Global warming

Not so long ago, somewhere in the beginning of 2007, Sir Richard Branson, founder of Virgin Atlantic, made an offer: 25million dollar for the one who could stop the "global warming". I became interested (was it greed or genuine interest?) and started to think, I considered it a challenge. Later I learned more about the offer. Sir Richard is a member of a group who are seriously concerned about the climate changes and global warming. Sir Richards offer is made to the person who could eliminate one billion tons of CO_2 from the atmosphere annually! That is a large quantity, but the more important question is: "Is this amount sufficient to solve this problem?"

I became inspired because I really thought I had some good ideas how to get carbon dioxide out of the air! But when I started calculating, I became very discouraged. By reading this report you will understand why.

The 25 Million Dollar Question

Can we save the world?

We have beginning of February 2007 now. Ever more we hear and notice: our climate is changing. In the last years we had several weather records: the warmest summers, the warmest November of the century, the hottest July, the wettest August, all in the last couple of years and more records will be broken. The earth is warming up and we hear ever more scary news about our globe: the sea surface will rise, but also: insufficient and therefore expansive oil, basic materials are getting scarce, the seas are becoming empty, all kinds of fishes, animals, plants are dying out, clean water is becoming a problem for more and more people, deforesting and flooding are happening more often, also fertile land is taken over by the desert. In short the future doesn't look good!

Recently reports from scientific institutes were published: the global warming is almost surely due to human activities, specifically by the emission of "greenhouse" gases. Immediately other scientists stood up and declare that this is not sure at all, the increased sun activity plays the most important role in this. One thing is for sure, the percentage of carbon dioxide CO_2 in the atmosphere has increased substantially in the last decennia. Also, carbon dioxide is seen as a "greenhouse" gas and therefore responsible for the increased global warming!

Can we save the world? This question is actually wrong. The world will save itself. The question is: can mankind save itself? "Mankind is rushing towards catastrophe!" Mere cliché words but unfortunately, they are true! The outlook is bleak. Not only the global warming and its consequences are a problem. The world population is increasing in a scary pace. New industrial countries, like China and India, are emerging and demanding more and more energy. It is getting so serious now that oil production can hardly cope with the demand.

Coal and natural gas are still available in sufficient quantities. But now raw materials, ores, metals and so on are getting scarce too and therefore more expensive. Food and water is also becoming scarce for increasing groups of people. Crises are threatening: an oil crisis, energy crisis, basic material crisis, food crisis, population explosion, fresh water crisis but above all a climate crisis! The weather is becoming extreme and unpredictable, most probably because of the increased temperature of seawater. Storms and hurricanes are becoming more energetic, winters extremely mild or frighteningly cold! Summers become hotter, drought and more and more areas are turning into deserts. Is there any good news? Oh yes, the ozone layer in the higher atmosphere, which is protecting us against UV radiation, is recovering, due to the ban of CFK gases in fridges and aerosols. In Europe: "Waldsterben", dying of the forest due to acid rain, is not heard of anymore.

But it is clear now that the climate of our earth is changing, maybe positive for some northern countries but very negative for many human beings and animals. This change of climate, the global warming, with the possible consequences: melting of the polar ice cap and consequent rising of the sea level is now seen by most scientists as definitely due to human activities, which is mainly due to the burning of fossil fuels for energy generating purposes.

The unbridled growth of the energy consumption and the rapid auto mobilisation of more and more people, now also in the oriental world, cause a frightening and tremendously increased demand for oil and gas! By the conversion of ever larger amounts of fossil fuel into energy, the CO_2 emission has increased strongly in the past few years. Even though, the CO_2 content of our surrounding atmosphere is still quite low. At first sight this tiny amount of carbon dioxide doesn't look very important, we are talking about a few hundredth of a percent! Air exists mainly of nitrogen (78 %) and oxygen (21 %). The remaining one percent contains all other gases, such as helium, argon, neon and many others, also CO_2 and, as I learned later on, also H_2O (water vapour). The percentage of carbon dioxide today is a little over 0, 04 %, so what are we talking about?

Well, we are talking about a "greenhouse gas". Science tells us that greenhouse gases prevent the radiation of a considerable amount of heat into the universe. This "greenhouse effect" is supposed to be the reason that the average temperature of the world is + 15 ^{0}C in stead of – 18 ^{0}C. So actually we should be glad with these greenhouse gases!

The most important greenhouse gas is water (vapour), which accounts for 62 % (Encarta) of the effect! (Some sources, f.i. wikipedia, even claim that water causes 90 - 95 % of the greenhouse effect.) Air is often humid, the humidity varies strongly and water is present in the air in all forms: as ice, as drops, but mainly as water vapour. And we know now that this water vapour in the air is the most important greenhouse gas. The next important greenhouse gas is carbon dioxide or CO_2, which is responsible for 22 % of the global warming (Encarta)! There are also other greenhouse gases: methane (CH_4), CFK's, (gases used in fridges and aerosols), nitro oxides ("NO_x") and some other gases, which are playing a less important role. Ozone (O_3), which, in the upper layers of the atmosphere, protects us against dangerous UV (ultraviolet) radiation, is a greenhouse gas on ground level. Ozone is generated when there is a lot of pollution (and no wind, as we all should know) in the air.

Back to carbon dioxide! Thousands of years ago, science says, the CO_2 percentage was much lower: 20 thousand years ago the percentage was about 0,017 %. In 1870 the amount was 0,028 % and in 1980 already 0,035 %! In the Encarta encyclopaedia (version 2003 on my laptop) the CO_2 percentage is set at 0,033 %. And Wikipedia writes that CO_2 has risen from 270 to 370 PPM (0,027 % - 0,037 %) since the industrial revolution! The precise figure is difficult to asses because of the varying percentage over the world's surface. At this moment, in 2007, it is supposed to be average a little over 0, 04 %. So, in a few decennia, the amount of CO_2 in the air has increased 25 %. So, although CO_2 is not the strongest greenhouse gas, the enormously risen emission of carbon dioxide in the last years is held responsible for the increased greenhouse effect and global warming! Why is CO_2 a greenhouse gas? According to science, this has to do with its absorption of certain wavelengths of infrared radiation! But is CO_2 really so important? The scientists are divided!

We saw that also “methane” (CH_4) is a greenhouse gas. It is a gas that is released in increasing quantities by the melting “permafrost”. Methane (the principal ingredient of natural gas) is a very powerful greenhouse gas, even 20 times stronger than CO_2. Although the concentration of CH_4 in the air is very much lower (200 times less) than CO_2, science thinks it is now responsible for 10 % of the greenhouse effect. However, methane could become a much larger problem. When the permafrost layer in Siberia and Alaska will really start melting on an extensive scale, large quantities of methane will be released.

Also the “NOx” (nitrogen oxides), emitted during combustion of fossil (but also of bio) fuels, are harmful for men, but the concentration is still low and there is, as far as I know, no greenhouse effect!

Is it really the greenhouse effect by CO_2 that causes our climate to change and the globe to warm? Global warming is real, even the most sceptical scientists will not contradict this any more! The polar ice is melting: the (northern) icecap is becoming smaller and smaller. About the South Pole one hears different stories. But we can’t ignore the fact that glaciers everywhere are getting smaller and retreat further and further. What is also real, the seawater temperature is rising, by which the water expands and the level rises, although so far only a few centimetres. Clearly noticeable, the mean temperature of our earth is going up. If we observe the Netherlands (my home country): the warmest summers of the last century occurred in the last ten years. The winter 2006/2007 was the warmest since 1706! The mean temperature measured was ± 3 centigrades above average. Is it greenhouse gas or is it due to increased sun activities, as some scientists say? There are also meteorologists who claim that all this is due to the bizarreness of the weather and that all is pure coincidence. According to them there are even areas where it is getting colder: the South Pole where temperature has dropped lately. There is another danger: because of the rising seawater temperature, the warm Gulf Stream, which strongly influences our climate (Western Europe), could disappear. That would cause a colder, instead of a warmer climate in our countries. What we all see is a change in our climate. In Western Europe we experience heavier gales, extremely hot summers, warmer winters and wetter showers which cause flooding in areas which were unknown so far. In the Caribbean and also in Asia we hear about dangerous, destructive hurricanes, which seem to occur more often nowadays and are stronger than ever. When such extremes take place, the man in the street quickly tends to blame this to climate change, although extreme weather is of all times. On the other hand, it looks as if these incidents happen more often nowadays.

Lately also strong earthquakes seem to occur more often. But earthquakes have nothing to do with climate change, neither with human actions (although small earthquakes can be caused by pumping up oil and natural gas.) What is the matter then? An explanation can be found in the increased world population! Parts of the world which used to be uninhabited before are populated now. So if there is an earthquake, a tsunami or a storm with flooding somewhere, more people are likely to suffer from it and are confronted with damage and loss of properties. Also because of the improved communications, we hear all these catastrophic events as “news”!

“An inconvenient truth”

Some time ago Al Gore, former vice-president of the United States, was in the news. He visited many countries, also the United Kingdom and the Netherlands, to promote his film: “An inconvenient truth” and to wake up mankind. Sir Richard Branson was probably so shocked by the movie that he made his proposition, supported by Al Gore and Al’s former boss Bill Clinton.

Al Gore was the democratic candidate for the presidency of the USA in 2000 and running up against Bush. “George W” won the elections with a few more (maybe even less) votes and became president of the United States. Al Gore lost and had to do something else. In the mean time we have seen that “winner” Bush is not at all environment conscious. He refused to sign the Kyoto protocol about the emission of greenhouse gases such as CO_2. A reduction of 8 % less CO_2 emission by 2004 was agreed on. Shame on Bush, the USA is the largest consumer of energy and therefore also the largest emitter of CO_2 in the world. Although many nations signed the treaty in the knowledge that something had to be done, Bush called the protocol invalid (“The Kyoto protocol is flawed”) and not in the interest of the American economy. No, not on the short term, but on the long term also the United States has to participate. For me and many others not understandable: in the election for a second term as president of the US, this man was re-elected with a clear majority. “Those Americans are even more stupid than I thought!” someone said. Even today, Bush still doesn’t want to have anything to do with the Kyoto protocol and other treaties. Understandable, because than he has to take very unpopular measures, measures which the Americans, who are addicted to energy, would not accept!

Al Gore went the environmental way and made the above mentioned movie: “An inconvenient truth”. Unfortunately I haven’t seen the movie yet (spending the winter in Spain), only fragments on TV. I saw images about melting polar ice, polar bears in trouble, the sea level rising meters, causing coastal areas, where many people live, to be flooded. The movie blew up a lot of dust and in the mean time it even got an Oscar.

Bush probably has been shocked by it too; in his last “State of the Union” in 2007 he indicated that the petrol consumption must be cut 20 % in the coming 10 years, by new technologies. Quite easy to say that on the end of his second term, but how do you get the Americans in small, economic cars?

Also in Europe we have a problem. Although everybody reads the papers, hears the news and notices that oil becomes scarce and very expensive, more and more SUV’s are sold. In stead of changing over to smaller, more economic cars, still more four wheel drives, jeeps and the likes are sold, vehicles with big strong engines which of course are quite thirsty and certainly will not cooperate to the reduction of the emission of harmful gases.

Still, when the European Commission gets its way, also Europeans have to tighten the belt and cooperate. In 2020 there must be a 20 % reduction in CO_2 emission!

CO_2, carbon dioxide

Carbon dioxide or CO_2 is supposed to be the guilty one. But what is really the matter with CO_2? What is CO_2 exactly? How much carbon dioxide is present in the atmosphere? Where does it come from? And….how do we get rid of it?

If I would know this, I could get 25 million dollar from Sir Richard! But actually it should be reverse! If I had 25 million dollar, I could try to develop a method to remove the CO_2 from the atmosphere, or at least a significant part of it (one billion tons annually!). Unfortunately the world is not like this. First one should invest, perform and acquire results, only than you can cash.

But also, who am I to state that I could solve the greenhouse gas problem? “Jacob saves mankind, with a new method!” It won’t go like that, but at least I may think about it and try to find a solution for it! Immediately when I heard about Sir Richard Bransons offer, I began to think about the CO_2 problem and started writing this report! I am not a scientist, but I am a technical man, ex ships engineer, have always been working as a technician and am very interested in energy subjects. I have a general know-how and a good memory, especially about what I learned long ago. I still speak several languages, mainly based on knowledge I obtained long ago and with this knowledge I am translating this report in (Dutch) English. I also like calculation and working with numbers, but…am now a retired, grey 70+ man, who spends the winter in Southern Spain. That's why I have plenty of time to think about environmental subjects! For the necessary data I consulted the newspapers, the Encarta encyclopaedia on my laptop and sometimes "Google" and "Wikipedia" in the nearby internet café!

I could have thought: "It will serve my time." And: "Après moi le déluge!" However the bad news of the last time worries me and also, I have a wife who will probably last quite some time longer than I do.

Chemistry

Let's go back to the carbon dioxide. What is it? Well, it is burnt carbon and it is produced when carbon (or products containing carbon such as fuel) is combined with a surplus of oxygen, in other words, when carbon is burnt! And all plants, trees, wood and fuel such as: coal, oil gas, but also our food, all this stuff consists mainly of carbon. All fuels, whether liquid, solid or gas, contain carbon and are belonging to the group of "hydrocarbons", being a chemical combination of hydrogen and carbon! And our food, all we eat, contains carbon and mainly these foodstuffs are: "carbohydrates." Beside carbohydrates we eat proteins which also contain carbon. All this stuff, whether it is of vegetal, animal or fossil origin will produce carbon dioxide: "CO_2" and water: "H_2O", when burned, digested or degraded, in short, when it is "oxidized".

