Open Access

Exploiting the Deep Oceans for Energy Retrieval and for the Burial of Carbon Dioxide

Carl T.F. Ross*

Department of Mechanical & Design Engineering, University of Portsmouth, Portsmouth, PO1 3DJ, UK

Abstract: The paper describes two concomitant problems of much concern in the 21st century; namely of dwindling energy resources and of the effects of man-made climatic change, largely due to the over-production of carbon dioxide. The paper shows that these problems have occurred due to man's continuing requirement for a more comfortable life and how the deep oceans can be used to achieve this. The paper explains that man's requirement for a longer and more comfortable life is natural and as we cannot look back, the problems must be addressed; possibly by the skills of the scientist and the technologist.

1. THE PROBLEMS AND THEIR SOLUTIONS

1.1. Energy Resources

To continue expanding the economies of the world there is a growing requirement for energy, from fossil fuels or otherwise. Apart from the West's increasing use of energy, emerging countries are even more interested in using fossil fuels for expanding their economies. For example China is building a new coal-fired power station every 4 days. In terms of Gross Domestic Products (GDP), China has the fourth largest economy in the world. Many economists believe that within about 20 years, China will have the largest GDP in the world. Similarly, the world's largest democracy, namely India, now has a middle class of about 50 million people and to increase the size of this middle class, they will have to burn more fossil fuels.

Sir Winston Churchill once famously said, "Do not pull the tail of the Chinese dragon or you will awaken it!" Today the Chinese dragon is awake and flapping its wings and very soon it will be in full-flight. When this will occur, one billion or so Chinese people will want private motorist transport; because private motorized transport is so much more convenient; much better than public transport. Similarly, the Indian tiger will also want this lifestyle of 'milk and honey' and then Planet Earth will be in even greater danger of suffering an energy resources' crisis, together with the effects of man-made climate change. For example, today India, with a middle class of about 50 million people, has ca. 61 million 'cars' on the Indian roads. Economists believe that in the year 2030, India's middle class will swell to a staggering 543 million people and they will have ca. 613 million 'cars' on the Indian roads! In preparing for this, the Indians have already invented a people's car, namely the 'TATA NANO', which retails for about $2300-. This type of car will prove very popular worldwide and especially in second and third world countries. The Indians and the Chinese will turn their backs on public transport, because public transport has serious limitations in a number of cases. For example, try taking 10 bags of garden refuse to your local 'tip' by public transport. Try taking your elderly and infirm relative to the local hospital by public transport. Try doing your weekly shopping at the out-of-town shopping malls, which have been strategically placed to aid the owner of a private car to do his shopping conveniently and efficiently. Remember, the 'good old days', when some young students had to change their buses 3 times every trip, to travel to the best school in the area. In view of the convenience of using the private car to achieve the aims and desires of the modern day paedophile, will parents be happy if their 11 year old has to change buses three times per trip to get to a top quality school every day? In the 'good old days' parents had to put up with it, but in those days the parent and child had to put up with it because of the non-availability of the private motorcar, however, the paedophile was also restricted, as he too did not have private transport. Bio-fuels are not the answer to our fuel problems either, as today's world population of about 6.5 billion is likely to grow to about 9 billion by the year 2050. How are we going to feed such a massive and growing population if agricultural land is going to be used for growing 'grain' for bio-fuel production? It must be pointed out that the wheat required to feed one person for one year is roughly the same as the wheat required to produce enough ethanol to just fill a single fuel tank of a 4x4 motorcar. It must also be remembered that it takes about 10 calories of 'grain' to produce about one calorie of meat! Thus, if the West gives up meat, the East may not starve! However, there is a flaw in this argument, because as the burgeoning middle-classes of China and India continue to grow; these middle classes are increasing their meat consumption, unlike their less-educated cousins, which leaves us in a dilemma.

Additionally, western governments' interventions at trying to restrict the use of energy will only partially work, because, in general, the West enjoys healthy democracies. For example, if a politician promises the voter a lifestyle of a Premier League footballer, while his rival politician promises the voter a lifestyle of 'stone-age man' to gain his vote,

---

*Address correspondence to this author at the Department of Mechanical & Design Engineering, University of Portsmouth, Portsmouth, PO1 3DJ, UK; E-mail: Carl.ross@ntlworld.com

1874-2521/09

the latter contender is extremely unlikely to be elected. Remember, Stone Age man seldom survived 30 years of life. So we might as well get used to it, we need to burn more fossil fuels, and this must be addressed.

It must be emphasised here, that before the First World War, the percentage of CO_2 in the atmosphere was about 0.03% [1] and that in the year 2006, the percentage of CO_2 had risen to a value of about 0.038%, an increase of about 26% in a century. Many scientists [1, 2] believe that this increase in CO_2 in the atmosphere is largely responsible for the detrimental effects on climate change that we have recently experienced on our planet, namely global warming. Lovelock believes that this process must be changed as soon as possible or detrimental climate change may become worse. In Table **1**, it can be seen what the annual 'carbon footprint' of an average inhabitant of some countries is.

Table **1** [3] clearly shows that the West is largely to blame for producing large 'carbon footprints' and examining the output of the 2 African countries in this table, it can be seen that if Africa is to 'come into' the 21st century, it will be necessary for it to burn large quantities of fossil fuels. So where are we going to get these fossil fuels from?

Now according to press reports, Russia has 1/5th of the quantity of the world's methane. However, this information is based on the methane that is stored in the Earth's crust, on land and in shallow waters. This methane has been produced by biological decay and does not take into account the vast quantity of deep-sea methane that has been produced by the action of archaea [4] under very high water pressures and is in the form of frozen methane hydrates, which have been built up over a period of about 60 million years or so. Archaea are a group of prokaryotic single cell microorganisms, similar to bacteria, but which have evolved differently. According to Dickens there are two ways that this deep-sea methane has formed; they are as follows:

- By microbial methanogenesis of the archaea.
- By the "cracking" of organic compounds through thermogenic methanogenesis.

