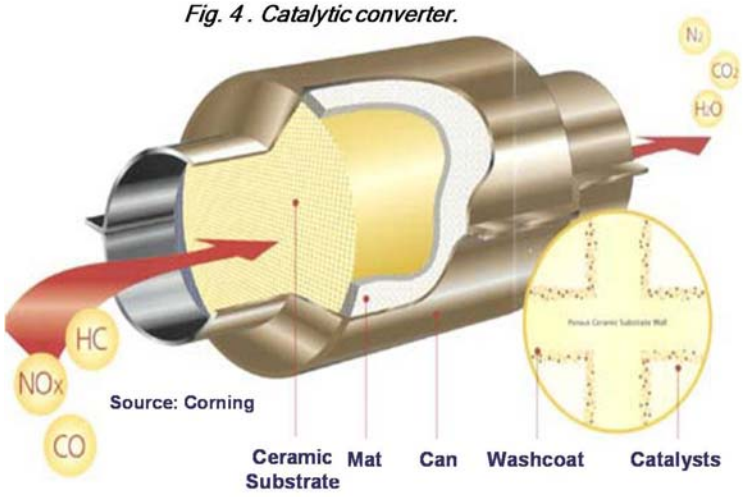
- Future security of energy supplies
- Accessibility, availability and afordabity of energy services
- Attainment of sustainable development
- Free market of energy supply to all countries
- Deployment of low-carbon energy carriers and conversion technologies
- The quantity of GHG emitted for the rest of the century
- Achievement of GHG stabilization concentration levels

Cross-disciplinary collaboration between many scientific area, including applied research and social science, are needed for successful introduction of new energy supply and end-use technologies necessary to combat the unprecedented challenge of supporting human growth and progress while protecting global and local environments. There is no single area of research that will secure a reliable future supply of energy. A diverse range of energy sources will be utilized and hence a broad range of fundamental research will be needed. Setting global priorities for technology development should be based on quantitative assessment of possible emissions and their abatement paths.

Transport

Transport activity, a key component of economic development and human welfare, is increasing around the world as economics grow. Economic development and transport are inextricably linked. Development increases transport demand, while availability of transport stimulates even more development by allowing trade and economic specialization. Industrialization and growing specialization have created the need for large shipments of goods and materials over substantial distances; accelerating globalization has greatly increased these flows. Urbanization has been extremely rapid in the past century. About 75% of the people in the industrialized world and 40% of the developing world now live in urban areas. Cities have grown larger The result has been a rapid increase in vehicles-not only cars but also 2-wheelers- and a declining share of transit. Transport predominantly relies on a single fossil resource, petroleum that supplies 95% of the total energy used by world transport. Transport activity is expected to grow robustly over the next decades unless there is a major shift away from current patent of energy use, world transport energy use is projected to increase at the rate of about 2% per year, with a highest rate of growth in the emerging economics, and total transport energy use and carbon emissions is projected to be about 80% higher than current levels by 2030.

Fig. 4 . Catalytic converter.



Air pollution control

The principal pollutants from gasoline-powered vehicles are hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx). For diesel-powered vehicles and engines, NOx and particulate matter (PM) are the principal pollutants; HC and CO are also emitted. Automobile pollution controls in the early 1970s were less sophisticated by today's standards. The introduction of advanced emission control technology, led by the catalytic converter, sparked an automotive revolution that saw the beginning of a dramatic and continuing reduction in automobile pollution that is still progressing today. The catalytic converter promotes the conversion of hydrocarbon (HC), nitrogen oxides (NOx) and carbon monoxide (CO) in the engine's exhaust into carbon dioxide (CO_2), nitrogen (N_2) and water (H_2O) vapour. A scheme of a catalytic converter is shown in Fig. 4.

