The Global Energy Crisis

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Human beings and the natural world are on a collision course.
We must move away from fossil fuels to cut greenhouse gas emissions.

World Scientists' Warning to Humanity (1992)

Is there a global energy crisis?
The answer depends on what one means by a crisis and also on who answers the question. Different groups have different perceptions of an energy crisis. In the industrialised countries like USA, any hint of shortage of oil supplies or even a small increase in the price of oil is considered a crisis. In the poorer countries like India, the shortage or increasing price of firewood in a village could be a crisis.

There are also widely varying forecasts on energy. Some believe that there will be enough energy for a long time to come; others are sure that a severe shortage is only a few years away.

Where do we get all our energy from?
Ninety-nine per cent of our energy comes from the Sun. The commercial energy we pay for is just one per cent of the energy we use. Without the Sun, life on earth would not exist, since the average temperature would go down to -240^0 C. It is this solar energy that gets stored in plants as biomass. The plants use the energy for photosynthesis that produces all the food.

We can also make use of solar energy directly to heat water and buildings or generate electric power. Wind energy and hydropower are again indirect forms of solar energy. It is the Sun that creates the wind patterns and makes water flow.

Where does the world's commercial energy come from? This part comes mostly from fossil fuels like oil, coal and natural gas (Table 1)

Energy source	Percentage of total energy	Sub-total %
Non-renewable sources		
Oil	32	
Coal	21	
Natural gas	23	
Nuclear	6	
Non-renewables Total		82
Renewable sources		
Biomass (mainly wood)	11	
Solar, wind, hydro and geothermal power	7	
Renewables Total		18
Total		100

Table 1 Share of Different Sources in Total Energy Use

What is the global energy consumption pattern?
About 27 per cent of the energy is used for transportation, 38 percent for industry and 35 per cent for domestic and commercial purposes. Transportation accounts for a substantial amount of oil use. About 36 per cent of the primary energy goes into the production of electrical power.

One third of the world's population, that is, about two billion people, lack access to adequate energy supplies. At least three billion people depend on dung, coal, charcoal and kerosene for cooking and heating. On the other hand, the industrialised countries, with only 25% of the global population, account for 70% of the commercial energy consumption, mostly oil that is cheap through subsidies. These countries are interested in maintaining or even increasing the current levels of energy consumption. The U.S. is the largest energy consumer in the world.

Why do we often hear about energy consumption in the U.S.? With just 4.6% of the world's population, U.S. consumes 24% of the total commercial energy produced. This exceeds the total amount used by the next four countries, namely, Japan, Germany, Russia and China. India, with 16% of the population accounts for just 3% of the total energy.

A comparison of per capita consumption of energy for transportation shows the stark differences among countries. For every 100 units of energy consumed by a U.S. citizen for transportation, a Danish citizen uses 45 units, a Japanese 30 units, and an Indian just 2 units! 76 per cent of Americans get to work by driving alone in a car, while just 5 per cent use public transportation.

It is still not clear why we should worry about what the U.S. does! First, we should note that 92% of the energy used in the U.S. comes from non-renewable fossil fuels that release huge volumes of emissions. The U.S. has 3% of the world's oil, but consumes 26% of the crude oil extracted in the world. They also waste tremendous amounts of energy. Clearly, their ecological footprint is very large.

Now, many countries including India and China are striving to reach the level of prosperity of the U.S. If we start consuming energy at the same rate as the U.S., we will run out of fossil fuels in a few years! (See Box 1)

What exactly are fossil fuels and why are they non-renewable?
Fossil fuels (coal, oil and natural gas) are the remains of organisms that lived 200-500 million years ago. During that stage of the earth's evolution, large amounts of dead organic matter had collected. Over millions of years, this matter was buried under layers of sediment and was converted by heat and pressure into coal, oil, and natural gas.

Once we discovered them, we began consuming them faster and faster. Over 110 years, from 1859 to 1969, the production was 227 billion barrels. Fifty per cent of this total was produced during the first 100 years, while the next fifty per cent was extracted in just ten years! (In the oil industry, the barrel is the preferred unit and one barrel contains 42 U.S. gallons or 159 litres.)

Today, our consumption rate is far in excess of the rate of formation of fossil fuels. We consume in one day what the Earth took one thousand years to form! That is why fossil fuels are considered to be non-renewable.

