Relation between CO_2, global temperature and energy consumption

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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].

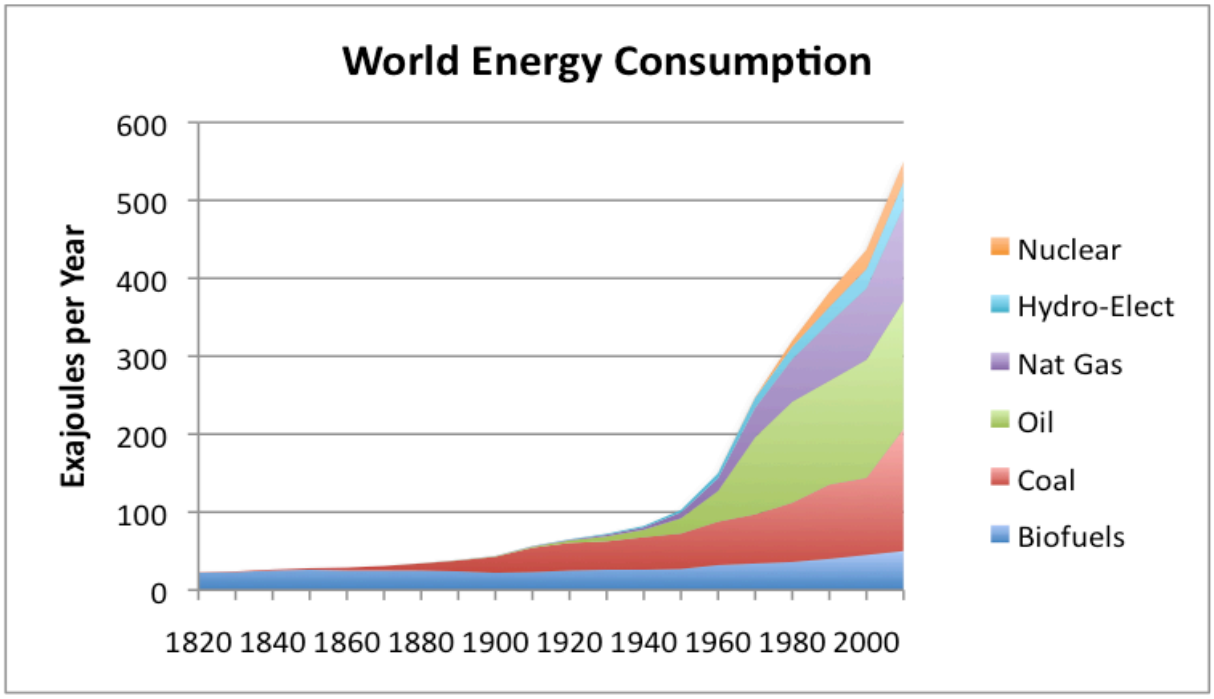

Figure 1. World Energy Consumption by Source, Based on Vaclav Smil estimates from Energy Transitions: History, Requirements and Prospects and together with BP Statistical Data on 1965 and subsequent

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.
Using the mathematical expression for this curve the expected value in the year 2020 has been calculated too. See figure 2.

