Relation between CO_2, global temperature and energy consumption

Sjaak Uitterdijk
sjaakenlutske@hetnet.nl

Abstract- The reason for the present study is the surprising observation of measurements showing that the increase in global temperature is, over a period of already 150 years, equal to 0,135 °C together with an increase in CO_2 *concentration in the atmosphere of 20 ppm, at each increase of the world population with 1 billion. So regardless of the explosively increasing industrialization in the past 50 years. The study indicates where, in the substance of the case, the cause for this apparent contradiction can be found, but does not explain the remarkably precise constant ratio over those 150 years. It brings a different, striking precisely, relation upwards: the one between the increase in worldwide energy consumption by mankind and the increase in global temperature. The article closes with the conclusion that the climate problem is a symptom of the world population problem.*

Introduction

In reference [1] is, by using curve- and polynoomfitting, noted that both the increase in CO_2 concentration in the atmosphere and the increase in global temperature, are surprising exactly proportional to the increase in world population. This study shows, by applying the same technic, that such a relation also exists between the worldwide energy consumption over the past 200 years and the global temperature.

Energy consumption by mankind

Global administrations of the consumption of fossil fuels has led to a graph (figure 1) of the annual energy consumption in the past 200 years [2].

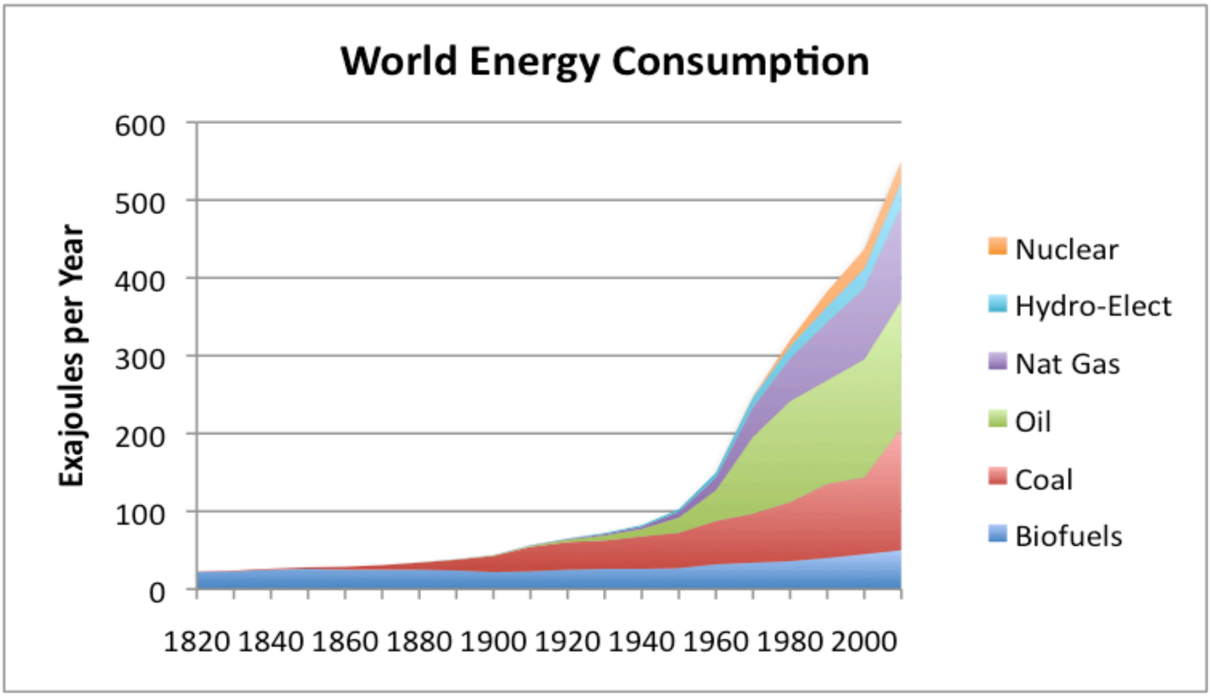

Figure 1. World Energy Consumption by Source, Based on Vaclav Smil estimates from Energy Transitions: History, Requirements and Prospects and together with BP Statistical Data on 1965 and subsequent

Figure 1 shows "humps" and "dents" that conflict with the extremely streamlined graph of the measured CO_2 concentration in the atmosphere over the last 60 years. See [1].
For this reason the graph of figure 1 has also been streamlined by means of curve-fitting.