To get a better understanding we need to know some chemistry. In chemistry an atom carbon gets the symbol "C", an atom oxygen gets the symbol "O" and "H" is the symbol for an atom hydrogen. In the following reaction we see how an atom carbon oxidizes and becomes a molecule CO_2 (carbon dioxide):

$$C + O_2 \rightarrow CO_2 \text{ (+ 393,5 kilojoules of energy per mol)}$$

Carbon can also burn partly, when insufficient oxygen is available:

$$2\ C + O_2 \rightarrow 2\ CO \text{ (carbon monoxide)}$$

Carbon monoxide is a poisonous gas, which will burn to CO_2 as follows:

$$2\ CO + O_2 \rightarrow 2\ CO_2$$

The hydrogen in carbohydrates and hydrocarbons forms water (vapour) while oxidizing:

$$2\ H_2 + O_2 \rightarrow 2\ H_2O \text{ (+ 571,8 kilojoules of energy per mol)}$$

From the carbon reaction we can also calculate the weight ratio of both elements C and O, by substituting their atomic weights. Carbon has atomic weight 12 and oxygen has got 16, so 1 mol C = 12 gram and 1 mol O = 16 gram. Here again the reaction and the weights:

$$C + O_2 \rightarrow CO_2$$

$$1 \text{ mol } C + 1 \text{ mol } O_2 \rightarrow 1 \text{ mol } CO_2$$

$$12 + (16.2) \rightarrow (12 + 16.2)$$

$$12 \text{ gram C} + 32 \text{ gram O} \rightarrow 44 \text{ gram } CO_2$$

This means that 12 grams of carbon produces 44 grams of carbon dioxide while burning, more than 3, 5 times the original weight of the carbon. So, when we burn up a ton of coal, with a carbon content of 80 %, we obtain almost 3 tons of carbon dioxide (and a certain amount of water in the form of steam).

Facts about CO_2.

What else do we know about CO_2? It is an odourless, non poisonous gas, which has several applications. It is used in pop sodas to give it a sparkling taste. In beer and sparkling wines it takes care of the bubbles. If this gas is compressed, it becomes liquid. When liquid CO_2 expands quickly, a kind of snow ("dry ice") is formed. This quality is applied in CO_2 fire extinguishers. CO_2 dry ice is a well known medium to extinguish fires, it is non poisonous and it doesn't conduct electricity, important when a fire starts in electrical installations, like switchboxes. Also, CO_2 dry ice doesn't cause any damage, as is the case with many other media, like powder, foam and water!

Although CO_2 is non poisonous, the concentration in the air we breathe, may not be to high. In general, the concentration of CO_2 in the air around us, should not be above 0,5 %. When it is 5 % one gets real problems and above 10 % one suffocates! Plants and trees "inhale" CO_2, withdraw the carbon out of the CO_2 to grow and "exhale" oxygen. That's why presently the CO_2, extracted from exhaust gases, produced by combined heating and power installations, is led to greenhouses to let the vegetables grow faster: CO_2 is food for plants! Also there: the CO_2 concentration should not be over 10 %.

As earlier mentioned, next to carbon **di**oxide, we also have carbon **mon**oxide. Carbon **mon**oxide is formed when hydrocarbons (gas, oil, coal) are burnt with insufficient oxygen supply. It is a very poisonous, odourless, dangerous gas, which has already made many victims. It may be produced unnoticed en enter living quarters, f.i. by malfunctioning burners in heating appliances, like central heaters and boilers. Therefore in the last years stricter safety laws are enforced for these units. Also in petrol and diesel engines small quantities of carbon monoxide are formed. The requirements set for emission by cars has also become much stricter lately. By lowering the limits set for CO (carbon monoxide) and NO_x (nitro oxide), car manufacturers are forced to develop cleaner engines, something in which they succeed better and better. But "clean" doesn't mean: CO_2 free! Just as you can't burn hydrogen without getting water, you can't burn carbon without producing CO_2 (or CO).

Outbursts of volcanoes cause the release of enormous quantities of CO_2 and according to some scientists the human activities such as burning fuel, fall short in comparison to these outbursts. Are they right? Comparing the gigantic amounts of CO_2 emitted by traffic and power plants to the volcano outbursts, which take place now and then, I'm sure they are wrong.

Talking about CO_2 emission by human activities, about what quantities are we talking? Let us have a look at the figures.

Calculating CO_2

To know more about the size of the problem, we need figures, data, to be able to do some calculations. How much CO_2 is emitted? How much CO_2 is present in the atmosphere? Lately CO_2 is a hot item in the news, no coincidence of course. The extreme weather of the last years cannot be ignored any more, and the movie of Al Gore seems to have wakened up many people. Almost every day articles about greenhouse effect and climate change appear in the newspapers. Here some figures which I gathered from Dutch and German newspapers.

- The average emission of European cars amounts to **160 gram CO_2 per kilometre.** The European commission now wants to force the automotive industry to bring this figure down to **130 g/km** (in 2020). Specially the German carmakers immediately protested and are having big problems with this decision (later on joined by other ones, like Fiat).
- In advertisements for (small) cars, the CO_2 emission per km. is now often mentioned. I'm afraid they do this only when the emission is low, because I see figures around **100 gram CO_2 per kilometer.** Big cars emit substantially more! The Germans are more honest, the weekly magazine "Autobild" gives all the figures, also high ones!
- The total CO_2 emission for the Netherlands only, a country with 16 million people, ads up to **180 million ton CO_2 annually**, according to newspapers beginning 2007. On the night before the European climate conference in 2007, suddenly a new figure appeared: **220 million ton CO_2** (for the year 2007?). This means that each Dutchman nowadays emits about **14 tons of CO_2 per year.**
- The traffic would be responsible for 20 % of the total emission. Unclear is if this includes all the transport means. Most probably, ships and aeroplanes are not included, but, buses and trucks are!
- The huge refinery in Rotterdam, one of the largest in this world, emits **one million ton CO_2 per year,** but…. they have plans to do something about it!

With these figures we can do some calculating. Let us first look at the (luxury) cars in Holland. The number of cars per capita I guess is about one on two. With 16 million people this means 8 million cars. We assume that they emit an average of 160 grams of carbon dioxide per km. When we also assume that they drive about ± 16.000 km/year, the annual emission of CO_2 is:

8.000.000 x 16.000 x 0,160 = **20, 5 million tons of CO_2 <u>annually</u>.**

So, in the Netherlands alone, the passenger cars blow the enormous amount of about **20,5** million tons of carbon dioxide in the air! Having the total CO_2 emission of 220 million tons in mind, the cars are responsible for: (20, 5 : 220) x 100 = 9, 3 % of the total CO_2 emission. We are talking about a huge quantity and trucks, buses and trains and aeroplanes are not even included, they will account for another 10 %. We see that the emission of luxury cars, 9, 3 %, is only a relatively small part of the total. This also means that the power plants, the industry and the households together emit the rest: about 80 %.

Germany

Later on I saw a diagram in a German weekly: "Autobild", from 30-3-2007. Although they didn't give a figure for the total amount of CO_2 emission, they gave a clear picture of who emits what. Something else was mentioned: Germany takes care of 4 % of the worldwide CO_2 emission. 3 % is due to human activities, 1 % is not! This means that this one percent is due to natural causes (such as forest fires, open fires and all the CO_2 the Germans and German animals breathe out!). Another figure: the average CO_2 emission for German cars is: 165 grams per kilometre in 2007.

Anyway here are the figures about CO_2 emission from 2004 and for Germany alone!

Passenger cars	13 %	Powerplants	43 %
Trucks	5 %	Industry	18 %
Other	1 %	Households, small business	20 %
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Traffic in total	19 %	the rest	81 %

How much CO_2 would entire Germany annually be emitting now? About five times the Netherlands? With about 85 million inhabitants that seems a realistic figure, so we can set the total annual emission on roughly

5 x 220 million = **1, 1 gigatons of CO_2 for Germany!**

How many cars would they have and what would the annual "milage" (kilometrage) of the average German cardriver be? Let's figure that out, first the emission:

Annual emission of German cars: 13 %:

0,13 x 1,1 billion tons = **143 million tons** CO_2

Number of cars: "n" , the annual milage in kilometres, the "kilometrage": "m" !
Emission is: m.n x 165 grams.

m.n = (143.000.000 x 1000.0000) : 165 = 0,87 x 10^{12} = 870.000.000.000

If we put the "kilometrage" on 16.000 km/year, we get:

870.000.000.000 : 16.000 = ± 54,5 million cars!

All this looks realistic, so until we have more exact figures we can use these data for Germany. To my great pleasure I later learned that this figure is quite correct!

United Kingdom

Let's also try to make a calculation for the UK cars: An English pensioner in Spain told me that there are 33 million cars in the UK! What's the average CO_2 emission per car? We take the European average: 160 grams per km. We assume UK cars drive about 10.000 miles or 16.000 km per year (as they are not allowed to drive as fast as the Germans, they may drive a liitle less!). Annual CO_2 emission for the UK cars is then:

(33.000.000 x 16.000 x 160) : 1.000.000 = 84.480.000 tons, so:

The UK: 84.5 million tons of CO_2 <u>annually</u>

How much would the total annual CO_2 emission for the UK be? According to the earlier figures about 8 to 9 times more, so roughly between:

(8 x 84,5 million = 675 million and 9 x 84,5 million = 760 million)

Overall figure about: **700 million tons of CO_2 <u>annually</u>**

United States

Let us now do some calculations for a larger country: the United States. The Americans are the champion energy consumers in this world. They have the most cars per capita and these cars very often fall in the category "gas-guzzlers" having a considerable CO_2 emission. There are more than 300 million people living in the US and, assuming that they have at least one car for two persons, we talk about 150 million cars. It is even more; from the Dutch TV, I learned that there are about 200 million cars in the USA. Let us suppose that these cars drive an average of 20.000 km per year and have a CO_2 emission of 200 grams per kilometre. As I noticed years ago, when I was in the States, Americans drive a lot more than the Europeans! We can now calculate the total emission of the American cars:

(200.000.000 x 20.000 x 200) : 1000.000 =

800 million tons of CO_2 annually!

This is an enormous amount and it's only a part of the total emission of the USA! If we assume that this is also, let us say 12 % of the total, than the USA accounts for a total **annual emission** of: about:

6, 5 billion tons of CO_2 !

These are all frightening figures. But are they realistic? We can check them by calculating in a different way. Knowing that the USA has 20 times the number of inhabitants as the Netherlands and knowing that the Americans are the greatest energy consumers, the total emission has to be about 30 times as much. The total **annual emission** for the USA comes up to:

30 x 220 million = 6, 6 billion tons of CO_2

Recently I found the following data: the Americans emit a total of 24 tons of CO_2 per person per year. (Dutchmen emit 11 tons and Chinese 2, 4 tons per person per year!) So we can calculate the total annual emission of CO_2 again:

300 million x 24 = 7, 2 billion tons of CO_2

I was not far off! These figures give us an idea about the gigantic amounts of CO_2 we are talking about.

The world

I once read that the Americans are responsible for a quarter of world emission of carbon dioxide! If this is true, the annual CO_2 world emission, due to human action, will than be:

$4 \times 7,2 \times 10^9 = 28,8 \times 10^9$ tons of CO_2 annually = ± 29 billion tons of CO_2

This is an enormous amount. Let's try to figure it out in another way. When we take the total German emission of 1, 1 billion tons of CO_2 which is supposed to be 4% of the total we get:

(100 : 4) x 1, 1 = ± 27,5 billion tons of CO_2

Not so far off. Actually in the German figure 1 % is due to natural causes. But we can calculate again, when we know the figures about the world's energy consumption.

World energy consumption

What is the world consumption of fossil fuels? These figures must be available. It was not so easy to find them, but here are some figures from various sources:

World consumption of crude oil

Last year, in 2006, I read in a Dutch newspaper, that the world consumes about 80 million barrels of oil per day. This gets down to

± 30 billion barrels (of 159 litres) **per year**.

Per world inhabitant the consumption is now about 2,2 litres a day. In comparison (from an internet site): the daily consumption of western people is nas follows: an American: 11 litre, an Englishman 4,8 and a Dutchman 9,1 litre (so Dutchmen are also gasguzzlers)! According to another news item (on Dutch TV) Americans consume 17 litres, the Chinese 2 litres and the Indians 1 litre of (crude) oil per day. All this means that a lot of people in this world behave very differently and consume almost nothing! How much longer will they accept such inequality?

The consumption of oil is still rising, **about 7 % per year**, and therefore it becomes more and more difficult for the oil companies to cope with the demand (and for me calculating the right amounts!). We are now balancing on the edge!

Some more figures: in 1996 the annual world consumption of oil was "only" 20 billion barrels and in 2004 it was 25 billion barrels.

World consumption of natural gas

On a site which I found by "googling", I read that in 2004 the amount of natural gas consumed by the world, was around 2500 Giga nm^3**.** We can make a rough estimate for 2007: Around **3000 billion cubic metres (nm^3) annually**

World consumption of coal

In 2002 the coal consumption was 5,8 million ton per year, in 2003 it was about 5,5 billion tons. After that, the trend was up again and when this trend continues the consumption will be 9070 million ton per year in 2025. We can conclude from this that the annual consumption for 2007 will be roughly around **6 billion tons of coal.**

World fossil fuel reserves

When we see these consumption figures, the question arises:
"How big are the reserves of the so called"fossil fuels"? How much oil, gas and coal are still hidden in the earth?"
The exact sizes of these reserves we don't know of course, but there are certain estimates.