These methane hydrates were formed when the water froze under high pressure around tiny methane bubbles, where the structure of the water cage surrounding each methane bubble is in the form of a clathrate like structure. A clathrate is a cage like structure, which is in the form of multiple cells. The walls of the cells are frozen water and each cell contains a compressed bubble of unfrozen gas, methane or otherwise.

This methane produced by the action of archaea is in the Earth's crust, is covered by water, some 1.5 to 7 miles (2.42 to 11.52 km) deep. According to Dickens *et al.* [5], the quantity of this form of methane could be as much as 10,000 billion tonnes. That is, its mass is twice that of all the fossil fuels on land and shallow waters, namely methane, oil and coal. If this quantity of methane is distributed equally amongst all of mankind, then each and every one of us will get a chunk of methane weighing about 1,670 tonnes. In monetary terms, this methane is worth about $1,200,000- per person on Earth. This methane hydrate is quite stable and has been so for about 60 million years, despite the fact that its density is 0.91 gm/cm^3 [6] and less than that of seawater, whose density is 1.02 gm/cm^3. Some scientists say that because the methane is stable, we should leave it where it is, but even if the West plays on a 'level playing field' and leaves the methane where it is, the present author doubts that the rest of the world will not show a very healthy interest in winning such a prize. Many senior British politicians do not seem to be aware of the existence of this vast source of untapped energy.

The problem with retrieving this methane is that much of it is frozen in the form of methane hydrates. For example in a typical gas field, such as the Blake Ridge, [5], there may be about 200 m of 'soil', without methane, immediately below the sea floor. Under this soil, for another 300 m or more, there is frozen methane hydrate and below this, there is a reservoir of methane gas. The present author believes that if the gas field is drilled vertically downwards into the bottom reservoir containing the methane gas and that if this gas is sucked out, it will cause a void in the bottom reservoir that originally contained the methane gas. This will result in a vacuum in the bottom reservoir, causing the methane hydrate immediately above it, to evaporate into the bottom reservoir, as shown in Fig. (**1**). By repeating the process, much of the frozen methane can be retrieved. In Fig. (**1**), the notation of the vertical axis, namely 'mbsf' represents metres below the sea floor.

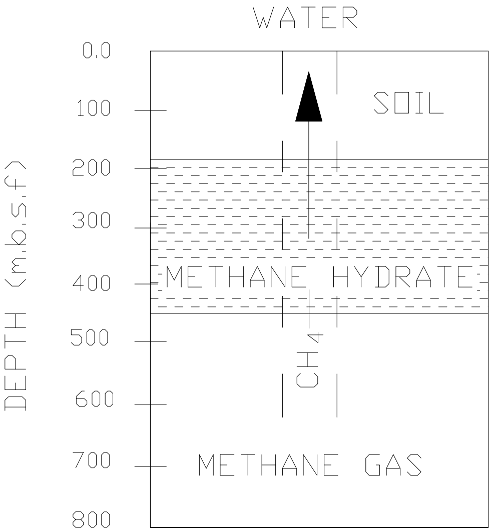

Fig. (1). Methane retrieval from the Blake Ridge.

Table 1. Average Annual 'Carbon Footprint' of an Inhabitant of Some Countries (Tonnes of CO_2)

USA	Australia	Japan	Britain	Switzerland & Sweden	Brazil	China	India	Ethiopia	Chad
20	18	10	11	6	2	3	2	0.1	0.01

So why will this frozen methane hydrate evaporate if we put it in a state of a ‘vacuum’? We must remember that the freezing and boiling points of liquids do not depend on the temperature alone, but also on the pressure. If the pressure falls, the boiling point and the freezing point fall and if the pressure rises, the boiling point and the freezing point rise. This is why we cannot make a good cup of tea at the top of Mount Everest; because the boiling point of water at the top of Mount Everest is about 72°C, due to the fact that the atmospheric pressure at the top of Mount Everest is about 0.34 bars (1/3 rd of atmospheric pressure) and the water cannot reach 100°C at this pressure. Thus, by putting the frozen methane hydrates in a ‘vacuum’, they will evaporate into the bottom reservoir.

Another method of retrieving the methane gas is to open cast mine the methane hydrate from the sea bed [7]. If this is carried out and because the density of methane hydrates is less than that of water, the methane hydrates will rise upwards from the sea floor. Thus, it will be necessary to trap the floating methane hydrate in a curved dome shell ‘roof’, concave to the sea floor and ’just above’ the sea floor. This is necessary because if the methane hydrate rises sufficiently high in the sea, it will reach a point where the resulting decreased ocean pressures are low enough for the methane hydrate to evaporate into methane gas and escape into the atmosphere, at our peril. The same process can be used in the ‘Arctic Permafrost’ to reclaim the methane, which is in danger of evaporating. Possibly, a hover submarine tanker will be required to collect the methane hydrate through the curved dome shell.

According to reports received by the present author from practising oceanographers, the Japanese who have no naturally occurring reservoirs of oil or methane on their land, are drilling in depths of water of up to 4.5 miles (7.25 km) [8]. Why are they doing this? Also, most of the deep-sea methane reserves that have been discovered, have been found around the coastlines of the USA and Japan; why not Europe and Africa? The reason for this is that the USA and Japan are the two top industrial nations in the world and in order for them to continue to achieve their high status; they will need to increase their use of fossil fuels and not decrease these commodities.