The data in figure 1 are first converted to a stylized graph. After that, curve-fitting has been applied, making use of the values at the years: 1810, 1970 and 2010.

Energy consumption = $12.15 + 1.23 * 10^{-137} * t^{42.272}$ ExaJoule/year (t is related year)

Using this mathematical expression the expected value until the year 2020 has been calculated. See figure 2.

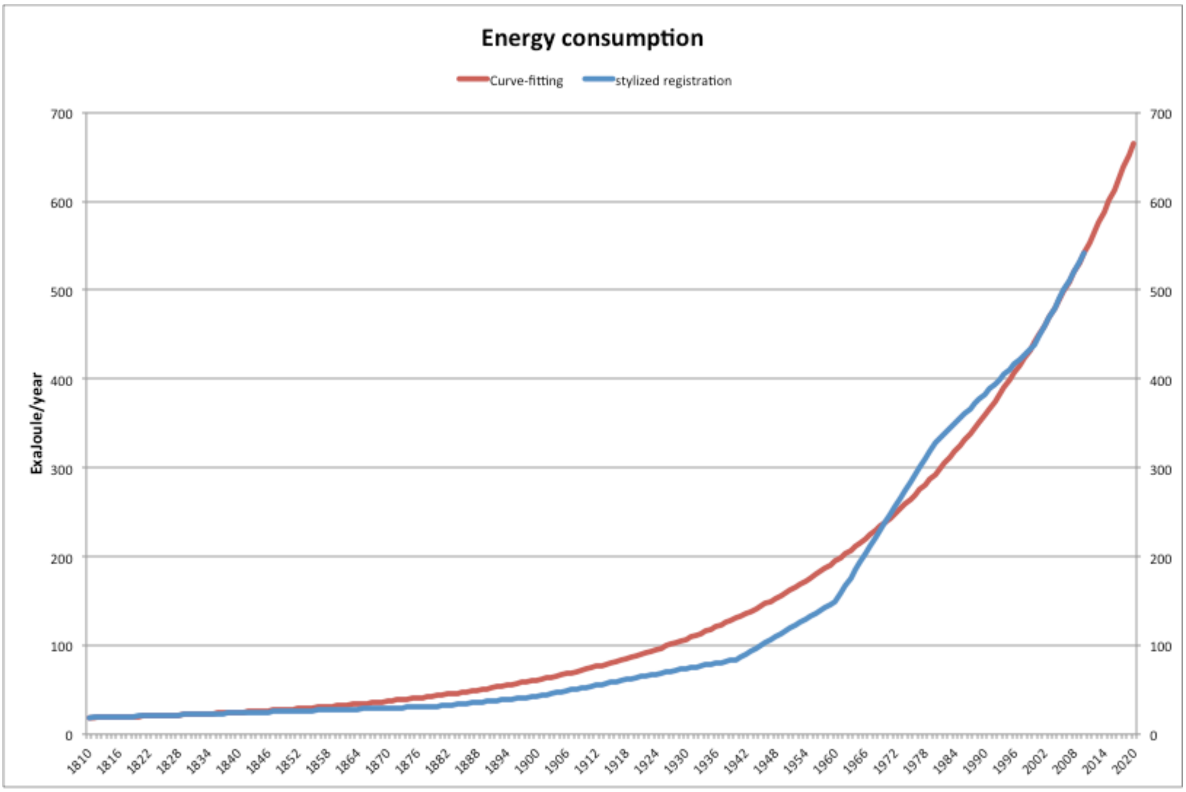

Figure 2. Worldwide energy consumption from 1810 to 2010/2020

CO_2 emissions based on the energy consumption

CO_2 emissions, as a result of the combustion of fossil fuels (so-called primary fossil fuel use), are for example expressed in terms of the number of kilograms of CO_2 per released amount of energy in kWatt-hours. This emission factor depends on the type of fossil fuel.

