ENERGY, ENVIRONMENTAL NEWS & VIEWS

CLIMATE CHANGE

CDM IS THE MOST VIABLE OPTION FOR CARBON EMISSION REDUCTION – PREVENTING GLOBAL WARMING

(*This article was written when Canada's CDM office was fully functional.)

Background

Dr. R. N. Pandey received his Ph.D. from Canada's most prestigious Queen's University and has 30 years of direct experience in Energy and Environment, having over 25 patents granted and several more pending. Dr. Pandey is the Director of the Research & Technology Division of Guelph Chemical, Chemisar & Maxima Laboratories and is the Chairman of the Canadian Consortium of Clean Energy & Environment.

This article presents an overview of the potential carbon emission reduction (CER) options available for meeting the challenge of global climate change. The article is particularly timely due to the recent year's meeting of the Conference of the Parties (COP-8), held in New Delhi, India. Canada's link with India is strengthening as is evident from the previous trade missions led by two of Canada's Senior Cabinet Ministers, Hon. Pierre Pettigrew, Minister of International Trade and Hon. Herb Dhaliwal, Minister of Energy. This has also recently been followed by the Premier of Ontario.

This article presents an independent view of the developments taking place globally in climate change, with particular reference to India and Canada. It also serves to promote the Clean Development Mechanism (CDM) as a means for sustainable development in India, as well as public awareness and exchange of information between the two countries.

The United Nations' Inter-Governmental Panel on Climate Change (IPCC), which engages hundreds of the world's leading scientists for reviewing the most up-to-date scientific knowledge, has confirmed that global warming does exist and is caused by six greenhouse gases (GHGs) emitted into the environment of which carbon dioxide (CO_2) is predominant (1).

About 85% of the world's energy needs are met by combustion of fossil fuels, which produce CO_2 and other pollutants such as nitrogen and sulfur oxides (NO_x and SO_x). To put this in perspective, the annual consumption of oil around the world is 20 billion barrels. Placing these barrels end to end would stretch to $1/8^{th}$ the distance between the earth and the sun (11.2 million miles). This is quite alarming. Although the fossil fuel supply is diminishing, it will remain in sufficient supply well into the 21^{st} century. Fossil fuels have been the major contributors in raising the standard of living in the industrialized world and will continue to do so.

(1) Climate Change Information Published by United Nations Environmental Program (UNEP) and UNFCC, Klaus Topfer, Executive Director, UNEP, Oct, 2001

ENERGY, ENVIRONMENTAL NEWS & VIEWS

Within the Consumption Revolution, there is now finally a hope for a Green Revolution brought about by **CDM & the Kyoto Protocol of the U.N.**

The earth's outlook for the 21st century is not promising unless corrective measures are taken to reduce the build-up of CO_2 levels in the atmosphere. The impact of global warming will affect the "cycling of seasons, water resources, extreme climate events, and an even greater impact in the more distant future." (source?) The causes and the effects of climate change are well established by the methods of science and will not be discussed any further. This article is focused on the options that are available to in solving and avoiding the upcoming problems due to climate change, such as rising sea levels resulting in coastal flooding, severe droughts, and significant changes in local climate conditions.

The damage caused by climate change will be irreversible, and the poor and developing world will be the most vulnerable to this change, though they have contributed the least to bringing about this change. The potential solution lies in the application of CDM programs to help developing countries achieve sustainable development. The World Commission on Environment and Development (the Brundtland Commission) has defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Drought in Portugal causes brushfires, 2003

Hurricane Mitch hits La Ceiba, Honduras, 1998

Desertification in Hebei Province, China, 2000

Above photographs taken from: Tibbetts, J., (2007). Driven to Extremes, *Environmental Health Perspectives*. 115(4):A196-A197

Top to bottom: AP Photos/LUSA, Paulo Barata; AP Photo/Victor R. Caivano; Mark Henley/Panos

CDM & Kyoto Protocol

Briefly, the CDM is a program of sustainable development envisioned by the United Nations. CDM was established by COP-7 in the October 29 – November 9, 2001 meetings in Marrakech. This was followed by the COP-8 meeting held October 2002 in New Delhi, India. The CDM is a cooperative instrument for cost-effective mitigation of greenhouse gases and promotion of sustainable development in developing countries. *Article 12* of the Kyoto Protocol states that, "The purpose of CDM shall be to assist parties not included in Annex 1 in achieving sustainable development."