The catalytic converter used on an automobile is a stainless steel canister that contains either ceramic heads or a honeycomb-like structure. There are no moving parts, just acres of interior surfaces where catalytic metals – platinum (Pt), rhodium (Rh), and/or palladium (Pt) –are uniformly deposited. The active surface area is so thin in either type of converter that less

New diesel engines are only part of the air quality challenge; existing diesel-powered vehicles and *Table 1. Major emission control milestones*

1950	California determined 13g/mile HC, 3.6 g/mile NOx and 87 g/mile CO causing smoggy skies over Los Angeles. Federal Govt. brainstormed to set air quality standard.
1964	California requires emission control systems on 1966 Model Year (MY) car.
1966	Federal Government requires emission control on all 1968 and later MY cars.
1970	Federal Government adopts first clean air act and establishes US EPA. (1975 MY cars must meet 0.41 g/mile HC, 3.4 g/mile CO, NOx 0.4 g/mile)
1971	New cars must meet evaporative emission standards (charcoal canisters to trap gasoline vapors appear).
1972	Exhaust Gas Recirculation (EGR) valves implemented to reduce NOx.
1974	Federal Government adopts the Energy Policy Conservation Act establishing the Corporate Average Fuel Economy program.
1975	First catalytic converter appears, with unleaded gasoline, to meet the HC and CO standards. Three-way catalyst strategy development to simultaneously control HC, CO and NOx.
1977	Federal Government amends the Clean Air Act. HC standard delayed until 1980, and CO and NOx until 1981.
1980	First commercial Pt/Rh Three Way Catalyst (TWC) commercialized.
1981	On Board Diagnostics (OBD) and oxygen sensors appear in most vehicles.
1985	EPA adapts stringent emission standards for diesel powered trucks and busses to take effect in 1991 and 1994.
1988	High temperature resistant catalyst formulations for TWC developed.
1989	First Pd only TWC catalyst developed and commercialized.
1990	Federal Government amends Clean Air Act with lower tailpipe HC and NOx standards, effective 1994 MY.
1992	Emission limits for CO at cold temperature (20°F) established. Oxygenated gasoline introduced.
1993	Sulfur limits on diesel fuels takes effect to reduce particulate matter emissions in diesel vehicles.
1994	Clean Air Act phase-in begins for cleaner vehicles
1998	LEV II California standards established
2002	Heavy duty Standard
2004	LEV II California standard phase-in begins
2007	Particulate Filter implemented in diesel operated vehicles
2008	Tier IV off-road standard phase-in begins
2010	New NOx standard. Introduction of NOx reduction systems in diesel vehicles

than two-tenths of a troy ounce of the metal is required. The exact combination of these noble metals differ according to the application and whether the particular converter is intended to control CO and HC or must also control NOx, in any case, by the time most of the harmful gases that enter the canister emerge from the other end, they have been changed to harmless water vapor and carbon dioxide (CO_2). Key components of this technology are the catalytic converters, advanced ignition systems, fuel injection, on-board computers, and electronic controls, indeed, since 1975; vehicles equipped with these advanced control systems have reduced pollution by over three billion tons worldwide by reducing pollution from vehicles and power plants. Right away, we should put existing technologies for building cleaner cars and more modern electricity generators into widespread use. Hybrid gas-electric engines can cut global warming pollution by one-third or more today; hybrid sedans, SUVs and trucks from several automakers are already on the market. If automakers used the technology they have right now to raise fuel economy standards for new cars and light trucks to a combined 40 m.p.g, carbon dioxide pollution would eventually drop by more than 650 millions tons per year as these vehicles replaced older models. To date, over 500 million vehicles worldwide have been equipped with catalysts and other advanced emission control technology components and by 2010 over 95% of the new automobiles sold around the world will have a catalysts converter.

Motor vehicle pollution has been substantially reduced with the help of advanced emission control technology for gasoline-powered vehicles. Over the past 33 years, EPA has effectively designed, implemented, and enforced the motor vehicle emission control program to achieve the clean air objectives mandated by Congress. The world market for emission control technologies was approximately $12 billion in the early 1990s and about $35.6 billion in 1998. In 2010, the world market is expected to approach $72.3 billion. The expanding domestic and international markets for motor vehicle emission controls, as well as other environmental products and services, will create new, high-skill and high paying jobs in the world. Advanced emission control technology has contributed to the high tech nature of today's gasoline-powered vehicles. A full range of available and emerging technologies and strategies exist to help reduce emissions. To reduce PM and/or HC, oxidation catalysts, diesel particulate filters, engine modifications, and crankcase emission controls can be employed. Catalyst – based strategies will also reduce the familiar pungent odor emitted by diesels. For NOx control, lean NOx catalysts, NOx adsorbers, selective catalytic reduction (SCR), and exhaust gas recirculation (EGR) can be employed.