- **Crude oil**

According to one figure (from 2002), the world reserve of crude oil in that year was: 5260 billion barrels. In the mean time a lot is used. Also, the oil companies sometimes exaggerate their proven reserves. Not long ago (early 2007) the big oil companies lifted a tip of the veil. They claimed to be able, with a lot more effort than so far, to pump up another 3600 billion barrels. This is an encouraging figure! Going out from the present consumption, this means we have oil for another 120 years. When I read these figures I asked myself if the huge amounts of tar sand and oil shale would be included in these figures. It is generally known that there are huge quantities of oil containing sand in Canada, Siberia and other countries. In the past it was much too expansive to exploit this stuff, but with the risen oil prices, it is now feasible and the industry has started to build the first installations to extract oil from this "tar sand".

These tar sand reserves are clearly not included in the above mentioned crude oil reserves. According to the Encarta encyclopaedia there are 500 times more hydrocarbons in this tar sand and oil shale than there is crude oil in the world. And, in Brazil and Estonia, oil shale is already used to generate electricity!

This all means that we don't have to worry about the oil reserves, there is more than sufficient. The price of oil however will go up considerably, because of the production problems. But the greatest worry is that, when all this oil will be burnt, a gigantic extra amount of CO_2 will come in the atmosphere. When we estimate the CO_2 emission of a barrel of oil being burnt, on 300 kg, this means for the 3600 billion barrels alone, that another 1080 billion tons of carbon dioxide will be added to the atmosphere by the oil alone!

- **Natural gas**

How much natural gas would still be hidden in the earth? I fear that a precise figure is not known, although there are estimates. In the fifties a huge natural gas source was discovered in "Slochteren" in northern Netherlands. At that time it was the second largest source in the world and it contained 2000 billion n.cubic metres (2000 Giga normal m^3). Later on I read that it would be even more: 4000 G.n.m^3, but this was never confirmed. In the mean time this source is getting quite empty, but more sources have been found in the Netherlands in recent years, although not as big!

Encarta mentions a world reserve in 1992 of 140 thousand Gnm^3 and a consumption of 2 thousand Gnm^3 per year (2, 5 thousand Gnm^3 in 2004). In the latter years huge new quantities were discovered. I think that we can estimate the world reserve of natural gas at minimally 150 to 200 thousand Gnm^3 now!

Natural gas consists largely of methane (CH_4) which contains a lot of hydrogen. Burning of this gas causes relatively low CO_2 emission but a lot of H_2O (water) is produced!

- **Coal**

Years ago I read that there is still coal for another 400 years in the ground. In the mean time this will not be so much any more. In the last decennia the consumption has increased tremendously and large quantities of coal have been dug up! But a lot of "new" coal has been discovered. Difficult accessible coal (as in Germany, England and Holland) is even left alone now; dangerous deep mines have been closed. There is sufficient, easy to win coal in countries like Australia, South Africa and others. Also we still have a lot of brown coal and peat. Huge quantities of brown coal are now being dug up in Germany (f.i. in Bergheim). But also this stuff will strongly increase the CO_2 percentage in the air, when it is burnt.

In view of a present consumption of about 6 billion ton annually, we can estimate the world coal reserve between 1000 and 2000 billion tons of coal at least.

- **Summary**

  World reserve of fossil fuels

Crude oil	: 3600 billion barrels (of 159 litre)
Natural gas	: 150 - 200 thousand Giga (billion) N.m^3
Coal	: 1000 - 2000 billion tons
Tar sand	: X000 billion barrels
Oilshale	: X000 billon barrels

If we continue burning all these fuels, an enormous extra amount of CO_2 will be added to the atmosphere. The present CO_2 percentage of the air will increase sharply!

Global CO_2 Emission

We still have to verify the global, annual CO_2 emission. With the data of the world's fossil fuel consumption, we can start calculating again. Indirectly, via the CO_2 emission by the United States of America and Germany, we calculated an emission of:

27,5 - 29 billion tons of CO_2 annually

Now with the figures about oil, gas and coal, hopefully we can get a similar figure:

First we have to know the emission figures for the various fuels and then substitute them in the world's fuel consumption. Not so easy to figure out, but we can make a rough estimate, with the following data: 1 litre dieseloil produces 2, 62 kg CO_2 , petrol does 2, 32 CO_2 and 1 n.m^3 natural gas emits 2, 23 CO_2 when burnt (Autobild march 2007). And coal? That depends on the carbon content. At 70 % it is about 2, 5 kg CO_2 per kg coal. Here the data for a rough calculation:

CO_2 emission of fossil fuels:

1 barrel of crude oil produces ± 300 kg CO_2 when burnt.
1 m^3 natural gas produces ± 2,25 kg CO_2, when burnt.
1 ton of coal produces ± 2500 kg CO_2, when burnt.

World consumption of fossil fuels:

Crude oil:	30 billion barrels per year.
Natural gas:	3000 billion n.m^3 per year.
Coal:	6 billion tons per year

Do we have all the necessary data now? Unfortunately not, there are also "bio fuels", fuels made from bio mass, sugar cane, oily seeds etcetera. Also not included are peat, brown coal and firewood. Furthermore men and animals exhale more CO_2 than they inhale. And than, we have the volcanic eruptions and forest fires which throw large amounts of CO_2 in the air. On the other hand we have the fauna, all plants, bushes and trees which inhale CO_2 and exhale oxygen (O_2). The easiest way is: let us assume that bio fuels and fauna compensate each other and work "CO_2 neutral". For a very long time, the CO_2 percentage remained more or less constant! On the other hand, the number of people in this world has increased tremendously: in 1850 the population reached 1 billion, in 1950: 2 billion! And now in 2007 we are 6, 5 billion and are approaching 7 billion!

Anyway we will calculate the emission for the fossil fuels, oil, gas and coal only, assuming that those fuels are mainly causing the problem. Using the data about the annual consumption and the emission figures, we can make the following table:

World's annual CO_2 emission by using fossil fuels

Oil:	$3 \times 10^{10} \times 300$ kg	$= 900 \times 10^{10}$ kg	=	9 billion tons per year
Gas:	$3 \times 10^{12} \times 2$ kg	$= 6 \times 10^{12}$ kg	=	6 billion tons per year
Coal:	$6 \times 10^{9} \times 2500$ kg	$= 1500 \times 10^{10}$ kg	=	15 billion tons per year
				------------------------------ +
Total annual emission of CO_2:		3×10^{10} ton CO_2	=	**30 billion tons per year**

This is slightly more than the 29 billion tons, figured out earlier via the figures from the USA and via Germany: 27, 5 billion tons**.** This means that the data are quite near. Thus we may safely say that the present annual CO_2 emission figure for the world is as follows:

The annual CO_2 emission because of the burning of fossil fuel in this world amounts to roughly <u>30 billion tons</u>!

These differences are so large, that I tried a third way to verify the figures: I went to the internet and found the following (astonishing) figures, which more or less confirm my findings:
On a site from "Planetark" I read:

CO_2 emission in 2003: **25 billion tons per year**
CO_2 emission in 2030: **43, 7 billion tons per year**

On Wikipedia I found:

CO_2 emission in 2006: **26, 7 billion tons per year**

More CO_2 emission

So far we have looked at CO_2 emission because of the burning of fossil fuel. According to some sources the annual CO_2 emission on global scale is supposed to be divided roughly as follows:

Transport:	**15 - 20 %**	**± 5,5 – 6 gigatons of CO_2**
Industry	**60 %**	**± 15 – 18 gigatons „ „**
Deforesting, vulcanoes etc.	**10 - 20 %**	**± 4,5 – 6 gigatons „ „**

So if all this is true, then the emission because of fossil fuel is "only" 80 % of the total. The rest is caused mainly by deforesting, including the use of firewood by people in the third world (the "alternative energycrisis"). Other sources are the vucanoes of this world. When a vulcanoe erupts, tremendous amounts of gas, also CO_2 , are thrown in the sky! Remember the eruption of mount St Helen! Also people and animals are eating food consisting mainly of carbon, which is eventually turned into carbon dioxide!

Let's have a look at the world's people, about 6, 2 billion of them. How much would they eat? It is better to say: "How much calories do they need per day?" To be on the safe side I put them on a daily diet of 1000 kcal per day. The average is 2000 kcal, I myself also eat

somewhat more than a 1000 kcal per day, but babies a lot less! (There is also hydrogen in carbo hydrates, which also may produce energy but will produce water!)
1000 kcal makes about 4000 kjoule (1 cal = 4, 18 joule). To obtain this amount of energy, one has to eat about 120 grams of carbon (in the form of carbohydrates and proteins of course). We have seen earlier that, when 1 mol carbon (12 grams) is burnt, 393 kjoules and 44 grams of CO_2 are produced.

Now we can calculate. The annual CO_2 emission by people will be:

365 x 6.200.000.000 x (44 : 12) x 0,120 kg = 6,2 billion x 160,6 kg = ± 1000 billion kg.

So we are talking about an "emission" of **1 billion tons of CO_2 annually**, by the world's population. A similar calculation about the CO_2 emission by all the animals of the world could also be made when the parameters would be known. As these figures are not available to me, all I want to say about it is that the CO_2 emission by all the animals will be larger than people's emission, not talking about the methane (CH_4) people and animals "emit"!

From all these data we can safely assume that the total annual emission of this world can be set at minimally:

30 billion tons of CO_2 emitted per year

(Lately I found evidence that this figure is pretty accurate!)

CO_2 in the atmosphere

Now the next question: How big is the total amount of CO_2 in our atmosphere, what is the weight of all this carbon dioxide in the air? This figure must be known by science, but is hard to find. Let us see if we can calculate it ourselves. We must know the total weight of the atmosphere, take 0, 04 % of that figure and we have the total amount of CO_2!

But… how do we know the weight of the total atmosphere of this world? Very simple! The average barometric pressure on the earth surface is 75 inches of mercury (or about 14 lbs) and that is equal to about 1 kg per cm^2. So a column of one kilogram air is pressing on every square centimetre of earth. If we now know the total surface of the earth in cm^2, we can define the weight. We also must know the earth's radius but we can derive that from the earth's circumference, which is 40.000 kilometres. The formula for the circumference of a circle is:

Circumference = 2 π **r**, where **"r"** is the radius and "**π**" = 3,14

With this formula we can calculate the radius:

r_{earth} = 40.000 : (2 x 3,14) = ± 6370 km

Now we can calculate the surface of the earth with the formula: Surface of a globe = $4 \cdot \pi \cdot r^2$

$4 \times 3,14 \times (6370)^2 = 509.645.864\ km^2 = \pm\ 5,1 \times 10^8\ km^2 = \pm\ 5,1 \times 10^{18}\ cm^2$

In this world an air column of 1 kg presses on every square cm, so the total weight of the earth's atmosphere is also:

$5,1 \times 10^{18}$ kg = **$5,1 \times 10^{15}$ tons**.

Now we know that 0, 04 % (± 400 ppm) of the atmosphere is CO_2. So if this percentage is referring to weight and not to volume, the total amount of all the CO_2 in the earth's atmosphere must be around:

0, 04 x 0, 01 x **5 x 10^{15}** = **<u>2 x 10^{12} tons of CO_2</u>**

There must be about: <u>2000 billion tons</u> (or 2000 gigatons) of CO_2 in our atmosphere.

Verification

Later, searching in the Encarta encyclopaedia, I noticed that the mass of our entire atmosphere is indeed around: **5 x 10^{18} kg.** So, although difficult to believe, also the calculated amount of 2000 gigatons of carbon dioxide must be correct. As it is such an unbelievable quantity, I searched for a while on the internet for a confirmation. As expected, I found different figures.

First I found a site, mentioning a figure of: 750 – 830 gigatons (= billion tons) of CO_2 in the air. What's the matter? Is my calculation wrong? In what year was that? When there is now 0, 04 % (or 400 PPM) of CO_2 in the air, then my calculations <u>must</u> be right.

Then, according to a (English) Wikipedia site, the radius and therefore surface of the earth is suddenly considerably smaller: 4, 41 x 10^{18} cm^2.

For the CO_2 in the air: a percentage by <u>volume</u>: 0, 0383 % and by <u>weight</u>: 0, 0582 %. These figures are supposed to be made up for the year 2007.

What's the matter, did I calculated wrongly? I consulted Encarta on my laptop again and they confirm the earth radius as being 6370 km and the earth's surface as: 5, 1 x 10^{18} cm^2. I have always understood that "0, 04 % CO_2" in the air, was referring to weight. But, out of curiosity, let us calculate with the Wikipedia figure of 0, 0582 % and their surface:

0, 0582 x 0, 01 x 4, 41 x 10^{18} kg = **<u>2, 567 x 10^{12} tons of CO_2</u>** (or 2567 gigatons)

The same site however mentioned a total of: **<u>2, 996 x 10^{12} tons of CO_2</u>** (or 2996 gigatons)

This doesn't correspond, so let us calculate "my" world surface with the new percentage (by weight):

0, 0582 x 0, 01 x 5,1 x 10^{18} kg = **<u>2, 968 x 10^{12} tons of CO_2</u>** (or 2968 gigatons)

THESE FIGURES PROVE THAT IT IS NOT SO EASY TO OBTAIN THE RIGHT FIGURES!