The CDM program strictly adheres to the following rules:

1. For Annex 1 countries (developed), there is a legal binding for arresting and reversing the upward trend in GHG emissions that started 150 years ago in the Industrial Revolution.
2. The developed countries must reduce GHG emissions to at least 5.2% below their 1990 levels.
3. Each country's emission target must be achieved by the period of 2008 – 2012. It will be calculated as the average over five years.
4. Demonstrated progress is to be made by 2005 against the base year of 1990.

The CDM program is guided and administered to the Kyoto Protocol by the Executive Board of the COP. In lieu of assistance to developing countries for sustainable development, the certified Carbon Emissions Reductions, CERs, can be used by developed countries to meet their emission reduction requirement in a win-win situation in accordance with the Protocol.

The Joint Implementation (JI) program assists the projects in developed countries with the ultimate objective of greenhouse gas reductions.

Since climate change is a **global problem**, there is flexibility in choosing the location for mitigation. It has been recognized, under the protocol, that a reduction of a tonne of CO_2 in India or anywhere in the world is equivalent to mitigating a tonne of CO_2 emissions in Canada.

The question to be asked, then, is what technologies are available to reduce CO_2 emissions? This aspect is briefly discussed on the following pages.

Emerging and Available Technologies for CO_2 Reduction and Their Pitfalls

Among the various greenhouse gases (CO_2, methane, nitrous oxide, halocarbons, sulphur hexafluorine, and water vapour), CO_2 is the predominant one. The main source of anthropogenic CO_2 is from the combustion of fossil fuels. The presence of water vapour in the atmosphere is not directly affected by human activity and the halocarbons are stabilizing due to emission controls introduced under the **Montreal Protocol**. This section critically examines the technologies that will allow us to enjoy the benefit of energy in raising and maintaining the living standards of all the people in the world while reducing the CO_2 levels to avoid the effects of climate change.

There are two approaches for CO_2 reduction: **(A) Complex Technologies** and **(B) Simple Technologies**, which are briefly defined and presented below. The complex mitigation strategies are associated with large uncertainties and, for some, with safety issues. The simple technologies may be termed as "least regrets" and must be implemented first. These include improving energy efficiency, switching from coal or oil to gas, reforestation, and the most preferred renewable energy applications wherever possible.

(A) Complex Technologies

Currently perceived strategies for abatement and mitigation of CO_2 suffer from numerous uncertainties and difficulties. One prospect that could offer significant advantages is the capture and utilization by transforming CO_2 into valuable and environmentally friendly products. The problem is that CO_2 is an inert gas and its use in the molecular form is very limited in relation to the amount required for abatement.

1. **CO_2 Removal by Capture**
   The largest source of CO_2 emission in the world is the combustion of fossil fuels, coal, oil, and natural gas, which is estimated to release 22 billion tonnes of CO_2 into the atmosphere each year. The other major human-induced emission of CO_2 arises from deforestation, with a contribution of about 7 billion tonnes a year.

   CO_2 separation and recovery is expensive and source-dependent. For example, in the case of power generation, CO_2 capture is projected to increase the cost of generation of electricity by more than 30%.

ENERGY, ENVIRONMENTAL NEWS & VIEWS

2. Different Storage and Chemical Utilization Options World-Wide

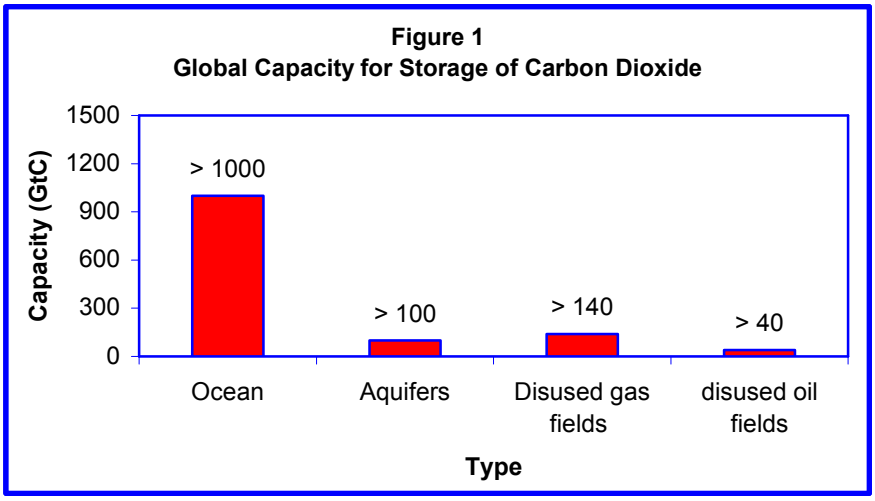
If CO_2 could be captured economically, it then must be stored or utilized. The various prominent options that are being developed for storage and utilization or CO_2 are:

- **Ocean Storage**
  There are a number of uncertainties associated with this option, such as the ecological impact on the ocean and marine environment and the final fate of ocean dumping, i.e. how long will it take for CO_2 to surface again? Also, not all countries have suitable access to deep oceans near the CO_2 emission sources.

- **Underground Storage**
  It is possible to store large quantities of CO_2 in underground reservoirs consisting of exhausted oil or gas fields. The use of aquifers is another possibility, but it is unknown if a suitable seal exists to prevent escape of the CO_2. The possible implication of this type of storage is unknown – eventual return of CO_2 to the atmosphere cannot be discounted.

  It must be possible to store CO_2 for hundreds of years, securely. Below are estimates of global capacity for storage of CO_2 (2):

Figure 1
Global Capacity for Storage of Carbon Dioxide



(2) P. Freund, "International Collaboration on Gases, Storage and Utilisation of Greenhouse Gases". Waste Management, 17, 283 (1997)

- **Forestation as a Sink of Carbon**
  Growing forests to combat CO_2 emissions is certainly a better option but the environmental impact of establishing very large-scale forests is still in question.

- **Capture and Recycle to Fuel Products**
  CO_2 already finds use in industry and could, therefore, be reused rather than released into the environment. CO_2 conversion processes to fuel and fuel additives are highly energy intensive. Edwards, by quantitative calculations, has shown that there is little or no net CO_2 reduction (3).

3. **Switching to Nuclear Fuel**
   This option has a potential for large reduction of CO_2 emissions by replacement of fossil fuels. However, in view of the dangerous nature of nuclear energy, it is not a very desirable option worldwide and, furthermore, nuclear waste disposal poses its own environmental problems.

(B) Simple Technologies

1. **Improvement in Energy Efficiency and Fuel Switching**
   The advancement in energy efficient buildings, equipment, and processes can achieve substantial improvements in energy performance and, consequently, reductions in CO_2 emissions. The major drawback of end-use-efficiency is that it is a short-term mitigation process, as there is a practical limit to achieving efficiency. Current power-generating fossil fuel systems are operating at low efficiencies. Increasing the efficiency of such power plants would require substantial capital investment.

   Another approach to reduce CO_2 emissions globally is to switch to a fuel with a lower carbon to hydrogen ratio, such as switching from coal and gasoline to natural gas, resulting in about a 15% reduction in CO_2 emissions. Switching to a single fuel is not viable on a long-term basis due to the problem of availability.

(3) J.H. Edwards, "Potential Sources of CO_2 and the Options for its Large-Scale Utilization Now and in the Future". Catalysis Today, 23, 59 (1995)

2. **Renewable Energy**
   Bio-energy (energy from biomass), small-scale hydroelectricity, photovoltaic (PV) energy (solar electric), and wind energy are examples of renewable alternative energy sources that do not contribute to greenhouse effect, global warming, or climate change.

   Wind is becoming the world's fastest growing power source. Being a renewable form of energy is a major challenge to fossil fuels, nuclear reactors, and hydroelectric power. It is possible that wind could provide 12% of the earth's electricity within two decades.

   The main drawback of solar and wind energy is the fact that it is intermittent since electrical energy cannot be stored. Thus, when the sky is cloudy and the breeze is down, the power turns off and other forms of energy must, therefore, be available. This technology is still in need of further development. One energy storage method receiving attention is to use the current from wind and solar energy to produce hydrogen from the electrolysis of water, which can be stored and used on demand.

   Numerous applications such as PV water pumps in the agricultural sector and PV lanterns and solar cookers in the domestic sector are receiving considerable interest.