1.2. The Greenhouse Effect

Scientists believe that the rays coming from our Sun are, in general, of short wavelength and this is why they can pierce most of the greenhouse gases on entry into the Earth’s atmosphere. However, when these rays are reflected back into outer space from the Earth’s surface, their wavelengths are longer and because of this they have difficulty in penetrating the greenhouse gases. Thus, a disproportionately large percentage of the Sun’s rays get trapped and as a result of this, they warm up our planet. The main greenhouse gases are: carbon dioxide, water vapour, methane, ozone and nitrous dioxide. The greenhouse gases are necessary to keep the Earth warm, because without them the Earth’s average temperature would be about –19°C (-2 °F, 254 K), rather than the present mean temperature of about 15 °C (59 °F, 288 K) [9]. That is, without greenhouse gases our planet would be uninhabitable. However, if the quantity of greenhouse gases becomes too large, they will cause our planet’s temperature to rise too much. For example on Planet Venus, whose atmosphere is composed of about 96% of CO_2, at a surface atmospheric pressure of about 95 bars, the surface temperature is so hot that it can melt lead. In contrast to this, on Planet Mars, although the percentage of CO_2 is similar to that of Venus, as Mars’ surface atmospheric pressure is only about 0.01 bars, the winter surface temperature at its poles is as low as –200°F (-129°C). The reason why Mars is so cold is that it has very little atmosphere surrounding it, because as the acceleration due to gravity on its surface is only about $3.71 m/s^2$, it has lost most of its atmosphere [10]. In contrast to this the acceleration due to gravity on Earth and Venus is some 2.64 and 2.39 times, respectively, of that of Mars and they, in general, do not lose much of their atmospheres to outer space. Oxygen and nitrogen, which are Earth’s main gases and make up about 99% of our atmosphere, are not greenhouse gases.

1.3. The ‘Deniers’

Some scientists [11] do not agree that we are suffering from man-made climate change due to the increase in the quantity of greenhouse gases. To elucidate descriptions of their views, let us call them the ‘deniers’. For example, they state that in the Middle Ages, the temperature was warmer when there was no increase in the quantity of greenhouse gases, so that in England it was possible to successfully grow grape vines; this was known as the ‘Medieval Warm Period’. This was true, but in those days the temperature was warmer in Europe only and in fact it was much cooler than today in the rest of the world. One must remember that the surface area of Europe is only about 1/70th of the Earth’s surface area and one cannot make a truly scientific judgement on the greenhouse effect with such a small percentage of the Earth’s surface. The ‘deniers’ also state that just after this period, about the 14th century, there was the ‘Little Ice Age’ and that there was no significant change in the quantity of greenhouse gases at that time; this too was in Europe only. However, according to Edinburgh University [12], this was caused by the Earth’s unusual orbit at that time. This phenomenon is well known to physicists and is known as the Milankovitch cycles.

The ‘deniers’ also state that the increase in the Earth’s temperature is related to the increase of sunspots and they attempted to prove their point by plotting a graph relating the number of sunspots to temperature rise up to 1980. However, when Edinburgh University [12] carried out the same exercise, they found that there was no correlation between the number of sunspots and temperature change. Indeed, for the 25 years after 1980, which was not plotted by the ‘deniers’, Edinburgh found that the number of sunspots went down, but in contrast to this, the Earth’s temperature rose fiercely upwards and against the trend of the density decrease of the sunspots.

The ‘deniers’ also stated that after the 2nd World War, the post-war industrial revival took place and the temperatures should have gone up, as CO_2 emissions had gone up but in fact they went down. The ‘deniers’ concluded that therefore this proved that the increase of CO_2 was not related to the temperature rise. However, Merchant [12] correctly points out that after the 2nd World War the industrial revival was fuelled by ‘dirty fuel’ namely coal and this caused what is now known as global dimming. The global dimming caused the temperatures to fall. One may recall the terrible smog we suffered in the 1940's and 1950's! After this period, the dirty pollution was cleaned up; remember catalytic converters, methane gas, etc., came into use and as the global dimming was reduced, the temperatures went up with the increase in CO_2 emissions. The author recalls during his boyhood days, the very thick 'pea soup' fogs caused by sulphates being emitted into the atmosphere, mostly through the burning of coal. On one occasion the author recalls how he had to find his way home after school, by more or less 'groping' his way along garden fences, walls, etc, as his view was restricted to about 1 m (3 ft).

1.4. Energy Consumption

Now, the average American consumes about 60 ft^3 (1.7 m^3) of methane per day. If we assume that for all his other energy needs, such as for electricity and transport, etc., are also produced from methane and if we round this figure upwards, we will find that he consumes about 2 tonnes of methane per year. If we then exaggerate this requirement for energy consumption and assume that all of mankind will consume energy at this rate, then by considering also frozen methane hydrates, there will be enough methane energy to last mankind for more than 800 (1,670 tonnes per person/2 tonnes per year) years! If alternative methods of energy production are used in addition to energy in this form, then we should have enough energy to last us for about 1000 years! Thus, we need not worry too much using nuclear power and its associated problems.