Where does all the oil go? The automobile may well be the second worst invention of man (after nuclear bomb). The millions of cars, trucks, and buses whizzing along the world's highways consume enormous amounts of oil and, at the same time, release large volumes of carbon dioxide. Oil is easy to carry and hence it is the most preferred fuel for transport.

Where exactly is all the liquid gold? 67 per cent of the world's crude oil reserves are with the 11 members of the Organization of Petroleum Exporting Countries (OPEC). These are Saudi Arabia, Iraq, Kuwait, Iran, United Arab Emirates, Qatar, Algeria, Libya, Nigeria, Venezuela and Indonesia. Saudi Arabia alone accounts for 26 per cent of the total. China and the U.S have three per cent each.

Why is there worldwide concern about oil?
The extraction of crude oil from the bowels of the earth is not a simple process. When a new oil field is tapped, oil gushes out, but not for long. We have to wait for the oil to seep slowly into the well from the surrounding rocks. The maximum annual production cannot exceed ten per cent of the remaining reserves. Thus, the annual production always declines, but the field never "runs out".

There is also the phenomenon of the Hubbert Curve. In any field, production rate increases until fifty per cent of the reserve has been extracted. The production peaks at this point and thereafter declines because it becomes increasingly more difficult and expensive to extract the remaining oil. At some point, the energy expended in extraction exceeds the energy yield from the extracted oil. As the price of oil increases, however, it may become economical to remove more and more of the oil. The net energy obtained will, however, be low.

The Hubbert Curve is applicable also to countries and regions. The production in U.S. peaked as far back as 1970 and it has been declining. It is oil from Alaska that keeps things going. The world peak will soon occur.

Oil prices have fluctuated based on political factors, global demand, and OPEC policies on production. From US$4 a barrel in 1973, the price went up to US$ 38 in 1982. Then prices dropped due to increased production, went up again during the first Gulf War. After the War OPEC increased production and the price fell to US$10.

Since 1999, however, the price has been steadily going up with increasing demand. In mid-2004 the price had reached US$44, 40 per cent more than it was a year earlier, and was expected to cross US$50. Such increases have an immediate effect on transportation costs and lead to inflation in many countries including India.

The environmental costs of oil have been horrendous: air pollution, damage to ecosystems, carbon dioxide emissions, global warming, and the list goes on. The world's seas are today crisscrossed by hundreds of huge oil tankers. Major and minor oil spills have caused untold damage to the ocean, coastal zones, and marine life. In addition, the ballast water from the tankers has carried deadly organisms and toxic substances to far-off lands.

How much oil is still left and how long will it last? There is no agreement on this question. We do not even know how much oil is still left. The OPEC countries often give inflated figures, because the amount they are allowed to produce is a function of the declared reserves.

The current world demand is about 24 billion barrels per year and is rising. Current new discoveries, however, amount to just 12 billion barrels per year and this is declining! The estimated recoverable reserves could be 2000-3000 billion barrels.

There are today 1500 major oil fields, of which the 400 large ones account for 60-70 per cent of the production. The discovery of new big fields peaked in 1962 and, since 1980, just 40 have been found. Geologists agree that there are no big ones left for us to discover.

Let us hear the worst! What are the doomsday forecasts of the end of oil?
Several research groups have suggested that an oil shortage could be imminent. By 2010, according to them, oil from wells will be insufficient to meet the demand and there will be massive disruptions in transportation and the economy. What is more important, we will not have enough time to switch from oil to other available sources. The impact of such a shortage will threaten global food security, due to lack of fertilisers and chemicals. We will also experience a shortage of 500,000 goods currently made from petroleum.

This is all confusing! When will oil production really peak? The diehard optimists think that world production (other than Middle East) will peak in 28-38 years and the pessimists swear that we have only 8-18 years. Most computer studies suggest that the peak will occur between 2010 and 2020. The Middle East will then have most of the oil and, when their production peaks, prices will soar. We can be sure of one thing: The next oil crisis will be permanent!

Don't we have huge amounts of coal?
At current rates of use, the world's coal reserves will probably last for another 200 years. There are, however, many problems with coal use. Coal has to be mined from underground or from the surface. Underground mines, besides being dangerous, also cause lung disease among the miners.

Among the fossil fuels, coal is most harmful to the environment. The mines create major land disturbances and the burning of coal causes severe air pollution. Coal is responsible for 36 per cent of carbon dioxide emissions in the world. In addition, it releases huge amounts of radioactive particles into the atmosphere, more than a properly operating nuclear power plant. Air pollution from coal kills thousands of people and causes respiratory diseases in thousands more

Delhi buses now run on natural gas. Is that a good option?
Natural gas, a mixture of methane, butane, ethane and propane, is found above most oil reserves. While propane and butane are liquefied and removed as LPG, methane is cleaned and pumped into pipelines.