Biomass Fuels

The biomass utilization in replacing fossil fuels should be a major part of any mitigation process. Howard Herzog, Elizabeth Drake, and Eric Adams of the Massachusetts Institute of Technology's Energy Laboratory have commented, "The potential for liquid fuels from biomass is more limited. Starch or oil crops used for conversion to Ethanol or Biodiesel are expensive, energy-intensive and produce only moderate (or sometimes negative) CO_2 mitigation if process energy is derived from fossil fuels. There may be niche uses because of desirability of liquid fuels." (4)

Global Power Generation

On a global basis, power generation accounts for the single largest source of CO_2 emission. The flue gas streams are large and relatively fewer in number than other sources of CO_2 emission, such as transport. Thus, CO_2 mitigation technologies can be deployed more easily in the power generation sector than elsewhere. The greatest potential for reducing CO_2 emissions lies in use of solid biomass in co-firing or stand-alone power plants (3).

(4) Herzog, H., Drake, E., & Adams, A. "A White Paper on CO_2 Capture, Reuse and Storage Technologies for Mitigating Global Climate Change". 1997. Submitted to U.S. Department of Energy

ENERGY, ENVIRONMENTAL NEWS & VIEWS

Sugarcane Bagasse & Other Biomass Energy

Among all the CO_2 mitigation options known to the world today, the use of renewable energy sources (sugarcane bagasse and other biomass materials) to displace fossil fuels is considered to be the least controversial. **Indeed, the renewable energy from biomass is necessary for life on earth.** Biomass includes all types of materials of plant origin, which can be used as renewable energy.

The most distinguished biomass residue that holds major promise to displace coal in the power plants for fuel supply is bagasse and other crop residues. Recent feasibility studies carried out in India (by a team of Canadian scientists, headed by Dr. R.N. Pandey) have confirmed the contention that sugar mill bagasse and regional biomass in the vicinity offer a rather large potential for power generation throughout the year. There are **114** sugarcane-producing countries in the world with **India**, Brazil, Cuba, China, Thailand, and Australia as the most prominent producers. Renewable power generation systems capable of utilizing bagasse, rice husks, and non-polluting agricultural fuels are needed.

Maximum potential for CERs are in developing countries. For example, there are 464 sugar mills in India alone. This offers the most cost effective conversion of biomass to electrical energy. The World Bank has indicated that there are emission reduction projects available in developing countries which would generate CERs many times that of Canada's total emission gap. Sun and wind power are also available in developing countries. It is the technological implementation which is being awaited.

Developments in India (5,6,7)

Historically, India has a 5,000 year old culture with peaceful co-existence. It is the originator of the power of non-violence and is the world's largest democracy with about 1 billion people. In recent years, India has become a major industrial power and is now the 4th largest economy in the world in terms of purchasing power parity, with a growth rate of above 6% per annum. Despite its economic progress, over 350 million people of India continue to live in poverty. Present-day energy systems rely heavily on fossil fuels, such as coal. Environmentally, India's atmosphere, water bodies and land are increasingly becoming polluted. Since its independence in 1947, India has been a recipient of Canada's assistance under International Development Programs.

Energy & Health (8)

The World Health Organization (WHO) states that, "Health and energy are interdependent factors which largely determine the progress of rural development… An energy strategy for rural areas will be critical in achieving lasting health improvements."

Opportunities for Power Generation & CO_2 Reduction in India

Recognizing the value and importance of renewable energy, India has launched a major incentive program for generation of energy from alternative sources, in which most of its provinces are participating.

Among the various options of renewable energy, sugarcane bagasse and other fast-growing biomass and crop residues are of special interest. There is no net emission of CO_2 when these biomass materials are converted to energy via combustion processes. This is due to the fact that during their earlier growth, the plants have absorbed CO_2 that is emitted during combustion. Thus, when coal is replaced by biomass to derive energy, there is a net carbon emission reduction.

(5) Canadian International Development Agency, January 2001
(6) Canadian International Development Agency, 1998
(7) Flowers. "Renewables for Sustainable Village Power". Proc. of the International Conference of Village Electrification through Renewable Energy". March 3-5, 1997, New Delhi, India
(8) WHO, Fact Sheet N132, Geneva, Switzerland (1996)

ENERGY, ENVIRONMENTAL NEWS & VIEWS

Energy & Climate

Of the total 6.1 billion world population creating anthropogenic emissions, 2.5 billion live in the developing world and have no access to modern energy. The economies of developing countries are expected to grow.

A comparison of GHG emissions per capita of different countries is illustrated in Figure 1 and CO_2 emissions total is given in Figure 2 below. It is projected that the world population will reach 9.3 billion by year 2050 and the energy demands will increase three times.