Going out from the present CO_2 percentage of around 0, 04 % or 400 PPM (by weight), then the figure will be:

A total of about **<u>2000 gigatons of CO_2</u>**, in the atmosphere!

According to other data this figure might be wrong and then the figure will be:

A total of about **<u>3000 gigatons of CO_2</u>**, in the atmosphere!

As the specific gravity of **CO_2** gas is 1,6 grams per cubic cm the difference can be caused by the weight / volume controversy.
Lately I found out that there is indeed about **<u>3000 gigatons of CO_2</u>** in the air!

Future CO_2 percentage

We can now also try to figure out how much the CO_2 percentage will increase annually, using the emission figures we calculated earlier. We have several figures, but I will use the minimum and the maximum values.
The real value will be somewhere in between. We can now start figuring again:

30 billion tons of CO_2 emission amounts to:

$\mathbf{3 \times 10^{10} : 3 \times 10^{12}}$) x 100 % = **1** **%** of the total amount (of 3000 gigatons)

Starting from the present 0, 04 % CO_2, this figure will annually increase with between:

(1 : 100) x 0,04 = <u>0,00040</u> and (1,5 : 100) x 0,04 <u>= 0,00060</u>.

So if we don't do anything and continue using and burning fossil fuels as always, the CO_2 percentage in the atmosphere will, because of human activities, increase in about **15 – 25 years,** from **0, 04 %** to **0, 05 %!** Taking the rapid increase from the last decades into consideration, this could very well be true! Later on I read that it is expected that the CO_2 content of the atmosphere will be 550 parts per million in 2040 (550 PPM is equal to 0,055 %!)

<u>Removal of CO_2 from the air</u>

So far we were discussing rising CO_2 percentages.

But we don't want the percentage to rise, it should go down!

But, how far does it have to go down? How do we get our oldfashioned, quiet climate back? Obviously, then we should go back at least to the old percentage of 0, 03 %! During a very long period in the last centuries, the CO_2 percentage hardly rose. In 1870 the percentage was 0,027 %. Later this figure varied around 0, 03 % and rose very very slowly. Only in the last couple of decades the percentage rapidly increased to the (little over) 0, 04 % now. So if we are able to do something about it, we should take 0, 03 % CO_2 as a target!
When we really want to go back to the old level of 0, 03 % (<u>a reduction of one quarter of the total amount of CO_2</u>), two things have to happen:

1) **From now on, mankind has to start (and learn) living CO_2 emission free, or at least: CO_2 neutral!**
2) **We have to begin removing a very substantial amount of CO_2 from the atmosphere.**

The quantity of CO_2, which should be removed from the air, in order to lower the CO_2 percentage with a quarter (from 0, 04 % to 0, 03 %), is gigantic: using the figure of 3000 gigatons, this comes up to:

0, 25 x 2 x 10^{12} ton CO_2 = **500 x 10^9 ton CO_2**
0, 25 x 3 x 10^{12} ton CO_2 = **750 x 10^9 ton CO_2**

We will therefore have to remove at least 500 billion tons of CO_2 from the atmosphere.

How to do this, that's the 25 million dollar question of Sir Richard Branson! But Sir Richard is happy with the removal of **1 billion tons** per year! It must now be clear that 1 billion tons of CO_2 is not sufficient to lower the CO_2 percentage. A lot more has to be removed!

Another requirement to realise that the CO_2 percentage in the atmosphere goes down, is the fact, that mankind from now on has to begin living "CO_2 emission free" or at least "CO_2 neutral". This is a way of living which is now being introduced on a very minimal scale! "CO_2 Neutral" or: "Climate Neutral", means that every amount of CO_2 which is emitted, is neutralised, for instance by planting trees! (Carmaker Daihatsu promises to do that!)

Will all this be possible in a world, addicted to energy? Serious "cold turkey" effects will take place, when we have to kick the habit! But if we continue living as usual, even more CO_2 has to be removed from the air. It is now March 2007. The European commission just agreed that the CO_2 emission must be reduced by 20 % within 14 years and that 20 % of the energy then has to be generated in a "clean" way. Also 20 % of the fuel consumption must be "green"! All this must be realised in 2020!

What can we say about this European agreement? Europe's CO_2 emission is only 10 % of the world's CO_2 emission (though others say it is more!). We cannot even call this reduction "encouraging", at best it is a small drop in a large ocean!

Although the consequences of the European measures will be enormous, the percentage of CO_2 in the air will not at all be lowered by this agreement; at best it won't rise as fast!

And the planting of trees, is that really a solution? We will see!

How to lower the CO_2 concentration of the atmosphere?

To resist global warming we must not only lower the emission of CO_2 but, more important, we have to bring down the concentration of carbon dioxide in the air. But do we have a good method to bring the CO_2 percentage down? Can we really lower the percentage of CO_2 in the air, substantially? What are the options?

1) **Remove the carbon (C) from the CO_2 by which the Oxygen (O) remains.**
2) **Binding the CO_2 to other materials in order to neutralize it.**
3) **Removing the CO_2 from the air and storing it underground.**
4) **Removing the CO_2 from the air and solving it in seawater.**

Method 1.

One method to remove the carbon from the CO_2 in the air is already known, for a very long time, by all the plants, algae and trees on this earth and is called "**photosynthesis**". Photosynthesis means that the carbon dioxide is converted into carbon and oxygen by means of (sun) light. Actually, we should formulate this in a more precise way:

"Photosynthesis is a process where CO_2 is converted into cell material under the influence of (sun) light. By this photosynthesis, foodstuffs will be, directly or indirectly, produced for all forms of life."

It is a very complicated process and unfortunately science doesn't know everything of this process yet. But….even the simplest plants and algae master it and do this for a very long time already! Explaining the process is not easy. In short the process works as follows:

The leaves of plants and trees consist of green stuff: the "chlorophyll", covered by a type of skin: the outer layers or "leaf skin". In the leaf flesh, one will find special green grains, the "*chloroplasts*". These grains are applying the photosynthesis. The leaf skin has little pores, "*stomata*", through which the leaves inhale air. By means of water, certain elements and (sun) light as energy, the CO_2 of the inhaled air will than be converted into "sugars", also named "carbohydrates", and oxygen, which is exhaled. These carbohydrates, a kind of cell material, form the building material for the construction of the plants and trees.

There are various ways for plants to execute the photosynthesis. Depending on the type of photosynthesis the plants are using, they are classified: C 3 and 4 and CAM. (C1 and C2 plants don't seem to exist!) Especially tropical plants of class C4 are converting CO_2 efficiently into cell material. The C3 plants, which grow mainly in colder regions, do this less efficient. As a lot of C3 plants are very important as food, scientist's try to improve the efficiency by crossing them with C4 plants. There are also "CAM" or "*crassulacean acid metabolism*" plants. They are the plants with very thick leaves, which grow in dry areas and are even less effective. Mankind makes use of photosynthesis for a very long time, by growing all kinds of plants, who are being consumed by humans and cattle!

Method 2.

This method proposes to bind the CO_2 to silicate materials. Carbon dioxide can very well be connected to certain siliceous materials (calcio silicates, olivine) which are available in ample quantities on this earth. The reason why this method is interesting is the fact that it is possible to bind more than 350 kg CO_2 to one kg of this material. In this way we will obtain a quantity of around 350 kg stony material, which can be used as building or filling material. To convert a few hundred billion tons of CO_2 into siliceous carbonates might be possible, but this will cost energy! But…how do we get all this energy? That energy has to be generated CO_2 emission free!

Method 3.

Another suggestion to get rid of the CO_2 is to store it underground, for example in empty natural gas sources. We could store very large quantities of CO_2 in them, but could we store hundreds of billions of tons? Even if we can, we have to separate and collect the CO_2, compress it and inject it in the empty gas fields (existing of porous stone). How do we do that and how do we get the energy for it? Also, we have to take care that the CO_2 gas cannot escape again and will stay there forever!

Method 4.

Maybe the easiest and best way to store the CO_2 gas is: solving it in seawater! Scientist's say this is very well possible. But again, to do this, we have to separate and collect the carbon dioxide first. But once it is dissolved in the oceans, who guarantee that it will stay there? And…what happens when the seawater temperature rises? "The solubility of a gas in water decreases when the temperature rises." The seawater temperature is already rising. What will happen, when part of the CO_2 gas escape again, when the temperature keeps on rising? There is already a vast hange of CO_2 between atmosphere and seawater, but it is not very clear which quantities of CO_2 are absorbed or are released by the oceans. Some scientists even claim that the varying exchange of carbondioxide by the seawater is the major factor in the increased CO_2 percentage of the atmosphere, probably due to the increased seawatertemperature.

Could we remove the carbon dioxide from the atmosphere with one of these methods (or a combination of them)? Can these methods be applied on a very large scale? Although the first method: photosynthesis, looks most promising, the other methods are certainly interesting too. To determine which the right way is, is not so easy. Let us have a closer look to these methods.

Photosynthesis

Nature's method to remove CO_2, "photosynthesis", is that really an option? Can photosynthesis indeed get the earlier mentioned **500 billion tons of CO_2** out of the atmosphere and convert it into carbon hydrates (or even better: in carbon and oxygen)? Can it be done by "natural" photosynthesis or does it have to be realised with "artificial" photosynthesis, which, by the way, yet has to be developed! The question is not only "if" and "how" and "where", but also: "how fast?" In how much time can we convert the enormous amount of CO_2 into C and O, by means of photosynthesis (or other methods)?

It took the world hundreds of millions of years to create the fossil fuels such as coal, oil and natural gas. However, mankind has been burning these fuels in a very short time at an ever faster pace. We do that to generate energy: heat and electricity. When "hydrocarbons" are burnt ("oxidized"), energy in the form of heat is generated in the following quantities:

-When burning 1 kg **hydrogen** into H_2O: 143 MJoule (34200 Kcal) energy is generated.
-When burning 1 kg **carbon into** CO_2: 32,8 MJoule (7845 Kcal) energy is generated.

This information shows that the hydrogen content of fuel is very important for energy generation. The advantage of hydrogen is also, that it changes into harmless water (vapour). For instance: the main ingredient of natural gas: methane (CH_4), is hydrogen and that is the reason that natural gas is so popular!

A question

When hydrogen burns (oxidizes), water is produced, mainly in the form of water vapour! As so much fossil fuel is turned into energy, not only an enormous amount of CO_2 is produced but also a lot of extra water vapour! Does this water also influence global warming? Water vapour is a strong greenhouse gas! Is this really "harmless"? I have never read anything about this subject, so all I can say: let us do some calculation! About wat quantities are we talking?

We assume that I kg H produces about 9 kg water and use the earlier figures indicating the annual consumption of fossil fuel.

OIL: 30 billion barrels= 4,500 x 10^{12} kg oil: 20 % H = 9 x 10^{11} kg H.
This gives: 9 x 9 x 10^{11} kg water = **8, 1 x 10^{9} tons of water**
GAS: 3000 billion m3 gas: about 0,136 kg H /m3: 400 x 10^{9} kg H.

This gives 9 x 400 x 10^9 kg water = **3, 6 x 10^{9} tons of water**
COAL: 6 billion ton coal: 10 % H = 0,6 x 10^9 tons H
This gives: 0, 6 x 9 = **5, 4 x 10^{9} tons of water**
--- +
Total annual emission: 17, 1 x 10^{9} tons of water

So we are talking about an emission of 17 billion tons of water vapour annually.
I found the following numbers about the water quantity on the world and in the air.
(1 km^3 water = 1 x 10^{9} tons of water, the specific gravity = 1)

Total water on earth: 1, 386 x 10^9 km^3 = 1, 386 x 10^{18} tons

Total water in the air: 1, 29 x 10^4 km^3 = 1, 29 x 10^{13} tons (this is ± 0, 001% of the total)

Total annual emission (by fossil fuel): 17, 1 x 10^{9} tons of water

This means that the annual emission of water vapour by burning fossil fuel is adding only:
(17,1 : 1,29) x 10^{-4} x 100 % = 0,1325 % annually to the total amount of water in the air!
The annual emission increase of CO_2 is: 1 – 1, 5 %, so we may conclude that:

The influence of the extra watervapour (0, 13 %), due to the burning of fossil fuel, most probably will not add significantly to the greenhouse effect!

Photosynthesis and energy

Back to the CO_2 problem and photosynthesis! The real problem is not only the huge quantity of CO_2, but also the amount of energy needed for conversion!
If we want to convert CO_2 back into carbon: C and oxygen: O, we will need the same amount of energy, which was first generated by burning this carbon to carbon dioxide!

In the last decades, enormous amounts of energy have been generated and consumed by burning fossil fuel. How do we generate this tremendous amount of energy again, but now in a real "clean" way?

Photosynthesis uses sunlight as energy and there we have the solution**,** but also the problem! Although our earth receives a gigantic amount of energy from the sun, every day again, the amount of solar energy per square meter (of course only when the sun is shining) is relatively small and it varies!

Looking at the energy the sun gives us in the Netherlands, (comparable to the UK and Germany), it appears that we are receiving an average of 110 watt/m^2 with a maximum of 1000 watt/m^2 of solar energy (1 watt = 1 Joule/sec). In southern countries these figures will be higher of course, but in northern countries less, so we have an average figure here. In view of the enormous amounts of CO_2 to be converted, we can understand now that not only will we need large areas with lots of sunshine but also….patience!

Natural photosynthesis

To determine if we can use large scale (natural) photosynthesis as a solution for the CO_2 problem, we have to answer the following question first.

How much CO_2 can be converted, per square kilometre and per year, in carbon (or carbohydrates) and oxygen by (natural) photosynthesis?