1.5. Carbon Dioxide Emissions

The good news is that methane is a cleaner fuel than oil or coal, but the bad news is that if we burn this methane, we will produce 27,600 billion tonnes of carbon dioxide; this figure is some 110,000 times greater than the recently agreed proposed annual emission of carbon dioxide by Britain. Do not worry; there is sufficient oxygen in the atmosphere to combust this vast quantity of methane; the mass of oxygen in the atmosphere being about 100 times more than the mass of deep-sea methane. The mass of the atmosphere is about 5.15×10^{18} kg and about 78% of it is nitrogen, about 21% of it oxygen and about 0.93% of it argon. The mass of CO_2 in the atmosphere is about 1.96×10^{12} tonnes at present. In any case, we are not going to combust this deep-sea methane all at once; hopefully we will combust it over a period of 1000 years. However, carbon dioxide is believed to be one of the worst culprits for causing environmental meltdown. According to press reports, the Arctic is melting and causing sea levels to rise. If the floating Arctic ice pack melts, it will not cause a significant rise in sea level, because according to Archimedes's Principle, the floating ice pack displaces its own mass in water. However, if some of the Ice Mountains on land, in the Arctic melt, it will be a very different 'kettle of fish'. For example, Greenland is the second largest island in the world; its surface area is about 9 times larger than the surface area of the United Kingdom. Now the surface area of Greenland is about 840,000 $miles^2$ (2.17 million km^2) and about 84% of this land has an ice cap on it, whose thickness is about one mile (1.61 km.) Thus, Greenland is covered by a block of ice, whose surface area is about 700,000 $miles^2$ (1.81 million km^2) and whose thickness is a little less than one mile (1.61 km)! Now the average temperature during the Arctic summer is about –14°C. In fact, during the summer of 2007, the temperature in a region of the Arctic Circle rose to a staggering 22°C! This high temperature is causing some of the Arctic's ice to melt and some scientists [2] believe that it may completely melt within 45 years if its present rate of melting continues. If this takes place, the world's sea levels will rise by about 22 ft. (6.7m) and large areas of cities such as London & New York will go 'underwater'. If the Antarctic melts it will be even worse, the sea levels will rise by a staggering 260 ft. (80 m), but fortunately the Antarctic's summer temperature is some 26°C less than the Arctic's summer temperature, so this may not be a problem for about a couple of centuries or so. Thus, at present, the possible melting of the Arctic is of more concern to us than that of the Antarctic.

Furthermore, according to Lovelock [2], by the turn of the century the temperature in the tropics may rise by about 5°C and the temperature in the temperate zones of our Planet may rise by about 8°C. According to Lovelock, such rises in temperature will cause much of the agricultural land to turn into desert; this in turn will wipe out much of mankind. Lovelock believes, that if the planet warms up at this rate, that within a century from now, mankind will be survived by a few breeding pairs in the Antarctic and Arctic circles. Additionally, according to many scientists, if the seas warm up, the basic food supply in the oceans, namely plankton can be destroyed and this will break the food cycle in the oceans, causing havoc to marine life. If the undersea methane hydrates are left where they are and the seas warm up, then a further consequence of this is that the methane hydrates can evaporate and cause even more greenhouse gas pollution in the atmosphere, as the density of frozen methane hydrate is less than the density of seawater. According to Lovelock, as a greenhouse gas, methane is 22 times worse than carbon dioxide! Also the methane can catch alight and burn for about 100 years or more [13].

Some scientists believe that the 'apparent disasters' met in the Bermuda Triangle can be attributed to the escape of deep-sea methane gas. They believe that if a large bubble of methane gas escaped and entrained a passing ship, the ship would lose its buoyancy and sink like a stone to the very 'bottom' of the ocean, without warning. Similarly, if a large bubble of methane gas escaped and entrained a passing low-flying aircraft, the aircraft will explode without warning.

1.6. Carbon Dioxide Removal

According to Attenborough [14], if an average car is driven for 30 miles (48.3 km) per day, it will produce 10 tonnes of carbon dioxide per year; this is an enormous output of carbon dioxide, especially as many families in the West have two or more cars per household! So how can we 'have' our private motorised transport and 'drive it' at the same time. Obviously, we have to eradicate the carbon dioxide somehow. One way is to plant 'trees', but according to press reports, some German scientists have found that trees and plants expel methane [15], which as a greenhouse gas is worse than carbon dioxide, as stated above, [2]! Furthermore, according to recent press reports, the methane expelled by trees and plants makes up from 10% to 30% of the methane in the Earth's atmosphere. So planting trees may not solve the problem. It must be emphasised here, however, that trees, at least, give off oxygen; much more than they give off methane and the disadvantage of burying CO_2, as the present author is about to propose, is that the oxygen will also be buried.

There is, however, another way to eradicate the unwanted carbon dioxide. That is, to trap it and either scrub it or bury it in the deep oceans, as shown in Fig. (**2**), where it will freeze as carbon dioxide hydrates due to the high pressures and low temperatures. Table **2** shows the pressure and temperatures at which carbon dioxide hydrates form [6], together with the water depths. According to Carroll the density of frozen carbon dioxide hydrate is 1.1 gm/cm^3 and as it is denser than seawater, it will sink to the bottom of the ocean. This is in contrast to frozen methane hydrate, which is less dense than seawater and it will float to the surface if it is disturbed. Thus, if the frozen methane hydrate has been stable for 60 million years in locations such as the Blake Ridge, there is no reason to believe that the frozen carbon dioxide hydrate will not be stable for millions of years, as its density is larger than that of both frozen methane hydrate and seawater. The process of burying the carbon dioxide is described in much detail later in this section. From Table **2**, it can be seen that frozen CO_2 hydrates can form at quite modest temperatures and depths of water.

Table 2. Carbon Dioxide Hydrate Formations at Temperatures, Pressures and Water Depths

Temperatures (deg C)	Pressure (kPa)	Water Depth (m)
-1	1334	121
0	1490	136
1	1667	153
2	1869	173
3	2100	196
4	2366	222
5	2676	252

It is worth pointing out here that the latest approaches of the United Nations Framework Convention on Climate Change/ Code of_Practice (UNFCC/COP), Intergovernmental Panel on Climate Change (IPCC), and/or International Maritime Organisation (IMO) for facilitating carbon dioxide capture and storage, namely 'Carbon capture and Storage' (CCS), is worth reading. Special reference should be made of the Special Report of Carbon Dioxide Capture and Storage, published in 2005 by the IPCC; this gives an overview of the current status of CCS technologies in various aspects, together with the latest revision of the 1996 London Protocol to allow the legal storage of CO_2 into sub-seabed geological formations (in November 2006)

It is also worth pointing out here that chemo-engineering studies have elucidated the possibility that the 'methane' in the deep-sea methane hydrate can be exploited by the injection of CO_2 and N_2 plume; this means that we can produce a double 'whammy', where the 'exploitation of resources' and the 'disposal of CO_2' can be carried out in a very stable manner and at the same time.