Figure 1
GHG Emission Per Capita

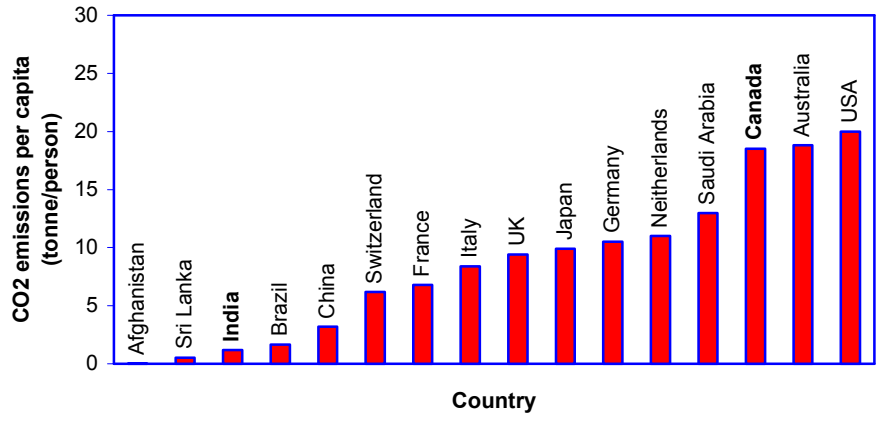
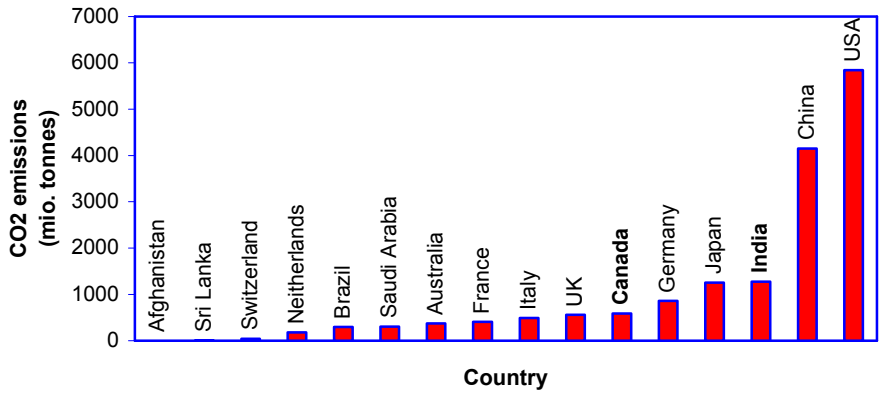


Figure 2
Total Emissions of World



As can be seen from Figure 2, Canada's total CO_2 emission is only $1/10^{th}$ of the United States emissions. The per capita (per person) CO_2 emissions for Canada, illustrated in Figure 1, have approached that of the U.S. mainly because of Canada's low population (31 million).

Canada is the second largest country in the world with an area of nearly 10,000,000 square kilometres and it is bordered on three sides by oceans. Winters are long and cold and require heating. The water resources provide hydroelectric power for domestic use and export.

The Upcoming Impact

Slowly and steadily, the developing countries, with their desire to share the prosperity enjoyed by select countries, will consume energy at rates approaching that of the U.S. as shown in Figure 1. If this demand of energy is met by the combustion of fossil fuels, then it is recognized that the world will be at peril by the tremendous impact that this will have on climate change.

It is imperative that the developing countries have growth of necessities to take care of their people by supplying food, shelter, schools and hospitals – all of which require energy. The world community, in general, and Canada in particular, is very supportive of such developments. Canada has contributed immensely towards such developments through its International Development Programs. India has already solved the problem of importation of food by agricultural and other technologies, and has achieved success in raising the standard of living of its people. The technologies for fulfilling the requirement towards development are now known, transferable, and are based on energy consumption. If the source of this present and upcoming energy demand is directed away from polluting sources to non-polluting sources, renewable sources, such as wind, solar, and biomass, the impact on global climate change shall be favourable and sustainable. The objective of Canada's CDM program is directed towards such favourable developments for the world community.

ENERGY, ENVIRONMENTAL NEWS & VIEWS

Canada's CDM Program

The CDM and Joint Implementation office of the Department of Foreign Affairs, Government of Canada, has taken a lead to facilitate sustainable development. One such development is in South Asia where GHG reduction targets can be achieved via transfer of Canadian expertise and technology to realize Canada's long-term International Development goals.

Canada's recently held workshop in New Delhi, India for South East Asia highlights Canada's mission towards CDM & Sustainable Development of the Developing World.