The types of fuel mentioned in figure 1 have, as shown by [3], the following CO_2 emission factor:

Pounds of CO_2 per 1000 kWh, at 100% efficiency:

Coal	709 pounds : 321 kg/MWh
Oil	559 pounds : 253 kg/MWh
Natural Gas	399 pounds : 181 kg/MWh

Table 1

The table lacks "biofuels" as shown in figure 1.
Biofuel is an incorrect word, because it nowadays is a general term for various types of fuels made from biomass. But in 1800 there was no biofuel made from biomass. Therefore the word biomass will be used.

In ref [4] it has been argued why the CO_2 emission factor of biomass is almost equal to that of coal. Biomass will therefore be included as coal.

The mentioned emission factor for coal in [4] (1018 kg/MWh) is much higher than the one in Table 1, because in Table 1 the heat energy, “at 100% efficiency”, is meant, while in [4] generated electrical energy is considered.
The same conclusion is valid for natural gas: 437 versus 181 kg/MWh.
So for fossil fuels and biomass, used for the production of electricity, an emission factor being 2 to 3 times as large as those listed in Table 1 have to be taken.
In the following calculations an emission-gain factor of 2.5 will be assumed, based on the assumption that in figure 1 the heat energy is meant.

The relative distribution of the energy of the fuel types in figure 1 for the 3 years 1810, 1910 and 2010 is as follows:

	2010	1910	1810
Nuclear	0,05	0	0
Hydro-Elect	0,05	0	0
Nat Gas	0,20	0	0
Oil	0,31	0	0
Coal+Biomass	0,39	1	1

Table 2

The unit ExaJoules, used in figure 1, will be converted to TeraWatt-year, with which ExaJoules/year results in a power, expressed in TeraWatt. The emission factor for the three types of fuel, including an emission-gain factor of 2.5, is as such shown below.

Natural Gas 2.5*181*10^{-6} Gigaton/TeraWatt-hour = 4.0 Gt/TeraWatt-year
Oil 2.5*253*10^{-6} Gigaton/TeraWatt-hour = 5.5 Gt/TeraWatt-year
Coal /biomass 2.5*321*10^{-6} Gigaton/TeraWatt-hour = 7.0 Gt/TeraWatt-year

Table 3 below is an extension of Table 2 to the emission factor for the individual types of fuel, in the relevant three years.

					emissionfactor in Gt/TeraWatt-year		
	2010	1910	1810		2010	1910	1810
Nuclear	0,05	0	0	0	0,0	0,0	0,0
Hydro-Elect	0,05	0	0	0	0,0	0,0	0,0
Nat Gas	0,20	0	0	4,0	0,8	0,0	0,0
Oil	0,31	0	0	5,5	1,7	0,0	0,0
Coal+Biomass	0,39	1	1	7,0	2,7	7,0	7,0
				weighed average	5,2	7,0	7,0

Table 3

With this information the CO_2 emissions will be calculated in the next chapter.

For the years 1910 to 2010/2020 a linear decrease has been chosen from 7.0 to 5.2/4.8

CO_2 emissions and concentration in the atmosphere expressed in Gigaton

The CO_2 concentration in the atmosphere is expressed in ppm, that is to say, the number of molecules of CO_2 in relation to the total number of molecules in the atmosphere.

The air pressure at the surface is, rounded, 1000hPa = 10^5 N/m^2 = 10^5 kgm^{-1}s^{-2}.
The surface of the earth is $5 * 10^{14}$ m^2.
The total mass of air in the atmosphere thus is $10^5 * 5 * 10^{14}$ / g with g, rounded, 10 ms^{-2}, resulting in $5 * 10^{18}$ kg.

Given the definition of ppm, this mass has to be converted to the unit mol, defined as the mass of N_A atoms/molecules of that substance. N_A is the number/constant of Avegadro.
Given the molar mass [kg/kmol] of both air and CO_2, the conversion from air to CO_2 is easy.

The one of air is 29, with which the $5 * 10^{18}$ kg of air in the atmosphere is $2 * 10^{17}$ kmol.
The ppm CO_2 has to be applied to this result.