To answer that question we need information. I have found the following data:

- There are now companies (in the Netherlands), who offer to compensate vacation flights by planting trees, for a fee of course: environment is business! They offer to compensate a CO_2 emission of 20 kilogram by planting one tree.
- A certain internet site indicates that: "a tree converts 0.059 kg CO_2 per day in carbon and oxygen." This means 365 x 0,059 = 21, 5 kg CO_2 per year.
- The same site uses a figure of 425 trees per hectare (10.000 m^2). So one tree occupies a space of: 10.000: 425 = 23, 5 m^2.

What is not mentioned is: for which kind of trees these figures are valid? Are they young or old trees, small or tall, oaks, pines etcetera? Are these trees effectively performing photosynthesis to absorb CO_2? Surely one tree performs better than other ones! But, if we want to remove 500 billion tons of CO_2 from the atmosphere, say in 10 years with this kind of trees, we can already see now that we will need immense surfaces! Anyway, let's do some calculating.

From the above mentioned numbers: 21, 5 kg CO_2 per 23, 5 m^2, we may conclude that an average tree will absorb about 1 kg of CO_2 per m^2 per year, easy for calculations! (In the meantime I also read a figure of 7, 1 tons of CO_2 per hectare, but I stick to the 1 kg CO_2 per m^2 per year.) With this figure we can calculate that a forest of one square kilometre (1000 by 1000 metres) will absorb 1 million kg = 1000 tons of CO_2 (per year!).
For Sir Richard's **one billion tons of CO_2** we need a space of:

$(1 \times 10^9) : (1 \times 10^3) = \pm 1 \times 10^6 \text{ km}^2 =$ **1 million km^2**

But, to really solve the problem we must convert **500 billion tons of CO_2**! We need a space of:

$\pm 500 \times 10^6 \text{ km}^2 =$ **500 million km^2**

It is immediately clear that these are impossibly big spaces! To improve the situation, we could start looking for more efficient trees or plants, which can absorb, let's say, tén times more CO_2. The absorbtion will then be: 10 kg/m^2 (in stead of 1 kg/m^2):

For 1 billion tons of CO_2 : 100.000 km^2

Let us do the 500 billion tons in ten year with these "super" trees, even then we need:

For 500 billion tons of CO_2 in 10 years: 5 million km^2

Such numbers show that natural photosynthesis in this way cannot help us; the necessary space is too vast.

The United Nations recently announced that they want to plant 1 billion trees in 2007. We saw that an average tree absorbs 20 kg CO_2 per year. That means: 20 billion kg = 20 million tons of CO_2 per year. Compared to the annual world emission of CO_2: between 25 and 30 billion tons, we can call this, I am sorry to use the word: "peanuts"!

Actually the situation is even worse! The trees which are planted don't live for ever! A large part of the absorbed CO_2 will return, later on, to the atmosphere, unless the forest is there to stay forever, like a protected rainforest.

According to the Encarta Encyclopaedia, the total vegetation of this world annually converts CO_2 into carbon in the following amounts:

Land: $1,6 \times 10^{10}$ tons of carbon
Sea: $1,2 \times 10^{10}$ tons of carbon

From this amount, scientists assume, 90 % is fed back as CO_2 to the atmosphere!

This mainly happens by micro-organisms, causing plants (wood, fruits, leaves etc) to rot, ferment and degrade. Also forest fires, natural or incensed, play a role! The remaining 10 % will thus be stored by nature itself. How? I presume that this begins as humus, moor, peat and finally via brown coal ends up as "fossil fuel", if you wait long enough! Also a part of the carbohydrates will be turned into all kind of "carbonates". Carbonates are stony materials where carbon is bound in such a way that it won't easily change back into carbon dioxide.

A solution?

All this doesn't sound very encouraging! But….as a famous Dutch football player once said: "Every disadvantage has its advantage!" All this carbon, which is enclosed in the world's vegetation, may present a solution! When nature annually stores 10 % of this carbon permanently, this is equal to:

$0,10 \times (1,6 + 1,2) \times 10^{10} = 2,8 \times 10^{9}$ = 2, 8 billion tons of carbon per year!

This means that all the vegetation on our earth, removes the following amount of CO_2 annually from the atmosphere and stores it permanently.

$(44 : 12) \times 2,8 \times 10^{9}$ = **± 10 billion tons of CO_2 per year**!

Should we live "CO_2 emission free" from now on, then it will still take 50 years to lower the CO_2 percentage from 0, 04 to 0, 03 %! (Elimination of 500 billion tons of CO_2**)**

These figures, given by Encarta, are determined a few years ago. In the mean time deforestation has continued on a frightening scale. So the annual decrease of 10 billion tons of CO_2 by all the forests might be considerably less by now.

It is clear that we must stop deforestation as soon as possible and guard the world's rainforests much more fanatically than now is the case!

For instance: the use of tropical wood, maybe all wood, for whatever purpose, furniture, building and such, should be sharply reduced or even banned, as soon as possible! The burning down of forest is a crime of the first order!

We need the trees alive to save us, not dead as wood to serve us!

Efficient photosynthesis?

We have seen that natural photosynthesis might help us with the CO_2 problem, but only in a very limited and slow way! The efficiency degree of natural photosynthesis is actually too low. Let us now try to calculate how much CO_2 we could theoretically convert into "C" and "O", per year and per square kilometre.

According to the Encarta encyclopaedia, the amount of solar energy received in the Netherlands, is equal to an average of 1000 kilowatt-hours per square metre per year. This is 3.600 mega joules (1 kilowatt-hour = 3600 kilojoules = 3, 6 mega joules) per square metre. Earlier we have seen that burning one kilogram of carbon, generates 32, 8 mega joules (and produces 3, 62 kg CO_2). It will cost this same amount of energy to convert 3, 6 kg carbon dioxide back into 1 kg carbon (and 2, 62 kg oxygen). So now we can start answering the following question:

Using solar energy, how much CO_2 can theoretically be converted, per square kilometre per year, into carbon and oxygen?

$$(3600 : 32{,}8) \times 3{,}62 \text{ kg} = 397{,}3 \text{ kg}$$

So about **400 kg of CO_2 per m^2 per year** could theoretically be converted in C and O by sun energy! This is much better than the performance by average trees: **1 kg/m^2**

Per square kilometre (1000 x 1000 m^2) this is: 400.000.000 kg = 4×10^8 kg

In **1 year** this is: ± **4×10^5 tons = 400 thousand tons**

In **10 year** this is: ± **4×10^6 tons = 4 million tons**

To convert 500 billion tons of CO_2 (5×10^{11} tons) in 10 years, we need a theoretical space of:

$$(5 \times 10^{11}) : (4 \times 10^6) = \pm 1{,}25 \times 10^5 \text{ km}^2 = \mathbf{125\ thousand\ km^2}$$

That's an area of 250 by 500 kilometres, also quite a big area, about five times the Netherlands! Can we find a space this big? When we go to a southern region with lots of sunshine, the area might be somewhat smaller, but it is still a large area. Is the Sahara an option? Photosynthesis also needs lots of water!

We see that even theoretical photosynthesis with 100 % efficiency needs vast spaces!

The low efficiency of natural photosynthesis doesn't help us, but even efficient artificial photosynthesis is not the answer we are looking for either! What could be the reason for the low efficiency of natural photosynthesis? Maybe it is the sun's light spectrum. The sun is emitting energy in the form of electromagnetic radiation (mainly light). The dangerous, but highly energetic radiation, like gamma, x- and UV radiation, is stopped by the outer atmosphere. Only the less energetic rays from visible light, infrared and a part of the ultraviolet light, are able to penetrate the atmosphere and hit the surface of the earth.

We have seen that only a very small part (1 / 400**th**) of that radiation is used as energy for natural photosynthesis. When the efficiency would be 100 %, we would live in a very strange world, with trees and plants growing very fast and absorbing all the suns energy! It would be quite cold under the trees! But is this true? Very recently (11th of april 2007) I listened on the Dutch radio to an interview with a Dutch agricultural scientist. The man stated, among others, that sugarbeets are **100 times** more efficient than trees in converting CO_2 in carbohydrates! Is this true? It is almost unbelievable! That would be an efficiency of 25 %! When we would be able to use sugarbeets to solve the CO_2 problem immediately the next question arises: "Where do we store all the sugarbeets permanently and forever?" Is the sugarbeet a solution? An undisturbed rainforest may stay forever, a sugarbeet field doesn't!

How about algae, in fresh or salt water, can they do the job? Only with a much higher efficiency they might play a role in lowering the CO_2 content of the air. The advantage of algae is that space is not a problem; we have much more sea space than land!

Artificial photosynthesis?

Natural photosynthesis has always been used by mankind for the production of food. All our vegetarian food contains carbohydrates (and also vegetarian proteins, f.i. soja), and is produced by means of photosynthesis. Actually it is strange that science never (?) has tried to imitate photosynthesis artificially. As far as I know, no one has ever tried or succeeded imitating it. But if we knew more about this process we might be able to improve the efficiency and use it for many more purposes, among them: efficient removal (and conversion) of CO_2 from the atmosphere. Maybe artificial photosynthesis could produce better carbohydrates, new types of food or non degradable carbon materials, suitable for storage or as basic material for plastics.

How could artificial photosynthesis take place? As nature does it with "leaves", we could think of a foil type material, in it "chloroplast" which converts the CO_2, by means of (sun) light, water and chemicals, into carbohydrates or, even better, carbon, and hopefully more effective. When we could produce pure carbon in this way, the volume will be two thirds smaller and also: the carbon could be used as basic material for carbon fibre, plastics and the like. Already for many years it is possible to turn carbohydrates into biodegradable synthetic material; maybe we could also produce non degradable materials from it.

But the big question stands: is artificial photosynthesis at all possible? Can we develop it within a reasonable time? Science has to start working!

Consequences of photosynthesis

Suppose we could develop and master effective, large scale photosynthesis, natural or artificial. Could we solve the CO_2 problem with it? There are several drawbacks: the limited solar energy per square meter, efficiency problems, and the need for huge spaces, availability of fresh water, and the problems with large scale storage of carbohydrates!

Suitable areas should have sunshine and water. Is the Sahara a possibility, or other deserts? Than we have a new problem. Photosynthesis needs water, fresh water. Seawater is relatively close by, but conversion into fresh water cost energy, lots of energy! So we have to develop a way to convert salt water into fresh water by means of solar energy! On a small scale this is possible. There are glass units which produce small quantities of fresh water if floating in sea water. These units use solar energy for evaporation and cool sea water for condensation. This should be possible on larger scale too.

Modern science must possess the ability to acquire more knowledge about photosynthesis. But, although a successful mastering over photosynthesis and large scale application of this process may offer a solution for the CO_2 problem, implementation will have serious consequences!

- Natural photosynthesis produces glucose (carbohydrates). If these carbohydrates are used as food or fuel, the CO_2 content of the atmosphere will not be lowered but will stay constant; this is called "CO_2 neutral"! We will reduce the CO_2 percentage in the air **only**, when the carbohydrates are not used as food or fuel.
- When CO_2 could be converted in carbonic material that can be hermetically stored, we then may obtain a significant reduction of the CO_2 percentage in the atmosphere! Another solution is the use as basic material. Research will be necessary for this!

- Very large quantities of CO_2 will have to be converted into carbonic material. Conversion into pure carbon would be the best option. Research has to indicate if this is possible. Conversion into pure carbon has the advantage that less volume is produced: 1 gram of CO_2 will produce about 1 gram carbohydrate, but only 0, 3 gram of pure carbon. Carbon could serve as basic material for many purposes.
- Storage of carbohydrates will be a problem. They are degradable and will produce gases as CO_2 and CH_4 (methane) when they are left alone: back to where we started. Carbohydrates have to be prepared (dehydrated) for storage, but that will cost energy!
- A possibility, as mentioned before, is: conversion into plastics. Conversion into "biopolymers" is already possible. It would be interesting to know if conversion into non degradable plastics is also possible. Such materials could replace building materials such as wood. Also metals could be (partly) replaced by, for instance, carbon fibre material.

Storage of CO_2

1) Storage of carbohydrates

Let us presume that large scale conversion of CO_2 into non degradable carbonic becomes reality. Large quantities of converted CO_2 will then have to be stored, preferably forever. Where does large scale storage of such material have to take place? Are we willing to sacrifice precious space for this purpose?

Fossil fuels are also carbonic materials ("hydrocarbons") and these have been stored for hundreds of millions of years (until we took them out). Obviously it must be possible to find suitable places for large scale storage.

About what volumes are we talking? Specific gravity of carbon and carbonic material can be set on an average of one (carbohydrates) and two (carbon). The volume to be stored is than between about 100 billion and 500 billion cubic meters. These are very large volumes! But… are they so large? Suppose we have a "field pit" of 10 by 10 kilometres, 100 metres deep! The volume is than:

$$10.000 \text{ x } 10.000 \text{ x } 100 \text{ m}^3 = 10 \text{ billion m}^3$$

It should be possible to find space for ten to fifty of these field pits! A good solution would be to use exhausted mining pits where gigantic quantities of coal are excavated. In various places of the world huge quantities of coal and ore are dug out, leaving enormous pits. These areas have become uninhabitable but may serve as large scale storage places for the carbonic materials.

All this however depends on the possibilities of science to master large scale, efficient photosynthesis.