Simple Solutions to the Complex Climate Change Problem

Complex CO_2 mitigation technologies such as CO_2 capture, ocean dumping, and underground storage have numerous uncertainties and are still in the process of development. **Priority must be given to the proven companion mitigation solutions**, which include:

- Increase in Energy Efficiency,
- Energy Conservation,
- Change of Lifestyle,
- Growing Biomass, and
- The use of all forms of Renewable Energy.

Renewable Energy

India is the world's largest producer of sugarcane and has about 465 sugar mills with 120 of these located in the province of Uttar Pradesh (U.P.). Sugarcane bagasse and other sugar mill and agricultural residues are non-corrosive, non-polluting, are considered to be the best source of renewables, and offer the cleanest sustainable development.

Benefits

The Ministry of Non-Conventional Energy Sources, Government of India, is taking a major stride in the field of Renewable Energy in general and particularly in the conversion of sugarcane bagasse to energy. The impact of Green Energy generated on the social and economic well-being of the people of India can be considered in terms of the following:

- Impact in terms of job creation.
- Impact on the living standards of the farmers.
- Impact on the major revenues and profitability of the sugar mill.
- Positive impact on local, national, and international climate change.
- Substantial mitigation of CO_2 and also of methane.
- Following India's demonstrations, those other sugarcane-producing countries, which have not already begun, will follow the lead. As a result, the Global Warming effect shall be reduced or eliminated with time by reverting to the poor man's source of energy.
- Progress of the world would continue in a constructive rather than a destructive manner.

Biomass to Energy Process

The conversion processes of biomass to energy must be efficient and must possess the following advantages:

- Increased combustion efficiency of furnace.
- A very low particulate emission rate in exhaust gas.
- Low excess-air factor implying low heat losses from flue gases leaving the stack.
- Reduction of NO_x emission (from fuel-bound nitrogen) due to a well-controlled air to fuel ratio.

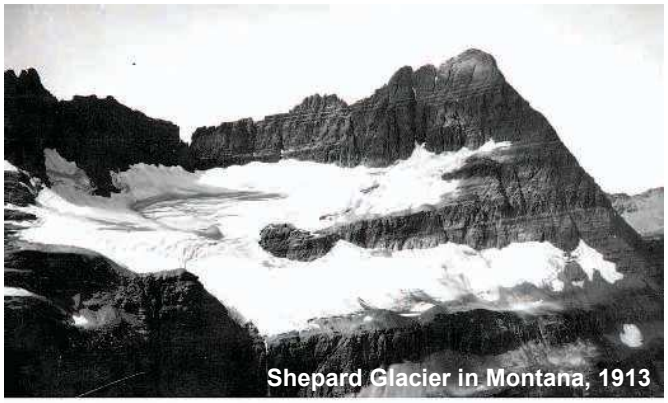
Another innovation must be incorporated, in which the moisture content of bagasse should be reduced. A proprietary design has been developed by CCEETI, which does not require the use of an external energy source and results in an increase in the steam to bagasse ratio, resulting in an increase of power output of 14%.

ENERGY, ENVIRONMENTAL NEWS & VIEWS

Year 2050

Numerous scientists from around the world agree that human-produced greenhouse gases are aggravating our planet's climate. Dangerous consequences have already resulted from climate change in many parts of the world. This trend is expected to continue and worsen, and the number of natural disasters is likely to increase.

According to projections for the year 2050, the world population is to reach 9.3 billion and the energy consumption will be three times greater than it is now. If fossil fuels remain to be the source of this energy and if corrective measures to avoid CO_2 emissions are not taken, the coming, most environmentally suffering generations of rich and poor nations alike will jointly ask the question, "Why did we not act?" Is it due to the lack of mitigation technologies or the short-term gain of the rich and those in power, or the political will of nations? Canada is most certainly not ignoring these questions and is joining the team of 185 nations respecting the Kyoto Protocol.


Shepard Glacier in Montana, 1913


Shepard Glacier in Montana, 2005
The decline in the glacier is clearly evident

Above photographs taken from: Tibbetts, J., (2007). Driven to Extremes, *Environmental Health Perspectives*. 115(4):A202

"Vasudheva Kutumbkam"
"The World is One Family"

Top to bottom: AP Photo/W.C. Alden, USGS; 2005 Blase Reardon, USGS/Courtesy of Glacier National Park Archives

Canadian CCEETI

CANADIAN CCEETI