The current concentration is 400 ppm and the molar mass of CO_2 is 44 kg/kmol.
The current mass of CO_2 in the atmosphere therefore is $3.0 * 10^{15}$ kg = 3000 Gigaton/Gt.

The ppm CO_2 conversion factor to Gt in the atmosphere thus is 3000/400 = 7.5 Gt/ppm.

With this factor the concentration of CO_2 in the atmosphere, as function of the year, will be converted to Gigatons of CO_2 in the atmosphere, for comparison with the Gigatons CO_2 emission in these years.

Encore:
The ratio of the molar masses of air and CO_2 is by definition equal to the ratio of their respective specific weight. Rounded numbers: 44/29, respectively 2/1.3 = 1.5 at 1 atmosphere.

The conversion factor from ppm CO_2 in the atmosphere to Gt, could, in principle, also be calculated using these variables. Doing so, the total mass of the air in the atmosphere has to be translated, via the total volume of that air, to a *mean* specific weight of this mass.

The calculation of the total volume of air requires the knowledge of the height of the atmosphere in which the air is located. Somewhere between 15 and 20 km. So no hard data.

Conversely: If it is assumed that the air pressure in this range decreases linearly with the height to zero, until the hitherto unknown height, and using the above-mentioned conversion factor 7.5 Gt/ppm, it appears that this height is 20 km.

In Table 4 the following variables are shown as function of the year:

CO_{2A}	relative CO2 concentration atmosfeer[1]	[ppm]
ΔCO_{2A}	absolute[2] increase in CO_2 in the atmosphere	[Gt/year]
P	average power generated by mankind	[TeraWatt]
E	emission factor for CO_2, incl. a gain of 2.5	[Gt/TeraWatt-year]
ΔCO_{2U}	absolute[2] increase in CO_2 emission (E * P)	[Gt/year]
ΔCO_{2oa}	absolute[2] increase CO_2 at earth surface (ΔCO_{2U} - ΔCO_{2A})	[Gt/year]
$R\Delta CO_{2oa}$	relative ΔCO_{2oa} (100 * $\Delta CO_{2oa}/\Delta CO_{2U}$)	[%]

[1] CO_{2A} is based on the curve-fitting as described in [1].

[2] To be read as per year in the related year.

year	**CO_{2A}**	**ΔCO_{2A}**	**P**	**E**	**ΔCO_{2U}**	**ΔCO_{2oa}**	**$R\Delta CO_{2oa}$**
1800	263	**7,5**			**1**		
1820	264	0,7	0,67	7,0	4,7	4,0	85
1840	266	1,0	0,94	7,0	6,6	5,6	85
1860	269	1,4	1,31	7,0	9,2	7,8	85
1880	274	1,9	1,85	7,0	13	11	85
1900	280	2,7	2,62	7,0	18	16	85
1920	288	3,7	3,70	6,6	25	21	85
1940	300	5,2	5,22	6,3	33	28	84
1960	316	7,2	7,36	5,9	44	36	84
1980	339	9,9	10,4	5,6	58	48	83
2000	370	13,6	14,5	5,2	76	62	82
2020	413	18,6	20,3	4,8	98	80	81

Table 4

Note regarding $R\Delta CO_{2oa}$:
The value of more than 80% means that less than 20% of the emitted CO_2 is absorbed by the atmosphere.
Apparently, the absorbing capacity of the earth's surface for CO_2 is significantly larger than that of the atmosphere.

This observation is sufficient enough to understand the apparent contradiction, as mentioned in the abstract. The exact constant ratio, indicated in the abstract too, is not (yet) explained.

Given the conclusion regarding the variable $R\Delta CO_{2oa}$ the variables E up to and including $R\Delta CO_{2oa}$ don't matter anymore in the following considerations.

Table 4 shows that the variables ΔCO_{2A} and P rise, at first sight, rather equally, with the coincidental peculiarity that the numerical values are rather the same too.
That coincidental peculiarity caught the attention!
Because of the fixed factor of ppm to kg CO_2 the relation with P also applies to ppm CO_2.

Relation between the CO_2 increase in the atmosphere and the generated power

Displayed in a graph this relation looks as shown in figure 3.