About 40 per cent of the total natural gas is in Russia and Kazakhstan. The available reserves are expected to last 200-300 years. Its abundance, low production cost, and low pollution makes it the ideal fuel during the transition from fossil fuels to renewables.

What are the pros and cons of nuclear power?
In a reactor, neutrons split the nuclei of elements like Uranium and Plutonium and in the process release energy as heat. This high temperature-heat is used to produce steam, which runs the electric turbine.

In 1953, the U.S. President Eisenhower announced that nuclear power will be “too cheap to meter”. At that time, it was predicted that, by the end of the century, nuclear power would be generating most of the world’s electricity. Nuclear power seemed the ideal answer to the energy problem. The fuel supply was unlimited, the environmental impact was thought to be very low, and the safety was assured.

Things, however, turned out to be very different. Today, nuclear power accounts for just six per cent of the total commercial energy. Across the world, very few new plants are being set up. Many orders were cancelled, construction terminated in some cases even after heavy investment, and existing plants are being retired. One plant in New York was abandoned after just 36 hours of power generation! Germany and Sweden have decided to phase out nuclear power within the next 20-30 years. Only France and Japan are still committed to this source.

What went wrong with nuclear power? All the calculations and predictions were wrong. The plants cost much more than the estimates, the operating costs were also high, technical problems were more than expected, and economic feasibility came to be doubted. But worse was to come.

The plants generate large amounts of deadly radioactive waste. The low-level waste must be stored safely for 100-500 years, while the high-level waste remains radioactive for a mind-boggling 240000 years! Fifty years after the advent of nuclear power, we have no satisfactory way of storing the waste. Meanwhile more wastes are piling up in the plants. In addition, plutonium removed from old nuclear warheads have also to be stored somewhere.

Nuclear power plants as well as nuclear weapons testing have created thousands of contaminated sites, particularly in the U.S. and the former U.S.S.R. The cost of cleaning them up would run to millions of dollars. Similarly, decommissioning an old plant costs more than the original construction cost! 228 large plants are due for retirement by 2012. There is a move in the U.S. to extend the life of plants to 50-60 years, but this could be a risk.

The biggest problem, however, has been the loss of public confidence over the safety of the plants. Several minor accidents were followed by the major one in Chernobyl, which released radioactive dust over thousands of square kilometres and will ultimately cause 100000 to 475000 cancer deaths.

If we have so many problems with fossil fuels and nuclear power, can’t we move into safer renewable sources?
An estimated US$200-250 billion in invested in energy-related infrastructure every year and another US$1.5 trillion is spent on energy consumption, with nearly all of this investment going to conventional energy. Thus, the world is locked into indefinite dependence on unhealthy, unsustainable and insecure energy structures. Things are improving now, with increasing investments on renewables like solar and wind power.

What kind of energy do we get from the Sun?
We receive from the Sun a pure, non-polluting, and inexhaustible form of energy. Solar energy comes from the thermonuclear fusion reaction constantly taking place in the Sun. All the radioactive and polluting by-products of the reaction are safely left behind in the Sun, 150 million km away.

An enormous amount of solar energy falls on this tiny planet Earth. What we get from the Sun in one month is more than the energy stored in all the fossil fuels we have. Also, using this vast amount of energy will not affect the biosphere in any way.

Given the good news, why are we not using solar energy for all our needs?
There is also some bad news: solar energy is a diffuse source falling evenly over a vast area and the first problem is to collect it efficiently. The second problem is to convert it into a usable form like electricity.

You can guess what the third problem is: What do we do when it is cloudy and the Sun does not shine? We must have an efficient way of storing the energy. All research in solar energy is about finding cost-effective ways of collection, conversion and storage.

If there are all these problems, how has the solar water heater become so popular in Indian cities like Bangalore? The water heater is in fact a simple and successful use of solar energy. It is a flat-plate collector, with a black bottom, a glass top and water tubes in between. The collector is placed at a suitable angle to catch the Sun's radiation. The bottom gets hot and the heat cannot escape through the glass. It heats up the water in the tubes.

The insulated storage tank is placed above the collector, the cool water moves down into the tubes and the hot water moves into the tank by natural convection. An electric heater element is also provided as backup for cloudy days. The design of the solar water heater is being improved all the time, increasing the efficiency.