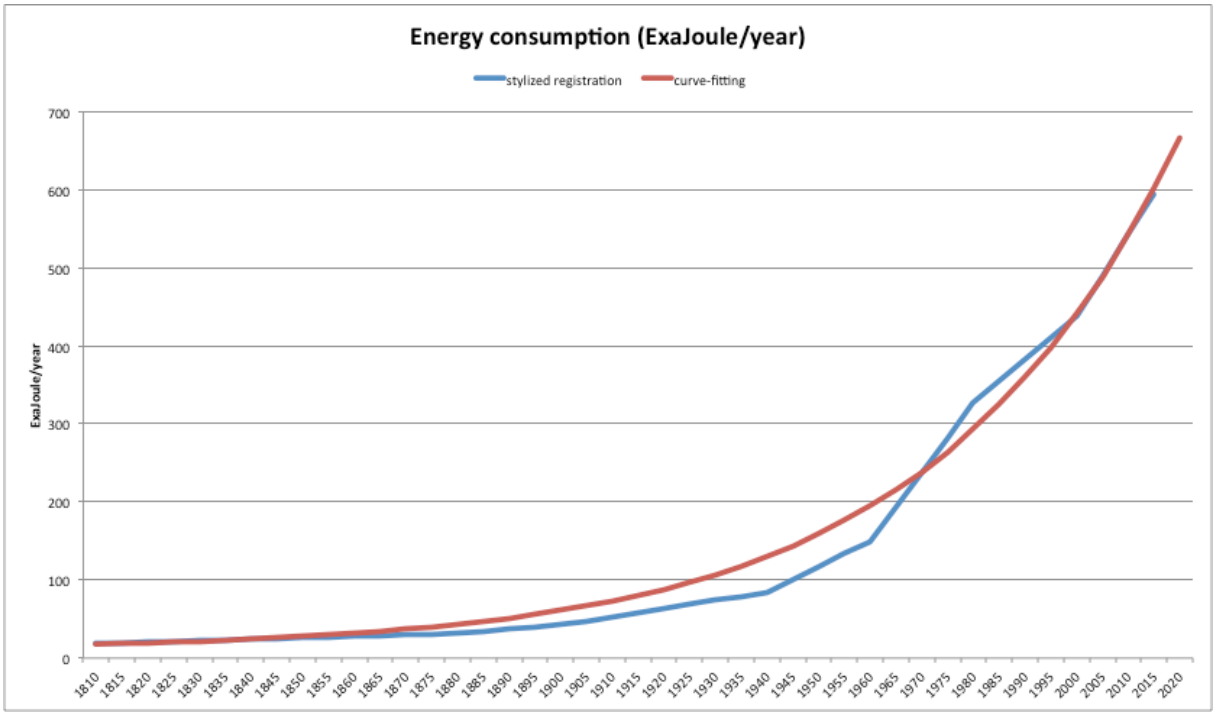

Figure 2. Worldwide energy consumption from 1810 to 2010/2020

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 CO2 per 1,000 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 is 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 fundamental energy is meant, while in [4] generated electrical energy is considered.
So for fossil fuels and biomass, used for the production of electricity, an emission factor being about 3 times as large as those listed in Table 1 have to be taken.
In the following calculations an emission-gain factor of 2 will be assumed, based on the assumption that in figure1 the fundamental energy is meant.

The relative distribution of the energy of the fuel types in figure 1 is for the 3 years 1810, 1910 and 2010 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, is as such shown below.

Natural Gas $2*181*10^{-6}$ Gigaton/TeraWatt-hour = 3,2 Gt/TeraWatt-year
Oil $2*253*10^{-6}$ Gigaton/TeraWatt-hour = 4,4 Gt/TeraWatt-year
Coal /biomass $2*321*10^{-6}$ Gigaton/TeraWatt-hour = 5,6 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	3,2	0,6	0,0	0,0
Oil	0,31	0	0	4,4	1,4	0,0	0,0
Coal+Biomass	0,39	1	1	5,6	2,2	5,6	5,6
			weighed average		4,2	5,6	5,6

Table 3

For the years 1910 to 2010/2020 a linear decrease has been chosen from 5.6 to 4.2/3.9.

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

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]
V	average power generated by mankind	[TeraWatt]
E	emission factor for CO_2, incl. a gain of 2	[Gt/TeraWatt-year]
ΔCO_{2U}	absolute[2] increase in CO_2 emission (E * V)	[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}**	**V**	**E**	**ΔCO_{2U}**	**ΔCO_{2oa}**	**$R\Delta CO_{2oa}$**
1800	263						
1820	264	0,6	0,7	5,6	3,8	3,2	85
1840	266	0,8	0,9	5,6	5,2	4,4	84
1860	269	1,2	1,3	5,6	7,4	6,2	84
1880	274	1,6	1,9	5,6	10	8,8	84
1900	280	2,3	2,6	5,6	15	12	84
1920	288	3,2	3,7	5,3	20	16	84
1940	300	4,4	5,2	5,0	26	22	83
1960	316	6,1	7,4	4,7	35	29	82
1980	339	8,5	10	4,5	46	38	82
2000	370	12	15	4,2	60	49	81
2020	413	16	20	3,9	79	63	80