2) Binding CO_2 to silicates

This is the method which is announced by the large refinery (one of the largest in the world) in Rotterdam, to get rid of the one million tons of CO_2 emitted annually by them. They plan to bind CO_2 permanently to silicate material, in order to produce building material. This method costs energy and material. However, this method is quite interesting, as the materials in question are in ample supply in this world. We are talking about silicates, olivine and others.

Another reason is the large quantity of CO_2 that can be bound to a small amount of silicate. For example: 1 kg of calcium silicate binds 380 kg CO_2 . The material obtained can be used to produce building material such as bricks. Also t may be used as filling material, for many purposes, instead of sand. This all sounds very promising and when this process can be done on a large scale with "clean" energy, this can be a very interesting method.

The question is: "Can we bind **1 billion ton of CO_2** to silicates annually?" Even if we can, we will need about 3 million tons of silicate. We will obtain an amount of over 1 billion ton of material! Let us do some calculation again:

Specific Gravity of the material:	± 2, 5
Volume of 1 billion ton:	400 million m^3 = 4 x 10^8 m^3
(Dutch) brick: 20 x 10 x 5 cm =	1000 cm^3 = 0,001 m^3

So we can make 1000 bricks from a cubic metre. For a good house we need between 50 and 100 thousand bricks (50 - 100 m^3). Let us be generous: 100. 000 bricks per house. So from the one billion ton of bound carbon dioxide we can make bricks for:

(4×10^8) : 100 = **4 million houses**!

Interesting! But don't forget, we have to get rid of 500 billion tons of CO_2 ….!

3) Underground storage

In March 2007 the European ministers decided that electricity should be generated by coal-fired power plants. Nobody but the French, wanted to give nuclear power plants a chance! The ministers decided that nuclear energy could **not** be seen as "clean".

But firing coal emits CO_2! "No problem, the CO_2 will be extracted from the exhaust gases and stored underground!" 12 Coal fired plants will be built in Europe to cope with the increased demand for electricity! The Dutch TV screened the news and announced that the first real clean, coal fired power plant would be built in the Netherlands. The emitted CO_2 gas will be collected and stored in empty subterranean gas fields! It became clear to me that these plans are very concrete, so the storage of CO_2 gas underground will soon be tried! They admitted that a lot of research still had to be done, but said that underground storage is possible. The plant will be different from the conventional power plants: the coal will be turned into gas first; the gas will be washed and than used to drive gas turbines. Gas turbines are flexible, easily started (and stopped) and have a reasonable efficiency grade! Also they are very suitable to cope with daily peaks in the demand for electricity.

It is clear that Europe has great expectations of the storage of CO_2 gas underground. In the Netherlands so much natural gas has been consumed that vast underground spaces will be available. There are problems however! Natural gas is not stored in underground cavities but in porous stone. When the gas is extracted for decades, as is the case in the Netherlands, the porous stone slowly compresses causing the bottom to lower. Unfortunately this is not going evenly. Small earthquakes take place and houses become damaged, show cracked walls and cause foundation to tear. The gas company is reluctant to pay for the damage! What will happen when carbon dioxide is pumped back into the ground? Will the ground level rise again? The cracks in the walls will certainly not disappear then!

Anyway, the method to store CO_2 underground certainly should be tried and applied. If CO_2 from powerplants can be stored in such a way also the CO_2 from the air may be stored like that. One more question. How can CO_2 gas be separated from the exhaust gases and eventually from the atmosphere in an effective, cheap way (other than the mentioned methods)?

4) Storage in seawater

Gas can be dissolved in water, so CO_2 gas can very well be dissolved into seawater. In this way tremendous amounts of CO_2 could be stored, there is plenty of seawater. But, already lots of CO_2 gas are dissolved in seawater! I have even read (Green university site) that **there is 50 times as much CO_2 gas dissolved in seawater, than there is present in the atmosphere!** The question is: “Can we be sure the extra amount of carbon dioxide gas can be stored in seawater permanently?” Solvability of gas in water decreases with rising temperature. Exactly that is happening now: seawater temperature is rising! Some scientists even say that the CO_2 content of the atmosphere has risen partly because of that!

Storing carbon dioxide in the oceans could be a great solution, but research is necessary!

CO_2 neutral

All signs show that the world is concentrating only on limiting the CO_2 emission and continuing in a so called CO_2 neutral way, hardly in a CO_2 emission free way!

This means that the CO_2 concentration of our atmosphere will not go down, on the contrary, it will still increase, at best in a slower pace!

On this moment more and more people favour this new way of living: “CO_2 neutral”. Whenever we drive, fly, work, produce, live, we use energy whith the consequence that CO_2 is emitted. “CO_2 neutral” means that all these actions will have to be compensated. This will be mainly done by planting trees! But does this really make sense? When we are making a flight, an amount of kerosene will permanently be converted in CO_2 (and H_2O). Trees will than be planted as compensation and these will temporarely (several decades) absorb CO_2. But….when the tree dies, 90% of the CO_2 will return to the atmosphere. The same will happen to the 1 billion trees to be planted by the United Nations! I won’t say that we should do nothing, all these actions are better than nothing of course. Creating new rainforests, that would be very useful, but “CO_2 neutral” alone is not the solution for the world’s problems: climate change and global warming!

Deforestation

An enormous problem in this world is the cutting down and burning of the world’s forests. On various places in the world, huge areas of forest are disappearing. The problem is that wherever the forest has gone, it won’t come back and finally infertile land is left. In many countries this ruthless destruction of forest has resulted in flooding, landslides, airpollution because of forest fires and the extinction of rare animals and plants. In some countries the land which was once forest is turning into desert. Apart from the need for all kinds of wood and space for farming, another reason for cutting down trees is the “alternative” energycrisis in poor countries. People there need wood for cooking and heating and as the population is growing, they need more fuel!

All this is worsening the CO_2 problem, the cut down trees won’t absorb CO_2 any more and the forest fires are even responsible for 20 to 30 % of the total CO_2 emission, according to some scientists!

The large scale cutting of trees has several causes:

- Increasing demand for precious wood
- Wood is needed by the industry: paper, textile, furniture, buildingmaterial etc.
- Space is needed for farming, expansion of industry and urbanisation.
- Increasing population.
- "Alternative energycrisis": need for firewood.

The burning down of forests takes place:

- Because of drought (Australia, USA)
- Due to natural causes (Africa, Australia)
- Demand for agricultural land
- Habitation of remote areas for a growing population (Amazone)

Generation of electricity

From all this it must now have become clear that removal of CO_2 from the air (by any of these methods) alone is not the answer. Much more will have to happen, living customs have to be changed and processes have to be invented and developed.

Do we really want to lower the amount of CO_2 in the air, in order to halt global warming and return the (average) temperature of the world to earlier values?

Then many things have to change! Let us first have a look to the generation of electricity. The way we produce most of our electricity now can no longer be maintained, when we want to prevent further global warming.

Some years ago I visited a power plant (in the Netherlands) which mainly fires coal but also, when available, "bio mass". Everything is done to produce electricity in a "clean" manner. The smoke gases are washed in an advanced, modern way: sulphur is separated and converted to "plaster", the flying ashes are filtered, collected and stored. Both products are being collected on fixed times by specialized companies, who turn it into useful building material. To my surprise they don't pay for the materials, even worse, they want to collect these materials only when they are paid for it!

Although this power plant is considered "clean", huge amounts of CO_2 are emitted. This plant consumes ± 1500 tons of coal per day. Although the carbon content of coal varies between 65 and 90 %, we can assume that one kilogram of coal produces at least two kilograms of carbon dioxide. For this plant it means a minimum of one million tons of CO_2 annually. The powerplants which fire oil and gas have a relatively low CO_2 emission, but are far from "clean".

However, there is some good news! As I mentioned earlier, Europe has decided to build 12 really clean coal fired powerplants! In the Netherlands the plans for such a power plant are in the final stages. The advantage of coal is that it comes from politically stable regions. To make these powerplants really clean, one will try to filter the CO_2 out of the exhaust gases and collect it for underground storage. As this is not tried before (on a large scale), we must hope that these plans will succeed.

Nuclear energy

Actually the only "clean" powerplants are the ones who use water power, wind power, sun power, "geo" steam and ….nuclear energy! All these have emission zero! When one succeeds in collecting and storing the full CO_2 emission, we can also add the new coal fired power plants to the list!

Nuclear power plants are not popular. Many people are afraid of the possibility of accidents which may cause radioactivity. Also the radioactive waste, nobody knows exactly what to do with it, doesn't help the popularity. People forget that the radioactive waste is relatively small, surely when compared with the enormous emission of CO_2 and other greenhouse gases by conventional power plants. Compare the annual emission of the earlier mentioned coal fired power plant: 1 million tons of CO_2, with the radioactive waste of the only nuclear powerplant in the Netherlands: a few cubic meters! Think also about the hundreds of miners which die each year in coal mines! Another figure: this Dutch nuclear powerplant prevents the emission of 2, 5 million tons of CO_2 annually! When the same amount of power had to be generated by using wind, the whole coast of the Netherlands (and more) would have to be provided with windmills. And… no wind: no power!

Unfortunately, no European country, except France, sees nuclear power as "clean". All the European ministers have decided is that they will continue to "study" nuclear power. We must hope that science at last will find a solution for radioactive waste!

Alternatives

In the last years new alternative ways to generate power have become normal. Windmills and solar panels are on the increase and bio fuels are becoming available. Can we stop the global warming in this way? Bio fuels are CO_2 neutral at best and the generation will need lots of fertile land that is now used for the production of food. Windmills and solar cells supply expensive power because of the high investment costs. Especially the energy produced by windmills, is problematic and too dependant of nature. No wind or too much wind? No power! Solar cells are more interesting. When there is sunshine, there will be electric current. Lots of sun, lots of power, cloudy sky: less power, at night: no power. But every day we have light! Some years ago I read that the manufacturing of a solar cell cost more power than it will ever generate. In the mean time this is not the case any more, the effectiveness is getting better all the time (although not more than 15 % now).

Can alternative power replace today's powerplants? An important handicap is the absence of a good, large scale storage system for electric power. Alternative power would be much more important if storage of large amounts of electricity would be possible. Unfortunately, such a method is still not available. There is a great need for a good rechargeable battery, small, but with a large capacity. Although new and better batteries appear on the market constantly, a real breakthrough has not taken place yet! And cars still have the oldfashioned lead battery!

The situation as it is now (in 2007) such, that alternative and "clean" generation of electric power cannot replace conventional powerplants **at all**, at best for a small part only (10 – 20 % at maximum). Clean energy is coming though. In southern France, near Marseille, a nuclear fusion reactor is being built: project "ITER". Although science is studying nuclear fusion for decades now, a breakthrough has not taken place yet. Even today, scientists think that it will take another 30 to 40 year before electricity can be generated with nuclear fusion. Only then we will have plenty clean emissionfree energy without nuclear waste!

For the households there is now a strong tendency to economize on the energy consumption. New houses are better insulated than ever. Energy saving lamps are being pushed. Germany says it can reduce the annual CO_2 emission by 6, 5 million tons by making these lamps obligatory. Better and more economic systems are developed and available for heating, systems which use heatpumps and geothermic energy. Also combined heat and energy units for households are becoming available. These units, mainly working on natural gas (in the Netherlands), can supply electric current ánd heat in a very efficient way. We also see more and more solar panels and solar collectors on the roofs. On the other hand: continuously more appliances, electronic systems, computers and robots appear in households, reason why the energy consumption is still growing!

How to go on?

Do we really want to generate electricity CO_2 neutral or better, emission free? Than we should give up power plants that burn fossil fuel and are emitting CO_2!

For large scale electricity generation we we have left the following options:

- Conventional powerplants, able to collect and store all of the emitted carbon dioxide.
- Nuclear powerplants, using fission of uranium or plutonium.
- Nuclear powerplants, using fusion of isotopic hydrogen. (Within 40 years.)

For medium scale electricity generation we can make use of:

- Water power
- Solar power (by concentrated sunlight)
- Windmills
- Bio fuel as intermediate solution

For small scale (household) electricity generation we have the following options:

- Solar power (photovoltaïc cells)
- Combined heat and power generators on bio fuel

Technical measures

What technical measures should be taken?

- Solar energy.

The sun's energy should become much more important. It should be stimulated to equip houses and buildings with solar collectors and photovoltaic cells. Many years ago rooftiles with built in solar cells were available! It must be possible now to manufacture solar rooftiles and roof coverage for a reasonable price. Could solar cells generate a substantial part of the household electricity need? Recently an important CEO of a large oilcompany said: "No!" He added that if all houses had a 4 m^2 solar panel, power generated in a year would be consumed in one week! Well, than it is simple: you need more solar cell surface: 200 m^2! According to Encarta the solar energy per square metre is 1000 watt. If a cel is 10% efficient en we estimate 1000 hours of sunshine per year, 1 m^2 solar cells generates 100 kilowatt hours annually. An average household needs about 3000 kilowatt hour per year. So a house needs about 30 m^2 of solar cells. Who is right? One kilowatt hour on a sunny day is already possible. All we need is a large set of good, rechargable batteries!

- Fresh water.

Also important is fresh water. Collection of rain and heating the water with solar collectors could be implemented in the houses of many countries NOW!

- Geothermic energy.

Geothermic energy should be more important. We have no geo steam like Iceland and New Zealand. But, the deeper you go, the warmer it becomes! New houses could have a "geo pit". Even aircondition is possible. A deep pit for heating, a shallow pit for cooling! The technology is there! But…let's do it indirectly, we shouldn't pump up the ground water, but rather use heat exchanging techniques. With such a "geo pit", houses could be heated during 40 – 60 years.