So how can we trap or scrub carbon dioxide from an automobile? We can scrub the exhaust fumes by blowing the carbon dioxide fumes through (say) soda lime or caustic soda or potassium super oxide or lithium hydroxide or some other chemical yet to be invented; the adopted chemical to reside in the automobile's exhaust itself. If carbon dioxide is blown through soda lime, it turns the soda lime into two harmless substances, namely calcium carbonate and water; calcium carbonate is better known as the chemical that is used to treat common indigestion; it is also known as common chalk. In the case of caustic soda, if CO_2 is passed through it, the resulting compound is bicarbonate of soda. From time to time, the soda lime will need to be replaced in the car's exhaust. That is, in this paper, the author has already 'invented' a means of scrubbing unwanted carbon dioxide emitted through an automobile exhaust. Other chemicals can be used for the same purpose; some of which are yet to be invented.

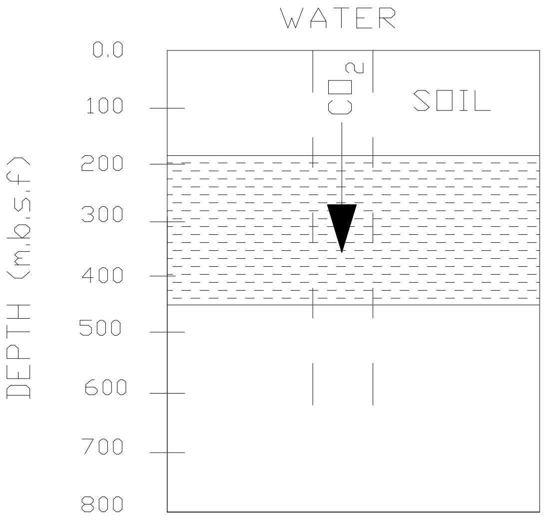

Fig. (2). Carbon dioxide burial in the Blake Ridge.

Alternatively, if the eradication of carbon dioxide is not to be left in the hands of the motorist, there is another way of dealing with the problem.

Tube and tunnel motorways can supplement conventional motorways [16], where large nearby cities can be linked by tube motorways. Here, the carbon dioxide can be trapped and treated or alternatively, buried in the deep sea. To encourage motorists to use the tube and tunnel motorways, a carbon tax can be levied only on the conventional motorways that are supplemented by tube motorways. These tube motorways will, in general, not be suitable to link cities that are far apart. To reduce the costs of the tube motorways, they need not be placed underground; instead they can be placed above ground level and be factory built. A large conventional motorway costs about $50 million per mile (1.61 km) and the author would estimate that the cost of a tube motorway would be about twice this value. The tube motorway will have the advantage that it is weatherproof and can also be made soundproof. In Figs. (**3** and **4**), the present author has shown what a North/South tube motorway may look like.

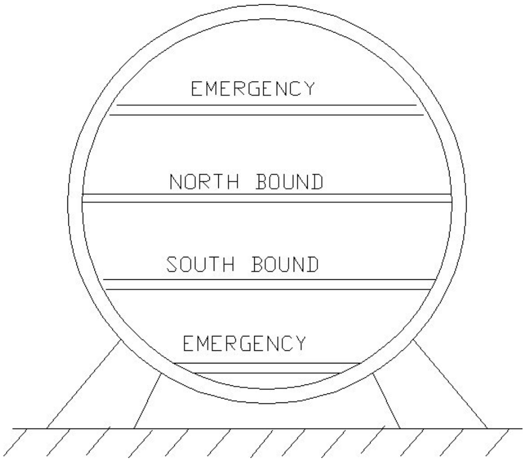

Fig. (3). Cross-section of North/South tube motorway.

An alternative to the tube/tunnel motorway is the enclosed double-decker motorway shown in Fig. (**5**).

In the case of the double-decker motorway of Fig. (**5**), the second deck can be built immediately above the bottom deck, the whole artefact possibly being covered in a transparent or translucent polycarbonate to trap the unwanted gases, which can be scrubbed. The double-decker motorway has the advantage that it will allow more cars to travel on it, without encroaching on our green and pleasant land; as would occur if a conventional motorway were widened. This procedure may be particularly useful in large cities such as Beijing and Calcutta, where they have massive air pollution problems. Now some drivers may not be too keen to drive through long enclosed tubes, but it must be remembered that already there is transport through long tunnels. For example, Japan's Seikan Railway Tunnel is 53.85 km long (33.5 mi.) and Norway's Laerdal Road Tunnel is 24.5 km (15.2 mi) long. The difference between Japan's Seikan Railway Tunnel, together with Norway's Laerdal Road Tunnel and the author's tube motorway proposed here, is that the former go undersea and under mountains, respectively, while the author's tube/tunnel motorway has an atmosphere above it. In any case the author, accompanied by his wife, travelled through the Mont Blanc Tunnel, which is 11.6 km (7.25mi) in length, 8.6 m (28.2 ft) in width and 4.35 m (14.3 ft) in height, without suffering any claustrophobic effects, whatsoever.

Likewise, the CO_2 from industrial chimneys can be trapped and scrubbed or buried in the deep oceans. Instead of outputting industrial chimney exhausts to the open atmosphere, the gases can be directed to vast underground chambers, where the CO_2 can be dealt with, either by eradicating it or burying it at sea.

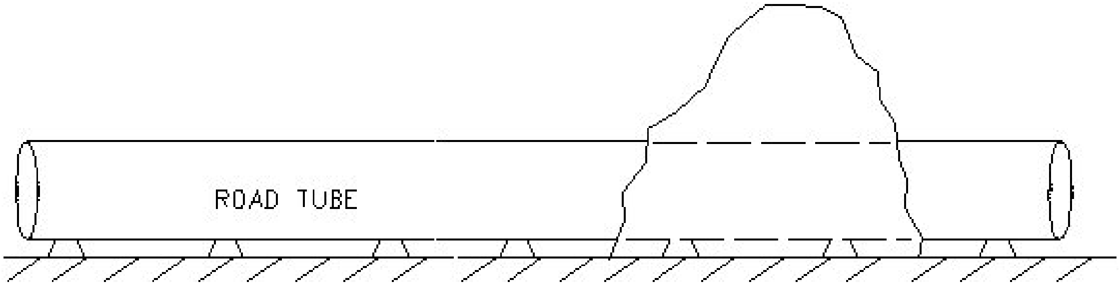

Fig. (4). Tube motorway.