Table 4

Note regarding $R\Delta CO_{2oa}$:
The value of roughly 80% means that roughly 20% of the emitted CO_2 is absorbed by the atmosphere. If the emission gain is taken 1 the ratio becomes about 30/70. A gain of 3 leads to about 10/90. Given the uncertainty in the gain of 2 (at least 0,5), the outcome is not more concrete than that by far the greater part of the emission is absorbed by the earth's surface. 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 summary. The exact constant ratio, indicated in the summary 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 V 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 also applies to ppm CO_2.

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

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

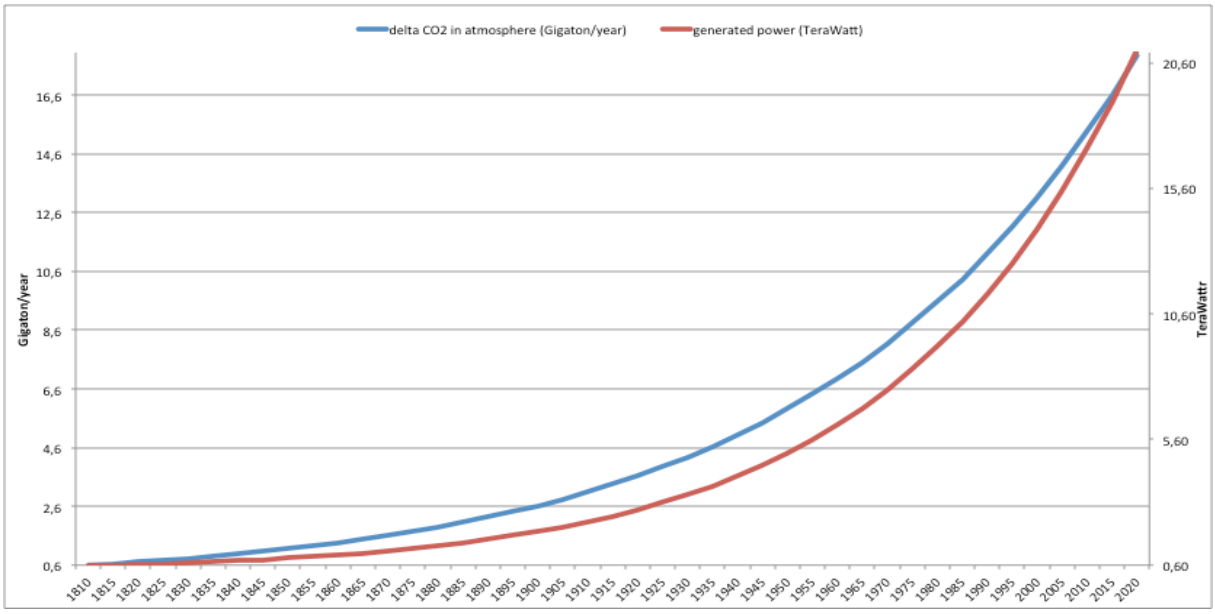

Figure 3. Generated power versus ΔCO_2 in the atmosphere (Gigaton/year)

The graph of the generated power is the red one from figure 2.

Note: The word "generated" is coupled with "power", the word "consumed" with "energy".
The word "consumed" actually means "ultimately converted into heat."

The graphs in figure 3 fit more precisely to each other, if the curve fitting for the energy consumption is chosen at the years 1810, 1985 and 2010, instead of 1810, 1970 and 2010. See figure 4, with ΔCO_2 in Δppm in the relevant year !