Since electric water geysers are energy-guzzlers, solar heaters are a very good option. They pay back their capital cost within a year or so. Now, soft bank loans are available for buying such heaters. Some cities in India have made it mandatory for all new houses to install solar water heaters.

How do we convert solar energy directly into electricity? This conversion is done by a photovoltaic cell (or PV cell), which consists of two layers of silicon. The lower layer has electrons that are easily lost and the upper one readily gains electrons. When light energy strikes the cell, it dislodges electrons from the lower layer. This sets up an electric current through the circuit carrying the electrons to the upper layer. Each cell generates only a small amount of power, but many cells, placed together on a panel, creates enough power to run a device.

The power from a solar panel is usually stored in a battery and the device is connected to the battery. Thus the power is generated and stored when the Sun shines on the panel and is used whenever needed. The direct current from the battery can be converted into alternating current through an inverter. You can then run normal appliances like a fan or television.

PV cells are used today in watches, pocket calculators, toys, etc. Larger solar panels can light up a house, run an irrigation pump, operate traffic lights, and so on. Solar power is a viable alternative in remote areas where power lines cannot be taken due to costs or difficulty of access. For example, Ladakh in the Himalayas is powered by solar panels and this has made a tremendous change to the people's lives. There are several companies in India that offer solar home lighting systems. One 100 X 50 cm solar panel can easily power eight lamps.

We can also integrate solar panels in buildings, on roofs, walls, and windows. The cost of PV cell is high, but it is coming down all the time.

We can make paper burn by focusing the Sun's rays through a lens. Why can't we use this approach to get usable energy? Make a parabolic reflector, something like a dish antenna and place a bowl with rice at the focal point. You will soon have your lunch ready. In fact, solar cookers of this type are available in India and some hotels and community kitchens use them.

In the international community of Auroville near Pondicherry, there is a large solar bowl, 15 m in diameter. It concentrates the Sun's energy on to a tube that carries a special liquid. The hot liquid intern heats water to produce steam, which is used for cooking. The solar kitchen serves 2000 meals every day.

For home needs there are small box-type solar cookers. Food cooked this way saves fuel, tastes better, and is good for the health. Put it out in the Sun facing the right direction and food will be ready in an hour or two depending on the intensity of sunlight.

What about tapping wind energy?
If you travel from Nagercoil to Kanyakumari in South India, you will see hundreds of sleek-looking windmills slowly rotating and generating electricity. India is now a leading player in the wind energy scene. Globally, about 25000 MW of energy is produced by wind farms, seventy percent in Europe. Denmark is the leader in this field (See Box 2). The global wind energy industry is worth US$ 7 billion and is rapidly growing. Europe plans to generate ten per cent of its electricity from wind by 2025.

Wind energy produces electricity at low cost, the capital costs are also moderate, and there are no emissions. Wind farms can be quickly set up and easily expanded.

It is too good to be true. Where is the catch? Obviously, you need steady winds and not every place is suitable. In any case, you will need some form of backup for windless days. It is a case of high land use, though the space below the windmills could be used for agriculture or grazing. There is some noise pollution and the monotonous view of hundreds of windmills is visual pollution. In addition, the windmills could interfere with the flight of migratory birds.

Hydropower should be a good alternative. The water is free!
Twenty per cent of the world's electricity comes from hydropower. In order to get sizable amount of power, we need a high dam on a river with a large reservoir. The potential energy of the water falling from a height runs the turbine.

Hydropower has several advantages. The cost of generation is low and there are no emissions. The reservoir can provide water for irrigation round the year and can also be used for fishing and recreation. It also gives drinking water to towns and cities.

We know there must be a flip side! What is the bad news? Dams cost a lot of money and take years to build. Most of the suitable rivers of the world have already been dammed and it is now difficult to find new spots. The reservoir drowns large areas of farmland, wildlife habitats and places of historical and cultural importance. An example is the Tehri town, which was disappearing under the waters in mid-2004.

Dams also cause large-scale displacement of local communities. The people lose their lands and become environmental refugees. Often, compensation for the lost land is meagre (and not even paid on time) and resettlement never satisfactory. Dams impede the migration of fish along the river and reduce the silt flowing downstream. In fact, the sediments pile up against the dam and reduce its useful life. There is a worldwide movement against the building of large dams.