Fig. (5). Double-decker Motorway.

Another proposal that the author had during the 1970's was to invent a 'chemical tree', which would neutralise some of the greenhouse gases, when the wind blows through these 'trees'. However, at that time, some of the author's colleagues berated him and as a result of this, he dropped the idea. Today, a scientist called Dr. Klaus S. Lackner [17] has successfully invented such an artefact and it was demonstrated on BBC TV. According to Broecker [18], Lackner invented a plastic type of material, which absorbed the CO_2 from the air and it was also possible to remove the CO_2 from this plastic with water vapour, so that the plastic could be reused again and again. It is the present author's belief that if this plastic were used in a tube highway, it would be more effective at removing the CO_2 than in the open atmosphere, because the percentage of CO_2 inside the enclosed tube would be much higher than in the open atmosphere.

The author has discussed the treatment of carbon dioxide with chemicals, but what about burying it in the deep oceans. The maximum depth of the oceans is in the Mariana's Trench, which is some 7.16 miles (11.52 km) deep, and the average depth of the oceans is some 2 to 3 miles (3.22 to 4.83 km) deep. Now according to Dickens *et al.,* [5] there are frozen methane hydrates in many gas fields, covered by water of about 2 miles (3.22 km) depth and more. These methane hydrates have laid there for millions of years and are quite stable, despite the fact that they are less dense than water. Thus, if we remove this methane for our own use, we can replace it with carbon dioxide, which should also freeze in the form of hydrates due to the high pressures and low temperatures, as shown in Fig. (**2**). One must remember that as the freezing point of carbon dioxide at normal pressures, is some $104^{o}C$ higher than the freezing point of methane, there is no reason why the carbon dioxide will not freeze as a hydrate and stay stable for millions of years. Moreover, unlike methane hydrates, carbon dioxide hydrate is denser than water, so if it gets disturbed and rises, it will eventually settle on the ocean floor. Another way of disposing of the carbon dioxide is simply to pump it out from (say) a submarine tanker at a depth of more than 3.6 km. Scientists believe that carbon dioxide will simply freeze at this depth, in the form of carbon dioxide hydrates and sink to the bottom of the ocean, as it is denser than water; the density of frozen carbon dioxide hydrate is about 1.1 times the density of water.

1.7. Underwater Rig

Fig. (**6**) shows a manned underwater drilling rig [19] for extracting deep-sea methane. This rig can also be adapted to pump the unwanted carbon dioxide into the sea at a suitable depth, where the carbon dioxide will freeze in the form of hydrates, due to the high pressures and sink to the ocean's bottom, as carbon dioxide hydrate is denser than water. The rig, whose internal diameter is 10 m, is very large and because of this it cannot be made in metal. This is because as the rig dives deeper and deeper into the sea, it is necessary to increase its wall thickness, so that it can sustain the resulting higher and higher pressures. This is shown in Table **3**, where the wall thicknesses of the toroids are shown for various materials, if they are to be designed to operate at a depth of 7.16 miles (11.52 km). The wall thicknesses of the toroids of Table **3** were obtained by using the thick-shell theory of Lame' [20, 21]. The column under the symbol 'W' represents the weight per unit length of the toroid, neglecting weights such as those due to machinery, personnel, etc. The column in Table **3** under the symbol 'B' represents the buoyancy per unit length of toroid.

It can be seen from Table **3** that at a depth of 7.16 miles (11.52 km), the wall thickness of the rig is so large that if it were made in metal, it would have no reserve buoyancy and it would sink like a stone to the bottom of the ocean. That is, if W>B the vessel sinks! Thus, the rig has to be made in a material that has a better strength: weight ratio than a very strong metal, such as high-tensile steel. Suitable construction materials for the rig are glass fibre reinforced plastic ('S' glass) and carbon fibre reinforced plastic, where the former is only $1/3^{rd}$ the cost of the latter, but the latter is a better construction material than the former. The rig is powered by a Pressurised Water Nuclear Reactor (PWR) and has a crew of 60. The rig is described in much detail in the above reference and because of this; its description is only brief in the present text.

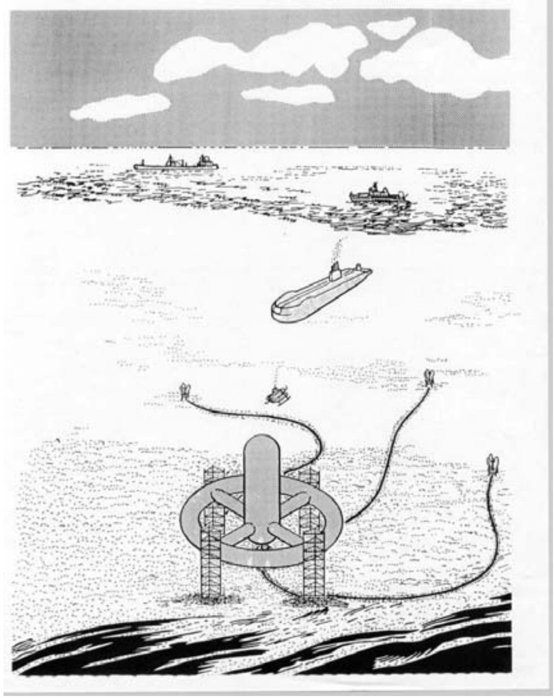

Fig. (6). Underwater drilling rig.