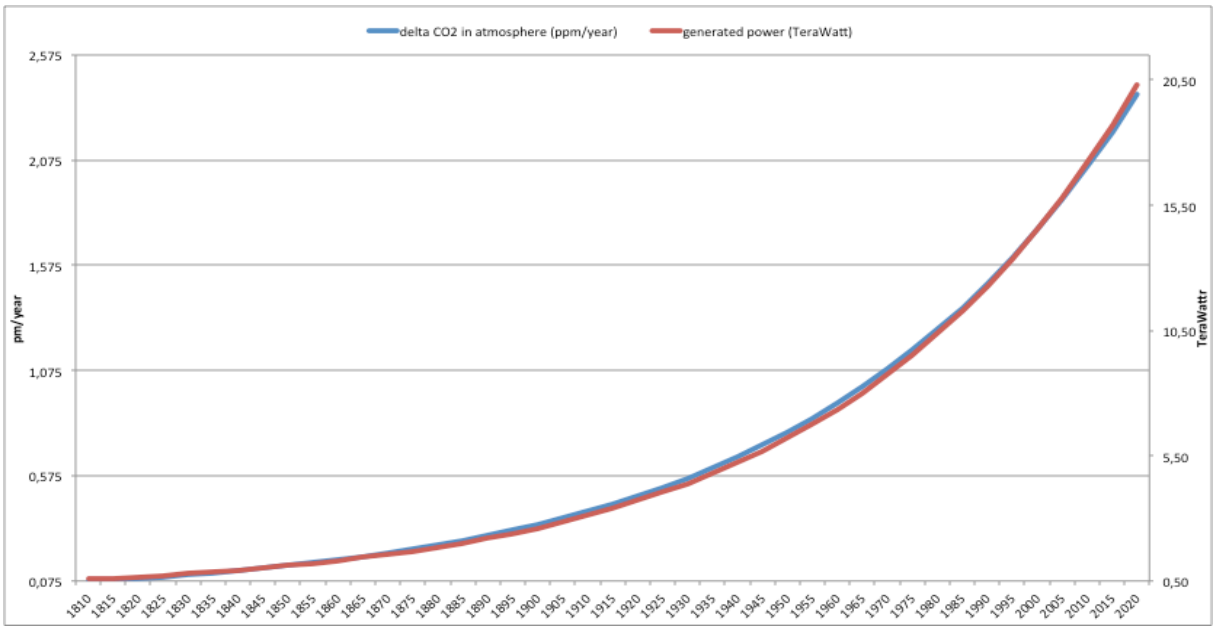

Figure 4. Generated power versus ΔCO_2 in the atmosphere (ppm/year)

The corresponding graph for the consumed energy to figure 4 is shown in figure 5.