There are other renewable sources like tidal energy, ocean thermal energy, geothermal energy, and energy from biomass (plant material and animal wastes). They are useful as small-scale alternatives, but cannot yet satisfy the world's enormous appetite for energy. In particular, they are not yet suitable for transportation.

What about hydrogen economy that is often in the news?
Many experts believe that, as we run out of fossil fuels, we will move towards using the element hydrogen as the main fuel to run the world's economy. When hydrogen burns and gives us energy, it combines with oxygen to produce water vapour. In this process, there is no air pollution or emission of carbon dioxide.

This is good news again! What are we waiting for? There is some bad news too. Hydrogen is not available in a free state. It is locked up in water and in compounds like petrol and methane. It takes energy and an effective method for getting the hydrogen out. We can split water by heat or by a process called electrolysis to get hydrogen. We can also get it from fuels like petrol, natural gas and methanol. Thus the first problem is one of collection.

As in the case of solar energy, we have the problem of storage too. Hydrogen is highly explosive and if it is stored as compressed gas, the tank will be large, heavy and costly. Only large buses and trucks could hold the tanks. If we store it as a liquid, we need very low temperatures and this will require energy. Another method being tried out is storage as solid metal hydride. Here again, energy is needed to release the hydrogen when we want it.

So there are always blocks just when we think we have found the ultimate source of energy! What about fuel cells that are often in the news? A fuel cell is so called because it is an electrochemical unit like a battery. Unlike the battery, however, the fuel cell draws its input (hydrogen and oxygen) from outside. Again, a battery requires recharging, but the fuel cell does not. Finally, there is no toxic output when a fuel cell is discarded.

The fuel cell burns hydrogen to produce electricity. In the process, hydrogen combines with oxygen to produce water vapour. Thus there is no pollution and it runs continuously as long as there is input.

Fuel cells were developed as far back as 1960 for space applications. The progress since then has, however, been slow. There are now experimental buses and cars running on fuel cells, but they are very expensive. Automobile companies like Daimler-Chrysler, Honda, and General Motors have made prototype fuel-cell cars. Such cars will become common, if we are able to produce hydrogen using renewable energy. We will of course need hydrogen fuelling stations too.

Let us get this clear! Hydrogen is a great fuel, but there are problems. Where is the catch? First, it takes energy to produce hydrogen. Obviously, against this input, we should get much more energy from the hydrogen we produce.

Second, if this input energy comes from fossil fuels, there will be environmental effects. Third, the situation is even worse, if we produce the hydrogen from fossil fuels themselves. Finally, we have not fully solved the problem of storing hydrogen.

Where is the hydrogen economy then? We must find first cost-effective ways of producing hydrogen from water using renewable energy like solar. We should solve all the storage problems too. In the best scenario, we would be using electrical and thermal energy produced for renewable sources like solar and incorporate hydrogen as the fuel for transport. (See Box 3)

We must remember, however, that neither hydrogen nor any other wonder fuel, for that matter, is going to save us if we keep increasing our energy use or even maintain the current usage levels. The hydrogen economy will be viable only if we use energy much more efficiently and reduce our consumption levels. As of now, there is no sign of such actions.

Once again we face the same hurdle: There is a natural limit to the amount of resources on this planet. When we overstep that limit, we will inevitably face an insurmountable hurdle.

Given all the limits and difficulties, are we using energy efficiently?
Increasing the efficiency of energy use will be equivalent to finding free sources of energy. There is tremendous scope for increasing energy efficiency in all our activities. The ordinary incandescent bulb has an efficiency of just 5-10 per cent. Most of the input electrical energy disappears as heat. Replacing it with a compact fluorescent lamp (CFL) will reduce consumption by 75 per cent. The initial cost is more, but it will pay back soon. At the same time, we are doing a service to society by consuming less energy. Incidentally, the cost of CFL has been steadily coming down.

The internal combustion engine (I.C.Engine) that runs our automobiles is another device that wastes 90 per cent of the input energy. Driven by the first oil crisis, the fuel efficiency of American cars gradually increased between 1973 and 1985. Since then, however, it has levelled off primarily because of the consumer craze for the so-called Sport Utility Vehicle (SUV), minivan, etc. and because of the availability of cheap oil. Makers like Toyota and Honda have recently introduced hybrid electric cars with much higher fuel efficiency. They run on petrol and a battery. The battery is kept charged by the petrol engine and an electric motor provides energy for acceleration and hill climbing. When the car is braked, part of the heat generated is used to charge the battery.