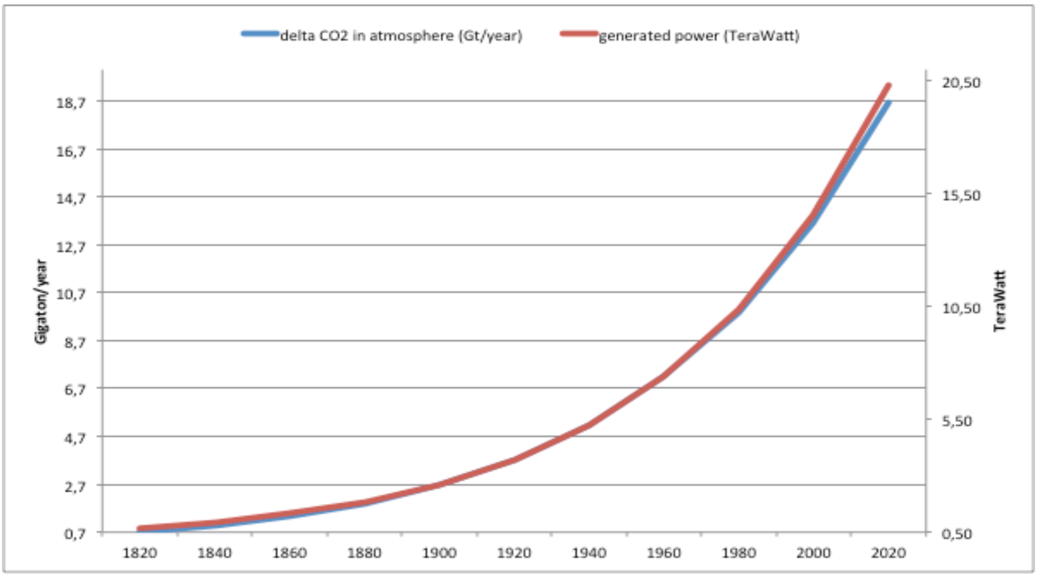

Figure 3. Generated power and ΔCO_2 in the atmosphere (Gigaton/year)

The graph of the generated power is the red one from figure 2.
Taking figure 3 as representative for the energy consumption, the *increase per year* of the CO_2 concentration in the atmosphere in the past 150 years is perfect proportional to the average power generated by mankind, according to the constant 0.13± 0.01ppm CO_2/Terawatt.

The mentioned constant is awkward to work with. Therefore it will be investigated how the variable $\mathbf{\Delta} CO_{2A}/\mathbf{\Delta} P$ [ppm/TeraWatt] for each year behaves in these 150 years. See figure 4.
The relationship between these two variables is thus equally as good as for the two in figure 3.
This ratio is 9.9 in 1820 and 8.6 in 2020, with an average of 9.2[ppm/Terawatt].