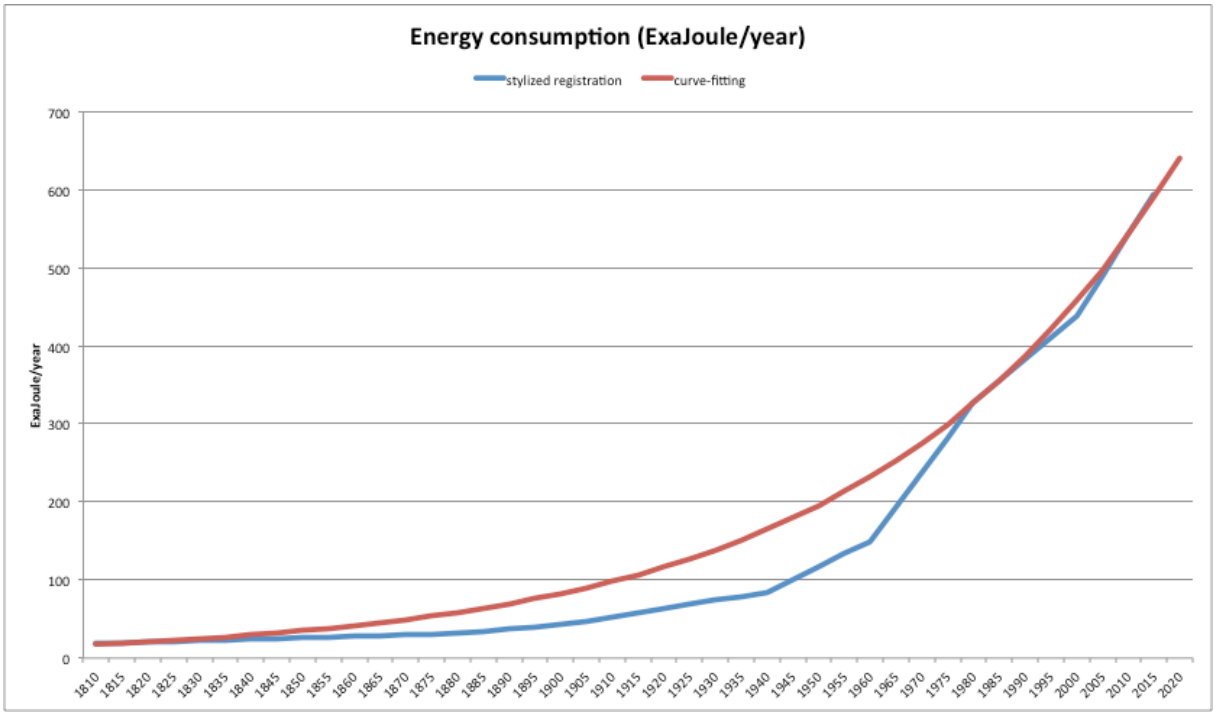

Figure 5 World wide energy consumption from 1810 to 2020

For the time being it is assumed, for two reasons, that figure 5 provides a more reliable picture of the consumed energy than figure 2:

- The "dent" round the second war does not fit with the then expanding war industry.
- The records are considered more reliable for the past 30 years than before, because the climate problem got more and more attention since 1970.

Taking figure 5 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 0,13ppm CO_2/Terawatt.
The period 1800-1850 will not be taken into account for these considerations, because of the unreliability of the data in that period and the relatively high sensitivity to small deviations due to the small absolute values.

The mentioned constant is awkward to work with. Therefore it will be investigated how the variable $\mathbf{\Delta}CO_{2A}/\mathbf{\Delta}V$ [ppm/TeraWatt] for each year behaves in these 150 years. See figure 6.

The relationship between these two variables is thus equally as good as for the two in figure 4. This ratio is 8.2 in 1850 and 7.3 in 2020, with an average of 7.7[ppm/Terawatt].

This conversion factor results in a *calculated* increase of the CO_2 concentration in 2015, relative to the level in 1800, of 7.7*(18.7-0,6) = 140 ppm, at a "*measured*" value of 401-263 = 137 ppm. Read for "*measured*": extrapolated from actual measured values. See [1].