Whenever we use energy, some waste is inevitable. However, there is a large amount of avoidable waste in energy use. One estimate is that we waste more than 40 per cent of commercial energy we buy. Examples are vehicles and furnaces that waste fuel and poorly designed buildings that use up huge amounts of energy for heating and cooling.

Technology exists today for increasing the efficiency of most appliances by 50 per cent or more. As the demand for energy-efficient appliances increase, the prices will also come down.

We must always consider the lifecycle cost of devices, that is, the total of the initial cost and the operating costs over the lifetime of the device. Such an approach will make us take better decisions that would save cost and energy.

Can't we end with some good news?

The good news is that wind and solar energy initiatives are growing very fast. Over the past decade, the solar energy industry has grown seven-fold and wind power thirteen-fold. As a result, the costs are steadily declining and this in turn is increasing their penetration into the energy market.

What can I do to conserve energy?

1. Gradually replace all the bulbs in your home with Compact Fluorescent Lamps (CFL).
2. Install a solar lighting system and use solar power during daytime.
3. If you use hot water, install a solar water heater in place of electric geyser.
4. Buy energy-efficient appliances when you replace old ones or you need new ones. Check always the specifications for energy consumption figures.
5. Turn off lights and fans when you leave the room. Install electronic regulators for fans and auto-switch off devices for areas like staircases.
6. If you are building a new house:
    - Minimise the use of materials like cement and steel that use up lots of energy during manufacture; use earth blocks instead of burnt bricks, vaults and domes in place of concrete roofs, and so on.
    - Provide skylights wherever possible to bring in natural light and reduce use of electricity
7. Minimise the use of automobiles for your personal transport:
    - Use bicycle for local work like shopping
    - Use public transport whenever possible.
    - Arrange car pools
    - Live near your place of study or work, if possible
8. Keep your vehicles tuned for low consumption of fuel
9. Check fuel consumption data while buying a new vehicle
10. Shut off personal computers, television sets, music systems, etc., when not in use; replace the bulky CRT monitor with the flat and thin LCD monitor that consumes much less energy and is easier on the eyes.
11. Follow the advice given by the Petroleum Conservation Research Association (PCRA) with regard to energy conservation

Box 1

Consume and Be Merry: The Chinese Model

An important threshold was reached in early 2004: China exceeded Japan in oil imports and became the second biggest importer. It is also the fastest growing oil consumer in the world. Two million cars were put on the road in China in 2003, which was seventy per cent more than in 2002. Today, there are 10 million cars in China and this number is rapidly growing.

If China starts consuming at U.S. levels, it will need 80 million barrels per day, which is 10 million more than entire world production in 1997. Even at current levels of growth, China would need at least 10 million barrels a day by 2025. Where will that oil come from and how much will it cost?

China, however, has huge coal reserves, enough to last the country for 300 years. The environmental cost of burning all that coal would surely be very heavy.

Box 2

Life after Oil: A Danish Solution

In 1998, the 4400 residents of Brundby on a Danish island decided that they would give up fossil fuels in ten years. There are now more than twenty wind turbines generating as much energy as the island consumes from fossil fuels. Home heating, which is a necessity in Denmark, is through hot water made from burning straw.

Over six years, the island cut its energy consumption by 25 per cent, drastically reduced emissions of nitrous oxide, sulphuric acid, and carbon dioxide. The European Union plans to replicate in 100 other communities so that twelve per cent of the total energy in the Union would come from renewables by 2010.

Denmark has been making huge investments on developing green technologies. Twenty percent of its electricity is now generated by renewable sources. It is also a world leader in wind power. Its windmills and generators are exported to many countries including India. The Danish wind power company, Vestas, has set up a manufacturing unit in Chennai.

The path to sustainable energy use, however, is always difficult. The latest news is that the new Danish government has cut the funding for renewable energy!

Box 3
Iceland: World's First Hydrogen Economy?

Iceland promises to become the world's first hydrogen economy over the next 25 – 30 years. For this purpose, the Government of Iceland has teamed up with companies like Daimler-Chrysler, Royal Dutch Shell and Norsk Hydro. The project is the brainchild of the chemist Bragi Arnason.

The project will produce hydrogen from seawater using the country's abundant renewable energy sources: wind, geothermal and hydropower. Hydrogen will run buses, cars, fishing vessels and even factories. Royal Dutch Shell will operate hydrogen filling stations.

Iceland's experiment will set a model for other countries.