equipment have remained in use for decades. Fortunately, many of the advanced diesel emission control technologies listed above can be employed to significantly reduce pollution from existing diesel engines. Over 40,000 diesel particulate filters and 550,000 oxidation catalysts have already been retrofitted on diesel engines worldwide. The key milestones of the

remarkable evolution in advanced motor vehicle emission control technology are listed (Table 1):

How to fight global warming

The biggest cause of global warming is the carbon dioxide released when fossil fuels like oil and coal for burning energy. So when you save energy, you fight global warming and save money, of course. Some of the steps to do: Raise your voice to steer the world for cleaner cars and cleaner power plans. We have to send a clear message to the policy makers that they will be accountable for what they do – or fail to do – about global warming. Choose an efficient vehicle giving higher mileage for fuel and least polluting. This cut fuel cost and fuel dependency. Drive Smart. Do not drive the car with flat tires etc. A proper tune up can boost 4 to 40% miles/gallon; a new air filter could get 10% more miles per gallon. Drive Less. Choose alternative to driving when possible (public transit, biking, walking, car pooling) and bundle your errands together to make fewer trips. Buy energy and efficiency appliances and replace light bulbs with compact fluorescence bulbs. We must use more efficient appliances and equipment in our homes and offices to reduce our electricity needs. We can also phase out the decades –old, coal-burning power plants that generate most of our electricity and replace them with cleaner plants. And we can increase our use of renewable energy sources such as wind and sun. Some states are moving in this direction:

Advanced emission control technologies

Emission control technologies for Low Emission Vehicles (LEV), Ultra Low Emission Vehicles (ULEV), Super Ultra Low Emission Vehicle (SULEV) and Partial Zero Emision Vehicles (PZEV) were developed for gasoline and diesel powered automobiles. Technologies such as oxidation catalyst, three way catalyst, lean NOx traps, particulate traps, hydro carbon traps, urea SCR and electrically heated catalyst are being used to meet the stringent emission standards.

Try to live green

The globalization of the world's people and nations, in their cultures, economics, and politics is accelerating. Those commenting on this globalization often focus on the collectivization of all individual into an organic system. A look toward the distant future, the year 3000, allows the very imaginative to think about the future without much constraint. So much has happened in only 100 years, it is not very reliable to explore trends a full millennium into the future. So, it's an earth day and time to reflect on personal practice. There are a lot of talks about innovative solutions. The objective is what you can do to achieve the results. Our family planted community supported agriculture farms to deliver fresh, organic produce. Many of our family members are serious sustainable agricultural enthusiast. Our reflection and projections should acknowledge this reality. Certain principles concerning man and his habitat can be stated as guidelines towards the future. Man's long term welfare is depended on a fruitful and resourceful environment. No individuals flourish when the habitat is degraded. The basic dignity of work by every person for physical sustenance must be coupled with environmental stewardship. This stewardship has both individual and common elements, meaning that each person has both individual and societal responsibilities in the use and enjoyment of our common habitat. Appropriate stewardship features are summed up in the concept of an earth trustee, because a trustee is one who has not only the inherent responsibility as an individual for proper earth care, but also the change to exercise earth – care function for the common good. Our view of the future, even the very distant future of the year 3000, should be seen as an exercise of prospective forecasting. We not only want to fix the future but also to help bring about the best future.

What needs to be done?

Emission control systems were implemented in the US in 1975 and in India in 1998. Due to various factors such as engine control, clean fuel availability, and emission requirements, there is a gap in the approaches. India is aggressively implementing emission control systems in new vehicles. Yet, a proactive cooperation between industries on a global basis is needed to transfer concept knowledge into confident product. India is rich in catalysis knowledge. Research and Development in National Laboratories and Technical Institutes succeeded catalyst development for various industrial applications. We need thrust initiatives on automotive catalyst development. Catalysis knowledge gained in organic and petrochemical areas are key elements for future alternate fuels and advanced emission control technologies. Product developments need to be implemented to close the gap between innovative research and industrial applications. Engineers need be trained on New Product Introduction, Product Development and Advanced Lean Manufacturing. Creative cooperation on Product Development is required between Global Industries and Science and Technology Research and Development Organizations.

We all can agree that we have only one Earth- a miracle planet teeming with life. With our amazing technology and awareness of earth's raw materials and natural resources we know that poverty and pollution, the breeding of crime and corruption, can quickly be eliminated. All that is needed is the will.

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