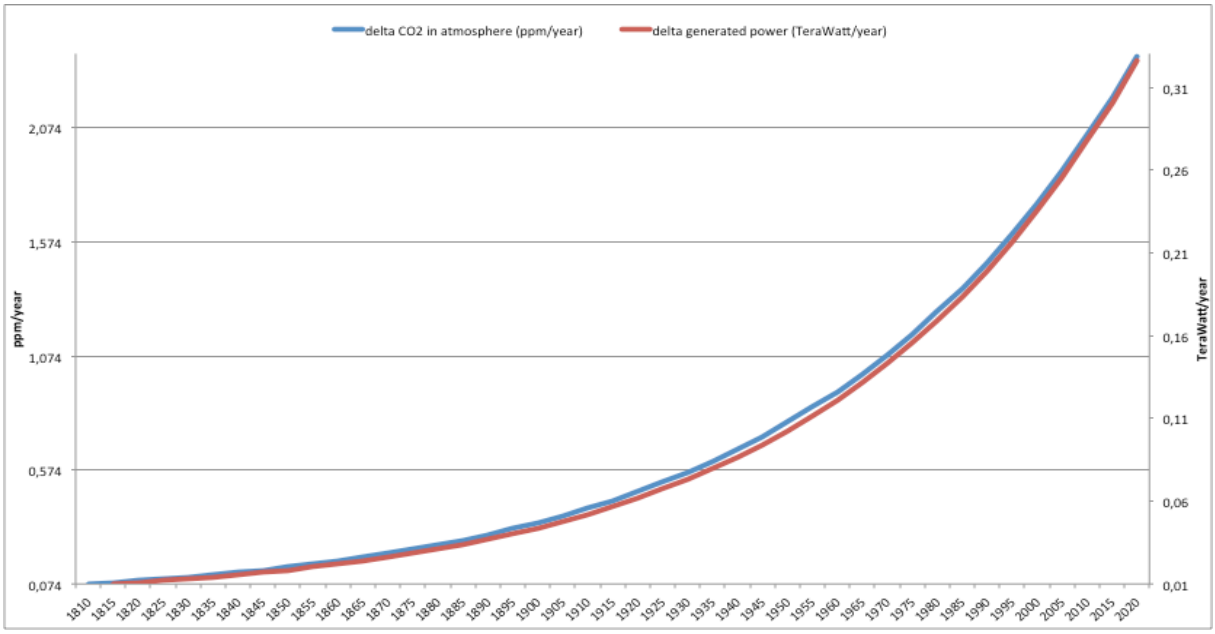

Figure 6: ΔCO_{2A} and ΔV as a function of the time

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

The consequence of $\Delta CO_{2A}/\Delta V$ being constant over 150 years is the following.
In [1] it has been proved 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)*7.7 ~ 0.05 °C. The conversion factor thus is: 0.05°C/TeraWatt.

This conversion factor leads to an increase of the well-known 0.95 °C in 2015.
This value is also found applying the mathematical expression shown in [1]:
$\Delta T(t) = 1.22*10^{-108} * t^{32.65}$ with t=2015. 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*.
The greenhouse model claims an increase in global temperature only based on the increase of the CO_2 concentration in the atmosphere!

Based on the physical principle that each TeraWatt by mankind generated power ultimately results in heat, the model of the living room with a stove to heat it, can also be considered as a, in principle, possible option.

The current 20 TeraWatt globally generated power is equivalent to an evenly, over the surface of the earth, distributed average thermal power density of 40 kWatt/km^2.
Otherwise proposed: 500 million continuous burning stoves of each 40 kWatt, evenly distributed over the earth.
This is equivalent to the imaginary model of each person on earth equipped with a 3 kWatt heater, evenly distributed over the earth.

Would mankind, "equipped as such", be able to hold the global temperature 1 °C higher?
A question that compels reflection on the measures to be taken (to try) to curb climate change.
Answering that question requires at least a pure thermodynamic study.

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.

As has been shown it could be that the heat, as a result of the energy consumption, only is responsible for the increasing global temperature. The here called living room model.

But whether it is de greenhouse, or the living room model, or a combination of both, the end result will, with a probability verging on certainty, be dictated by the amount of the world population.

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 The theoretical research has led to a further, also surprising relation: a constant increase of the global temperature with 0.05 °C per Terawatt power generated by mankind, notwithstanding the dramatically increase of this power during the past 50 years.

4 Each TeraWatt generated power ultimately leads to thermal power.

5 The 20 TeraWatt can be considered as realized for example by 7 billion heaters of each 3 kWatt, evenly distributed over the surface of the earth and steadily operating.

6 The intriguing, but most crucial, question is whether this 20 TeraWatt is able to cause the global temperature to increase directly by 1 °C, so without the intervention of CO_2. In case the answer to this question would be yes, the correctness of the greenhouse model would be questionable.

7 A thermodynamic study of the increase in global temperature directly by the heat output of the world wide consumed energy is crucial.
It could lead to an entirely different approach of the climate problem.

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

References.

[1] The Relation Between CO_2, Global Temperature and World Population. http://vixra.org/pdf/1601.0313v1.pdf

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

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

[4] http://www.greenfacts.org/en/biofuels/index.htm#1