Another, even cheaper method of eradicating the carbon dioxide, is to freeze it above sea level as dry ice and simply to throw it overboard from a ship, in the form of streamlined torpedoes, as described by Murray *et al.* [22] and as shown in Fig. (**7**). According to Murray *et al.*, that as the density of the frozen carbon dioxide (dry ice) is 1.56 times the density of water; the frozen carbon dioxide will sink and remain stable when it reaches the appropriate depth of water. It is true, that some of the frozen carbon dioxide will evaporate, before it reaches the appropriate depth of water, but this may be the inexpensive alternative of disposing of the unwanted carbon dioxide. In any case, experiments carried out by Langwell *et al.* [23], found that the loss due to evaporation by using this procedure, was very small, because the CO_2 torpedoes reached speeds of over 80 km/hour.

Table 3. Wall Thickness (t) of the Circular Section of the Toroidal Structure

Material	Specific Density	'Yield' Strength (MPa)	External Diameter (m)	Wall Thick(t) (m)	'W' kg/m	'B' kg/m
HY80 Steel	7.86	550	14.6	2.301	0.7E6	0.17E6
Aluminium alloy 7075-T6	2.9	503	15.2	2.6	0.27E6	0.19E6
Titanium alloy 6-4 STOA	4.5	830	13.78	1.39	0.22E6	0.15E6
GFRP composite Epoxy/S-glass	2.1	1200	11.8	0.91	0.066E6	0.112E6

The method of growing phytoplankton to absorb the CO_2 from the sea was also tried by Langwell *et al.* [24], but they found that it had serious limitations.

Furthermore, according to Attenborough [14], some 50% of the CO_2 in the Earth's atmosphere is naturally absorbed by the oceans. This phenomenon has the big disadvantage that it makes the oceans more acidic and if the Earth's oceans become too acidic, the plankton and other forms of sea life can be destroyed and thus damage the food chain. The CO_2 absorbed by the oceans takes the forms of carbonates, bicarbonates and carbonic acid. This phenomenon, however, does have an advantage; in that the CO_2 can be collected from the oceans by a submarine type vessel and then be pumped into the Earth's crust deep underwater, where it will freeze in the form of a carbon dioxide hydrate. Alternatively, the CO_2 can be collected by a surface ship or tanker, which will have the facility of freezing it and dumping the frozen CO_2 overboard, as illustrated in Fig. (**7**). It may be preferable to power the ship with a fairly conventional PWR nuclear reactor, so that the ship will have no need to use fossil fuels. The frozen carbon dioxide will sink to the ocean's bottom, where it will remain stable for millions of years in the form of a frozen carbon dioxide hydrate.

Lovelock [25] in his TV broadcast said, that during the 2008 Arctic summer, some 60% of the Arctic's ice cap had completed melted away. This effect caused the Arctic Ocean to become 'darker' and as a result, the Arctic Ocean absorbed more sunlight, causing positive feedback. The effect of positive feedback will be to cause an even more rapid growth in temperature rises, causing the Arctic ice cap to melt more rapidly in future years and Lovelock believes that in from between the next 5 to 15 years, the Arctic ice cap will completely melt away, causing more positive feedback and 'exponential' growth of temperature rises. Lovelock believes that when the Arctic ice cap melts completely, during one Arctic summer, we will not be able to re-freeze it again during the next Arctic summer. The consequences of this will be disastrous for Planet Earth, as the 'tipping' point; that is, the point of no return has been reached. The present author believes, however that the re-freezing of the Arctic ice cap during the Arctic's summer can be done if we resort to the following acts.

We can place mirrors on our rooftops to shine the Sun's rays back into outer space. We can make our highways and roof tops white, to shine back the sunlight into outer space. Some people may say that it would not be aesthetically pleasing to have white roofs and white highways; however the present author would like to point out that when it snows, we often have white roofs and white highways and most people find such scenes beautiful, when this occurs. Additionally, large parts of our oceans are quite 'dull' and must absorb an enormous amount of radiated heat from the Sun. By placing polystyrene floats in the oceans, we can radiate much of this sunlight back into outer space and we can cool down the Planet Earth!

Now, another method of 'cooling down' Planet Earth is to take advantage of the fact that methane consists of one part carbon and four parts hydrogen, that is, Methane is CH_4, so the reduction of carbon dioxide emissions can be carried out by separating the hydrogen from the carbon, in the methane and run engines, including the fuel cell and aero and ship engines, using the hydrogen. The output of burning hydrogen to power an engine, including aircraft engines, or using it in a fuel cell is water, which is pretty harmless. Thus, we can avoid the carbon footprints normally associated with aero and ship engines!

1.8. Flooding

In recent years there has been an unprecedented level of flash flooding on much of the Earth; remember the flash flooding in England, China, Mexico and Bangladesh in the year 2007. This effect is likely to become worse due to the increase in atmospheric CO_2. Scientists have found that the stomata in plants are opening less because of the increase in CO_2 levels [26]. The stomata are the tiny openings in the leaves and stems of the plants; they help to carry out the gaseous exchange between CO_2 and oxygen. Scientists have found that because of this, the plants are not evaporating as fast and as a result their roots are not absorbing as much water from the ground as in the past. One must remember that most plants are over 65 to 80% water [27]. Thus, the water tables and river levels are rising and this will worsen flash flooding in the future.

1.9. Energy Production Costs

The cost of producing energy (MW-h) by a number of methods is shown in Table **4**.

From Table **4**, it can be seen that the cost of producing energy by wind power is considerably greater than that produced by fossil fuels and by nuclear power. In the case of

Solar Power, the figure assumes that the Solar Panels will last for at least 25 years [28], with no maintenance costs. Will the voter in the developed world be happy if he/she is faced with an annual central heating bill of about $3000-, together with rapidly rising motoring costs? The present author doubts if the voter from the developed world will be happy with very large increases in heating and motoring costs. Thus, it can be concluded that the developed world will be very reluctant to give up the use of fossil fuels and something has to be done about this! The costs of obtaining energy from the deep sea frozen methane hydrates is unknown, but no doubt, when it becomes commercially viable to be retrieved, it will be mined in one way or another.