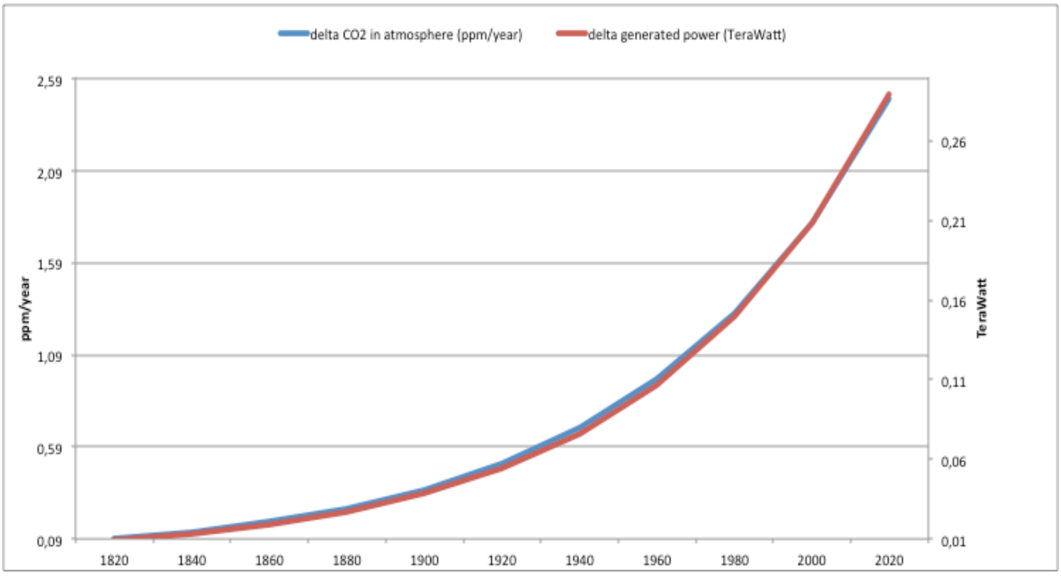

Figure 4: ΔCO_{2A} (ppm/year) and ΔP(TeraWatt/year) as a function of the time

Remark: the expression "/year" has to be interpreted as "in the relevant year".

The consequence of $\Delta CO_{2A}/\Delta P$ being rather constant over 150 years is the following.
In [1] it has been proven that there is a fixed relation between the CO_2 concentration in the atmosphere and the global temperature: an increase of the CO_2 with 20 ppm is associated with an increase in the temperature of 0.135 °C.
In other words: each TeraWatt increase by mankind generated power leads to an increase of the global temperature of $(0.135/20)*9.2 \sim 0.06$ °C. The conversion factor thus is: 0.06°C/TeraWatt.

This mean conversion factor over 150 years leads to an increase of 1.2 °C in 2020.
Applying the mathematical expression shown in [1]: $\Delta T(t)= 1.22*10^{-108} * t^{32.65}$ with t=2020 results in an increase of 1 °C. N.B. This is the long-term increase, not taking into account the extremely periodic variation on top of this as shown in [1] too.

The increase in global temperature can thus be easily and directly calculated also from the increase in the world wide generated power, *without considering CO_2 emissions*.

Politically oriented encore

The hard relation between the increase of the global temperature and the energy consumption by mankind has the following consequence.

The part of mankind that has a higher IQ will always need intellectual challenges. The most striking example regarding technical issues is the aerospace industry.
Automation and mechanization are high ranked on that list, because these also satisfy the other part of mankind by means of an increasing level of prosperity.

What kind of developments it may be, the global industrialization will not only continue to increase with the number of people, but, as history proves, especially with the increasing energy consumption per person.

Current developments in the field of sustainable energy also provide the necessary additional industrialization along with it. The demand for energy is, and will remain so, large relative to what sustainable energy can produce.
It thus will always remain with a magnitude of only a few per cent.

Because of the vast majority of the emitted CO_2 being absorbed by the earth's surface and because of the accompanying increasing industrialization due to the production of wind turbines and solar cells, saving on this emission will always remain with a negligible significance for the CO_2 concentration in the atmosphere.

Based on the above consideration, thus despite the developments in the field of sustainable energy, the increase of the global temperature most probably will in 2050 rise to ~ 1.7 °C. Double the present increase, relative to the temperature in 1800.

As well as the observed 'law', that this increase is proportional to the population, as the observed 'law' that this increase is proportional to the energy consumption, leads to this outcome.

In other words: mankind's fundamental problem is not a climate problem, but a population problem. The climate problem is a symptom of the population problem.

Conclusions

1 The vast majority of CO_2 emissions is absorbed by the earth's surface, explaining the apparent contradiction in the relationship between CO_2 concentration in the atmosphere and the world population.

2 The background for the precise, and already 150 years existing, relation between CO_2 concentration of the atmosphere and the world population is not found.

3 Mankind's fundamental problem is not a climate problem, but a population problem. The climate problem is a symptom of the population problem.

4 The theoretical research has led to a further, also surprising relation: a constant increase of the global temperature with 0.06 °C per Terawatt power generated by mankind, notwithstanding the dramatically increase of this power during the past 50 years.

References.

[1] The Relation Between CO_2, Global Temperature and World Population. http://vixra.org/abs/1610.0091

[2] http://www.theoildrum.com/files/world-energy-consumption-by-source_1.png

[3] http://www.physics.uci.edu/~silverma/units.html

[4] https://tasma-bioenergy.com/bioenergy/