- Insulation.

Insulation of most houses can be improved! Roof and wall insulation is still absent in most of the older houses. Triple glass is now available. So far insulation is not compulsory; it should be, anyway case for new houses.

- Combined power and heating units

These units can provide an intermediate solution for the transfer to emission-free power for households and small companies. Many vegetable growers in the Netherlands already use such units. As they use natural gas as fuel, the CO_2 emission is relatively low and they use the CO_2 to stimulate the vegetables to grow faster! But large companies will stay dependent of the large powerplants. Our hope must be based on clean, zero-emission powerplants. They should be the only ones being permitted to be built!

- "White" power

In mountainous countries like Switzerland and Austria the "white" power, by means of water, is used extensively to generate electric power: clean emission-free power! In flat "low countries" like Holland, water hardly plays any role in the generation electric power, but this should be changed. There are definitely possibilities: there are huge rivers, the sea is close by, and tidal power could be used. Waterturbines are less dominant than windmills!

Peaks in demand are a big problem for powerplants, as electricity cannot be stored. But old mineshafts could be used as buffers, to cope with these peaks in the demand: one water reservoir above, one reservoir underground with a pump, waterturbine and generator. When the demand is high, the water from above runs through the turbine into the lower reservoir.When the demand for electricity is low; the water from the lower reservoir can be pumped back up again. Countries lacking high mountains can still make use of water power, when the will is there! Coastal countries could use the power of the sea! Costly but emission zero!

- Wind energy

Wind energy is by far the least ideal source of power. Windmills are costly, noisy, take birdlives and contaminate landscapes. Windmill parks use lots of space. Wind and therefore the power are unreliable. As long as large scale storage of electricity is not possible, windpower can only serve as a secundairy source of electricity. Due to the high costs for investment and maintainance, the electricity generated is very expensive. But we can't stop the development, windmills appear everywhere. One advantage: emission zero!
One more remark: when the entire Netherlands would be filled with windmills, the power generated would be equal to the amount generated by óne modern nuclear powerplant! If we do that, the birds would be happier too!

- Lighting

Lighting costs lots of energy. We waste a tremendous amount of energy to unnecessary and superfluous streetlights, neonsigns, publicity boards etc. and an even more to lighting which we consider necessary but in reality is not. Huge savings in energy could be realised when we really want to live with less light. The easiest way is: change tungsten bulbs by the modern energy savers and LED lights. This is exactly what governments are stimulating now, beginning in Australia. But this is only a beginning, a lot more should be done and we all know which lights can be switched off, but do we want that? One wild idea: put remote controlled mirrors in orbit! Also, already available: lamps combined with a solar panel for outdoor lighting!

Transport and traffic

About 20 % of the total CO_2 emission is caused by all the means of transport. Luxury cars emit about 11 - 13 % of the total. Planes and ships, besides trucks and trains, are taking care of the rest. It is very worrying that there is no indication yet, that the total emission of transport will decrease. Engines are indeed more efficient and have less emission than ever before, but people are buying more and bigger cars, "SUV's" are increasingly popular, fuels become cleaner, hybrid drives are available, but the CO_2 emission is on the rise, not in the least by the frightening pace with which countries like China and India are automobilising.

What can, or rather must, be done to this? Let's have a look at the different propulsion means now available.

- **The piston engine**
  Still the most popular engine: the reciprocating piston engine: It is a perfected absurdity, but generally in use in all passenger cars, trucks, ships and also in small planes. Why a "perfected absurdity"? Here we have a motor where a piston is moving in a cylinder; but just when the piston picks up speed it has to be de-accelerated and start moving into the opposite direction. In spite of this disadventage, the piston engine now is one of the most perfect motors and converts fuel into a rotating movement quite efficiently: output up to 40 %. This still means though that 60 % of the energy is lost, partly in the radiator, the rest disappears through the exhaustpipe! There are piston engines for various fuels. The most efficient engine is the Diesel engine, running on dieselfuel (or heated boiler fuel for ships diesels). A lot worse is the "Otto" or petrol engine, using petrol or LPG (liquefied petrol gas). There are still other type of engines, like the "Sterling" (hot air) motor and the "Wankel" motor with a rotating piston, but they have never become very popular.

Although the Dieselengine is the most efficient engine of them all, this engine is very unpopular with some governments, f.i. the Dutch government. The emission of nitrogen oxide, sulphur oxides and soot particles by these diesel engines, is appearantly more important for them than the considerable lower emission of CO_2 compared to the Otto (petrol) engine. Don't they know? The diesel engine has the lowest fuel consumption of them all! And also, I have news for them: soot can be filtered out, nitrogen oxide is being converted by the katalyser and sulphur is already taken out by the (diesel) oil companies. Just make katalysers and soot filters obligatory (but this is resisted by the EC). So the popurity and stimulation of petrol engines by governments (in view of the CO_2 emission), is unjustified! On the other hand we see that the dieselengines are becoming more popular anyway, due to the low fuel consumption. Also, trucks and ships are almost eclusively driven by dieselengines.

- **Hybrid drive**
  A new modern, economical way of driving is the car with a hybrid drive system begins to gain popularity. Production models are available by Toyota (Prius and Lexus) and Honda. In environment consciencious California lots of these cars are driving around already! These cars have a piston engine, an electric motor and a large set of rechargeable batteries. In the city the electric motor (emission zero) drives the

car, on the highway the piston engine takes over and charges the batteries! A promising development, but not the solution!

- **Electric drive**

Still very rare but coming up: cars with just an electric motor and a set of batteries. Batteries are still heavy and voluminous and the action radius of these cars is rather limited. The CO_2 emission is shifted from car to powerplant, as they supply the power to recharge the batteries. A new possibility for this type of car is the fuel cell, which converts fuel and air directly into electricity, more or less CO_2 emission free. Although the combination of fuel cell and electric motor is very effective (80 %), these units are not yet commercially available.

- **Gas as fuel**

In stead of liquid fuel also gas is quite suitable, although not as convenient! Piston engines run well on gas, when a few adaptations are made. In the Netherlands LPG (liquefied petrol gas) enjoys varying popularity, due to changing government regulations. Although LPG is one of the cleanest fuels with low CO_2 emission due to the high hydrogen content, this fuel is not popular at all with the Dutch government. A pity, because a lot of this gas is now burnt as waste gas, see the "eternal" flames of refineries! More difficult is natural gas, but not impossible, the first cars are now on the road. The same goes for hydrogen, experimental cars driving on hydrogen are on the road now. Hydrogen is available but only very limited. Both fuels have advantages: low (natural gas) to zero (hydrogen) CO_2 emission! Unfortunately producing hydrogen without emitting CO_2 is a problem!
Another possibility to drive a car on gassy fuel is: by a gasturbine. Long in use to drive ships, generators and propellor planes they have never made it to cars (except as booster). That's a pity because they are very reliable. So far, gasturbines didn't make it in cars, mainly because of their low efficiency, I understand.

- **Bio fuels**

More and more governments are promoting bio fuel to substitute fossil fuel. What do we mean by "bio fuel"? It is fuel made of plant material. We have "ethanol" (ethyl alcohol) which can be made from all kinds of plants but is mainly made from sugar cane and corn. Vegetable oil, made from all kinds of oil seeds is another one. These fuels can be used quite well in piston engines, after some adaptions have been made. But bio fuel is not ideal: it may be more aggressive, ethanol contains water and also katalysers have to be modified. In certain countries, like Brasil, the fuel for passengercars is now a mixture of petrol and ethanol. Dieseloil is reserved for trucks only, all this because Brasil wants to be less independent of imported crude oil. The results can be seen. When you're driving through the Brasilean country, for miles and miles, you see nothing but waving sugar cane fields. Several European countries are also thinking about adding ethanol to the petrol and vegetable oil to the diesel fuel!

What are the advantages of using bio fuel? It's CO_2 neutral and makes you less dependant on import oil! But there are also disadvantages. Producing bio fuel costs lots of agricultural land. A lot of land which before was used for the food production, has then to be used to produce crops like sugar cane, oil seeds, corn. Since corn (mais) is used to produce bio fuel the price has risen substantially, directly hurting poor people whose main food is mais: the "tortilla crisis".

Bio fuel is mainly suitable as an intermediate solution, but can certainly not solve the CO_2 problem! Also the emission of bio fuels is more toxic than the emission of “normal” fossil fuel.

- **Hydrogen**

Hydrogen is a great fuel, but is also having some disadvantages. When converted into energy the only emission is water, also the calorific value is high. But hydrogen is dangerous, difficult to handle and storage and distribution are a problem. Hydrogen will only be interesting when we can produce it CO_2 emission free!

Hydrogen can be produced by means of electrolysis, taking place with really “clean” electric current. This could be produced by solar power plants and solar cells. When ‘photovoltaic” or solar cells would be available in large quantities at a low price, we could think of installations in (there it is again) the Sahara, lots of space, sun and nearby (sea) water. Transport would not be so easy, but natural gas is already being transported from North Africa to Europe by large LNG (liquid natural gas) tankers! They could transport the hydrogen too!

What else can be done to make traffic CO_2 emission free? I will not comment on all kind of measures governments may and will take. Measures will surely come: one government knows even better what to do than the other one. In the mean time very little happens and traffic grows and grows. But something has to happen. Doesn’t everyone feel that it cannot continue as it is now: a situation where everybody is free to drive whereever or whereto he wants, in Germany even as fast as you want**?**

Do we want global warming to stop and are we really sure that CO_2 emission is the main cause?

Then here are some solutions.

- Transport of people.

All means of transport, cars, buses, trains have to become electric and the electricity has to be generated CO_2 emission free or at least CO_2 neutral. We already know how: by nuclear, solar, water and (rather not) windmill power. Aeroplanes and ships, that’s another story, it won’t be easy, but there are possibilities: wind for ships, hydrogen for planes? It is very well possible! Planes are exceptionally polluting. Compare a trip from London to Paris: the plane emits 122 kg of CO_2 per passenger; the HSL train can do with 11 kg per passenger!

- Freight transport

Another big problem! Trucks could also be driven electrically! A courageous solution, which already exists in the Netherlands, is an “electric wheel”. It consists of a normal wheel and tyre with a built in electric motor. The advantage is the high efficiency in converting electricity into a rotating movement. As soon as high capacity batteries are developed, this will become very interesting to propel trucks, for buses it is already possible now (but nobody is interested!).

- Shipping

Ships are consuming an enormous amount of (fossil) fuel. Big tankers have a bunker capacity of around 10 % of their cargo capacity, and on a long trip, let us say between the Persion Gulf around the Cape to Western Europe, they will need all of it. Can ships be driven electrically? During the second worldwar oil was transported on a large scale, by turbo electric, so called T2 tankers, built in the USA. The ships' propellor was driven by a huge electric motor. The power was delivered by generators driven by steam turbines. But the steam was of course supplied by boilers, fired with fossil fuel! It will take some time before this can be done CO_2 emission free! In submarines this is done, by nuclear energy. Years ago there was a merchant navy ship, the Savannah, also propelled by nuclear energy. They stopped this experiment! In most ports the ship was not welcome… Is there another possibility? For centuries there was only one way, wind and sails! Japan tried it, they planned a ship with computer controlled sails. If it is ever built, I don't know, I have never heard about it again. But now there is a new promising solution: a kite! When the wind is favourable a huge kite can be let up, which trails the ship! For oiltankers this can already be a solution now! Not solved is the problem ships had for ages: unfavourable winds or no wind at all, but it is a step in the right direction!

The industry

The industry is the main polluter and emitter of CO_2! But the industry provides us with everything we need: cars, furniture, appliances, paper, textiles and wood, building materials, electronics, all kind of chemicals, medicines, fertilizers, tools and lots more. In combination with farmers they supply us food and beverages. Whatever we may think of this, people need food, housing and clothing!

To liberate the industry of CO_2 emission is maybe the greatest challenge for mankind, a challenge for science and the industry itself. Is it really so bad? Think about the gigantic amounts of energy used by steelfactories, aluminium smelters and refineries. Refineries, which eventually should disappear all together, have to refine crude oil without emitting CO_2! Factories which make all kind of products: glass, foodproducts, textile, paper, metal products, you name it, how could we force them to produce all this in a "clean" way, i.e. CO_2 emission free! How can we scrap ships in an environmental friendly way in stead of sending them to a beach in India where they are cut to pieces with torches, which use enormous amounts of acethylene gas?

We could help the industry by supplying them "clean", emission free electric power. The next step is recycling. Recycling is a baby now, it should grow up. Recycling has to be enhanced much more. This is asking for very difficult measures and regulations. Take paper nowadays: in the Western countries (f.i. in the Netherlands) more than half of the paper is being recycled. But is it necessary that we get so much publicity, folders and catalogues in our mailbox? Most of this paper goes straight into the paper bin, but whole forests have to be cut to produce it. Take glass: a great deal of the glass we use goes back into recycling. In many countries used glass is now collected and even sorted out on color. But all this glass has to be molten again, although a lot of it is perfectly reusable. Why don't we have standardized bottles? Take the waste: enormous amounts of waste are now being burnt, sometimes to generate electricity, but then all kind of harmful gases are emitted. Maybe some toxic gases are filtered out, but certainly not the CO_2!

To liberate the industry from CO_2 emission is maybe the most difficult task of them all. It will have to come from the industry itself, forced by strict regulations that have to be valid for everybody. An almost impossible task, as long as the E.C. or the U.N. has so little power.