Table 4. Costs of Energy Production (MW-h) by Various Methods

Coal	Gas	Nuclear Power	Solar Power*	Wind Power
$60-	$76-	$78-	$103-	$170-

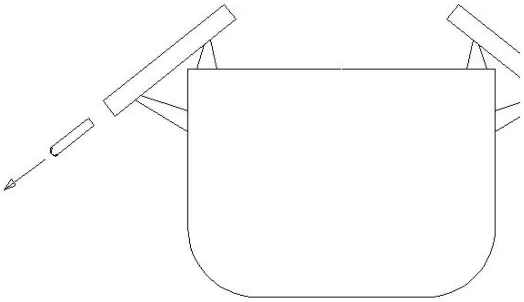

Fig. (7). Dumping frozen CO_2 torpedoes from a ship.

CONCLUSIONS

The paper has shown solutions for solving the energy crisis problem and preventing climate change. It is unlikely that mankind will not be tempted to 'mine' the frozen methane hydrate from the deep oceans, as its monetary value is about 536 times the annual GDP of the USA! Combustion of this methane will result in the emission of 27,600 billion tonnes of carbon dioxide and this will have to be dealt with or we will suffer from detrimental man-made climate change of biblical proportions. The release of this quantity of gas into the atmosphere will increase the build-up of man-made CO_2 by about 1511%. The paper has shown that it is possible for science and technology to eradicate much of this greenhouse gas, which is the worst offender of the greenhouse gases. In the author's opinion, if the scientists and technologists are 'given the tools', they can 'finish the job'; we can save the planet! Urgent action is, however, required.

REFERENCES

[1] Lovelock, J. Gaia. UK: Oxford University Press 1995; p. 33.
[2] Lovelock, J. The revenge of gaia, UK: Penguin Press Ltd 2006; p. 58.
[3] Wikipedia. List of countries by carbon dioxide emissions per capita. 2009. Available from: http://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions
[4] Dickens GR. Private Email to Ross CTF 2008.
[5] Dickens GR, Paull CK, Wallace P. The ODP Leg 164 Scientific Party: direct measurement of in situ quantities in a large gas-hydrate reservoir. Nature 1997; 385: 426-8.
[6] Carroll JJ. Carbon dioxide sequestration in the Ocean. 1999. Available from: http://www.telusplanet.net/public/jcarroll/CO2.HTM
[7] Ross CTF. Letter to the Editor. The Independent on Sunday. London, UK, 2009; p. 30.
[8] Lewis LH. Sources of Power could last 100 years. The Times 2008; p. 33.
[9] Wikipedia. Global Warming. 2009. Available from: http://en.wikipedia.org/wiki/Global_warming
[10] Haberle R. Why is the martian atmosphere so thin and mainly carbon dioxide? 2009. Available from: http://humbabe.arc.nasa.gov/mgcm/HTML/FAQS/thin_atm.html
[11] Durkin M. The great global warming swindle. Channel 4, 2007; Available from: http://www.dvd.co.uk/DVD/Great-Global-Warming-Swindle/WAGTV0005/product.htm
[12] Merchant C. The Scam of the great global warming swindle. edinburgh university, 2007; Available from: http://video.google.com/videoplay?docid=-1656640542976216573
[13] Ross CTF. Letter to the Editor. The Independent on Sunday. London, UK 2005; p. 30.
[14] Attenborough SD. Climate Chaos. BBC 1 TV broadcast, UK 2006.
[15] Hirsch T. Plants revealed as Methane Source. BBC News, 2006; Available from: http://news.bbc.co.uk/1/hi/sci/tech/4604332.stm
[16] Ross CTF. Letter to the Editor. The Independent. London, UK 2005; pp. 28.
[17] Bentley M. Synthetic trees could purify air. 2003; Available from: http://news.bbc.co.uk/1/hi/sci/tech/2784227.stm
[18] Broecker WS. Hardtalk. BBC 24hours News. 2008.
[19] Ross CTF, Lafolley-Lane G. A conceptual design of an underwater drilling rig. Mar Technol 1998; 35: 99-113.
[20] Ross CTF. Mechanics of solids, Chichester, UK: Horwood 1999; p. 312.
[21] Ross CTF. Pressure vessels: external pressure technology. UK: Horwood, Chichester 2001; p. 15.
[22] Murray CN, Visintini, L, Bidoglio G, Henry, B. Permanent storage of carbon dioxide in the marine environment: the solid CO_2 penetrator. In: Goldemberg J, Ed. International Conference On Greenhouse Gases: mitigation options, London, UK: Pergamon 1995; 37: pp. 1067-72.
[23] Langwell J, Basil S, Kevin Le. Ways to save the planet: fixing carbon. Discovery TV, 2009.
[24] Langwell J, Basil S, Kevin L. Ways to Save the Planet: Hungry Ocean. Discovery TV, 2009.
[25] Lovelock J. High anxieties: the mathematics of chaos. BBC 4 TV, 2008.
[26] Fletcher B. Stomata control; how the atmosphere affects plants. 2008; Available from: http://www.shef.ac.uk/aps/apsrtp/fletcher-ben/atmosphere.html
[27] Wikipedia. What of water is a plant made up of? 2009. Available from: http://wiki.answers.com/Q/What_percentage_of_water_is_a_plant_made_up_of
[28] Wikipedia. Levelised cost of Solar power, 2009; Available from: http://en.wikipedia.org/wiki/Solar_thermal_energy#Levelised_cost

Received: September 10, 2008 Revised: April 23, 2009 Accepted: May 4, 2009