Sometimes there is good news: that large refinery in Rotterdam tries everything to find useful purposes for the emitted carbon dioxide. It is collected and supplied to the greenhouses in the nearby "Westland", to stimulate the growth of vegetables. Also they have plans to combine the CO_2 with silicates, like "calcio silicate". The material produced can be used to make bricks and other building and filling materials.

Our food

The agricultural sector, very important for mankind, does not work emission free! Not only CO_2, also methane and ammonia are emitted. But slowly things go better, more and more food is produced environmentally friendly, farmers grow food "biologically" and don't use chemical fertilizers any more. But the big agricultural companies can't do without fertilizers. Meat production without emission of methane and ammonia will not be possible. And we also have the manure problem! Become a vegetarian? A lot has to be changed!

The fishing industry is solving the problem in a very peculiar way. By emptying the seas, by catching the last fishes, they will extinct themselves. No fish, no fishing! A lot of fish which, not so long ago, was abundant has now all but disappeared. By stubbornly ignoring the advice of biologists, certain types of fish are now almost extinct, the seas are getting empty. So, what is happening now? Certain popular but now scarce fishes, like salmon, tuna, cod and eal are bred in large ponds, enclosed parts of sea or in fjords in Norway! However, these fishes need special food and the question is: "is that food produced CO_2 free?"

I am waiting for the day that people finally understand that emptying the seas doesn't pay and that the disappearing fishes like cod, sole, plaice and others deserve a chance to come back again. Better a couple of years without fish than any fish at all any more!

Overpopulation

Certainly the main cause of the rapidly increasing CO_2 percentage in the atmosphere is the overpopulation of this world. Humanity needed about half a million years to go from zero to one billion people, to go from one billion to more than six billion took only 150 years! Everybody sees it, feels it and notices it: there are too many people on this world. Still, hardly anything is done: to the contrary, in many countries the production of children is subsidized and stimulated. In poor countries people want a lot of children as a kind of insurance for their old age!

In some western countries, f.i. Germany, the population hardly increases and the average age of the people is rising too. In stead of welcoming this development, the government gets worried and is taking measures to increase the birthrate! Wrong, we should go back in population!

As the world is confronted with a frighteningly increased demand for all kind of things: oil, food, metals, other basic materials, space and a decreasing supply and reserve of these matters, the world should be aware of the fact that all this can't continue forever!

The continually increasing problems of this world, hunger, shortage of food and drinking water, epidemic increase of deseases, flooding, natural disasters, drought, waste problems, more and more plants and animals becoming extinct, large scale killing of domestic animals due to deseases, wars, deforestation, increasing criminality, pollution, climate change, all are due to overpopulation.

Not true? Many people don't agree! The subject itself is taboo. "There is room for many more! Plenty of space! Enough food, it's the distribution that should be better." Future will point out who is right. As long as governments don't dare to take measures, the outlook is bleak. Unfortunately, in this world, measures are only taken when it is too late. If nothing is done to overpopulation, all possible measures to restrain CO_2 emission won't make sense! Something has to be done!

European measures

In March 2007 the European ministers announced a binding agreement:

- In 2020: CO_2 emission must be lowered by 20 % .
- In 2020: 20 % of the energy must be generated CO_2 emission free (or neutral?).
- In 2020: 20 % of the energy must be saved.
- In 2020: 10 % of the fuel for cars must be replaced by bio fuel.

From these measures it appears that the CO_2 emission must be limited by energy saving, use of bio fuels and "clean" energy generation by wind, sun and the likes. Coal fired powerplants without CO_2 emission are seen as thé possibility.

But…..**nuclear energy is considered "not clean".**

As they have a lot of experience in this, France was the only one who insisted to include nuclear energy as a clean source of energy, but the other countries would not agree! All they want to do is "study" it. They see energy saving lamps as a very important measure! It could be that tungsten bulbs are totally banned! What a vision!

What can we think of these measures? It's only 13 years to 2020. Will Europe be able to achieve the set goals? Even more important: will the problem of global warming be solved by these measures? The answer on both questions is a clear NO!

A couple of remarks on this "NO":

- The total CO_2 emission of Europe is only 10 % of the world's CO_2 emission. So 20 % reduction in Europe is only 2 % of the worlds' CO_2 emission! In the next 13 years the global CO_2 emission will increase substantially, nullifying the European reduction.
- The CO_2 percentage of the atmosphere will not go down, it will probably even increase faster than ever because the rest of the world is not doing anything (or very little) and in countries like China and India the demand for fuel and energy is increasing tremendously, also in the coming years.
- The worlds'population will strongly increase in the coming years. The 20 % decrease in energy consumption by Europe, will be overruled by the increased demand for energy by the growing world economy and world trade in the coming years. No measure, sanction, agreement, treaty, contract or whatsoever will alter that!
- The binding agreement signed by the European ministers will be so costly that many countries have to step out. Will the richer countries then take over? The industry will get competion problems and can't grow any more, they are forced to shrink! That will not happen of course.
- To meet the agreed goals, people's way of living has to alter drastically! They have to get out of their big cars, give up gasguzzling SUV's, skip vacations to exotic destinations, must live in a darker world, get used to colder houses in winter, and switched off airco's in summer. Very painful changes have to take place in the coming years, only in Europe! Will these measures be accepted, will the reductions really take place in the coming years? Germany, one of the initiators, started with a flat refusal to impose a speedlimit on its highways!
- It is unbelievable that governments don't see the immense consequences of their decisions and the goals they have agreed on. The goal agreed on in the Kyoto protocol: CO_2 emission reduction was: 8% by 2008 for the EC. Only 1 % is realised, was lately announced, and…. I have my doubts about thát.

- Production of bio fuels will require huge areas of agricultural land which now are supplying our food. These types of food will therefore become scarce and much more expensive (as is the case now already with corn).
- The most disappointing and frustrating factor is that all the measures now agreed for Europe, will have **no effect at all** on the climate change and the global warming, even when CO_2 is the real cause of global warming!

SHOULD WE DO NOTHING THEN?

Yes and No, both answers have their disadvantages.
"Yes: better do something than nothing!" So: "Yes, we must do something." But if we do, if we will try to reach the set goals, great unrest will be created under the European population. People will loose their jobs, have to give up their lifestyle and poverty may even appear!
"NO: we better do nothing, the measures are useless!" So: "No, don't do anything because otherwise we will have serious economical problems and it's all to no avail!" If Europe does nothing, this is such a bad example to the rest of the world, everything will then worsen even faster and other continents will feel free to go on as usual.

Conclusion

What I have tried to make clear in this publication is that the removal of one billion tons of CO_2 per year from the atmosphere is insufficient and won't stop global warming. It was not so easy to find the right figures to do all the calculating, not in the least as they are contradicting each other (as are the scientists). Although the calculated figures may not be completely accurate (I'm no scientist, just an interested bystander), the conclusions drawn here are definitely valid.

We know that our atmosphere now, in 2007, contains about 0.04 % of CO_2. This means a total of about 3000 billion tons of CO_2. Also, the calculations show that the annual CO_2 emission of the world is around 30 billion tons of CO_2. This annual emission is increasing with 1% to 1,5 % per year.

From these figures it must be clear that the removal of 1 billion tons of CO_2 annually, is insufficient to reverse the global warming.

Back to our common goal:

"**Let us stop climate change and global warming!"**

If we want to reverse the trend, we should bring the CO_2 percentage from 0, 04 % back to 0, 03 %, the level we had 50 years ago. We must then remove a quarter of the total CO_2 content (at least 500 billion tons) from the air. If we decide to do this in 10 years, that means the removal of 50 billion tons of CO_2 annually. In the meantime we must stop the current emission of CO_2 completely. To stop CO2 emission right away is of course not possible. As the emission is now around 30 billion tons per year, it means that we have to begin removing 80 billion tons of CO_2 annually! The removal of such amounts of carbon dioxide takes such efforts that I come to the following statement:

Lowering the CO_2 percentage from the atmosphere substantially, is asking such drastic actions, that we have to be 100 % sure that it is indeed CO_2 which causes the global warming!

As I mentioned before, according to a number of scientists it is not sure at all that CO_2 is the guilty one. But even the convinced scientists have to admit the following: even when

CO_2 really acts as a greenhouse gas, than it is only partly responsible for the global warming (the figures vary between 5 and 40 %). What's also clear: the strongest greenhouse gas is: water vapour, responsible for 60 – 95 %). The other danger is methane (CH_4). Methane is even supposed to be a 20 times stronger greenhouse gas than CO_2! The concentration is still low, 1/200 of the CO_2 concentration, but may rise quickly because of the melting "permafrost"! According to a number of scientists, it's not the CO_2 emission, but the increased activity of the sun theat causes global warming (started in the sixties).

Let us forget all this for a moment and suppose that science is 100 % sure that it is the risen CO_2 concentration which causes global warming. Suppose also that science is 100 % sure that the solution to stop global warming is: lowering the CO_2 content of the air. How can we do this?

WHEN CO_2 REALLY IS THE CAUSE OF GLOBAL WARMING, THEN THE FOLLOWING POSSIBILITIES TO LOWER THE CO_2 PERCENTAGE SHOULD BE RESEARCHED.

- Deforestation

The gigantic deforestation in this world has to stop, how difficult this may be. The use of wood must be limited, tropical wood totally banned. The forests of the world are even more important than we ever anticipated. If deforestation would be stopped and reforestation started now, it will take fifty years to go back to the old situation, but first the world has to become CO_2 emission free! As this will take time, the recuperating time will be much longer now, but could be shortened when the measures to remove CO_2 from the atmosphere are taken early enough!

- Storage of CO_2

Science says it is possible: When we can separate large amounts of CO_2 from the air, it could be stored: both underground and in sea water. But first we have to develop methods to get CO_2 in an effective way out of the air.

- Binding of CO_2

CO_2 can be combined more or less permanent to various silicates. We should try this for large amounts of CO_2 and use the material for all kind of purposes such as building material.

- Photosynthesis

The natural way to absorb CO_2 is photosynthesis. Although natural photosynthesis is to slow and ineffective for large scale extraction of CO_2, science should study this process so we can develop methods to use enhanced photosynthesis (natural or artificial) to absorb the CO_2 from the atmosphere faster and more effective.

- Convertion and storage of carbohydrates

Carbohydrates produced by photosynthesis are now used as food, basic material, wood, paper, textile and fuel. When large scale photosynthesis can be applied to remove CO_2 from the air, we have to find new ways of dealing with the produced carbohydrates (f.i sugarbeets) and prevent that they are converted back into carbondixide (as now is the case with 90%).

- Nuclear energy

Nuclear energy must be taken serious again. It's the only real CO_2 emissionfree way to produce large scale electric energy. New ways have to be found to improve fission reactors and to deal with the nuclear waste. The construction of a nuclear fusion reactor (near Marseille), should be speeded up. Fusion energy might solve all our energy problems.

- Solar energy

The industry should be stimulated to produce cheaper and more effective solar cells. The use of solar cells to generate small scale power for lighting, households can become very important. Solar energy should also be used much more than now, for heating purposes.

- CO_2 emission by transport

The means of transport must become CO_2 emission free. The use of fossil fuel for transport should be permitted only when there are absolutely no other possibilities available yet (ships, aeroplanes).

- Overpopulation

At last, the world should do something to the overpopulation. Overpopulation in this world is the main cause of all our problems. Governments see the growing grey of the population as a threat. A decreasing population, as now is taking place in a few western countries, is seen as a disaster! The governments should learn to see this as a blessing, stimulate it and begin to adapt.

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BUT….IF CO_2 IS NOT THE CAUSE OF GLOBAL WARMING?

WE MUST BE SURE THAT CARBONDIOXIDE IS THE MAIN REASON FOR CLIMATE CHANGE AND GLOBAL WARMING BEFORE MAKING WILD DECISIONS AND TAKING ACTIONS AS IS HAPPENING NOW!

JACOB HUISMAN

ADDENDUM

World:		
Circumference:	40.000 km	
Radius:	6370 km	
Surface world:	5,1 x 10^8 km^2	= 5,1 x 10^{18} cm^2
Total weight of atmosphere	5,1 x 10^{18} kg	= 5,1 x 10^{15} tons
Percentage of CO_2 in atmosphere	± 0, 04 %	= ± 400 PPM
Total weight of CO_2 ,,	2000/3000 billion tons	= 2000/3000 G.tons
Percentage of CH_4 ,,	± 0,0002 %	= ± 2 PPM (by weight?)
Total weight of CH_4 ,,	± 10 billion tons	= ± 10 G.tons
Percentage of H_2O	0,13 %	
Total weight of H_2O ,,	1,29 x 10^4 km^3	
Total weight of H_2O on the world	1,386 x 10^{18} km^3	

<u>Annual world fuel consumption</u>	
Crude oil	30 billion barrels = ± 430 billion kg
Natural gas	3000 billion n.m^3 per year
Coal	6 billion tons
<u>Annual world CO_2 emission by fossil fuel</u>	
By oil	9 billion tons
By natural gas	6 billion tons
By coal	15 billion tons
Total	30 billion tons of CO_2 emission

<u>Annual world H_2O emission by fossil fuel</u>	
By oil	8, 1 billion tons
By natural gas	3, 6 billion tons
By coal	5, 4 billion tons
Total	17, 1 billion tons of H_2O emission

<u>World reserves of fossil fuel</u>

Crude oil	3600 billion barrels
Natural gas	150 – 200 thousand billion $N.m^3$
Coal	1000 – 2000 billion tons
Tar sand and oil shale	X000 billion tons (500 x crude oil)