Calculations on the Lifespan of Vehicle Production and Petroleum Production

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Preface

Petroleum production and driving are connected like Siamese twins. Without fossil fuels, hardly any vehicle moves. Petroleum provides the energy for the drive. Petroleum also provides energy for oil production. Worldwide, almost only combustion engines are used for motor vehicles, the proportion of electric vehicles is in the percentage range (according to wikipedia: 1,4% worldwide). Siamese twins can sometimes be separated, otherwise they live and die at the same time.
Based on openly accessible data on car manufacturing and petroleum production, the lifetimes of this twin were determined in several ways. The mathematical methods used are standard methods for data evaluation. The calculation methods and results are presented, but no details of the calculations[1].

Methods:
1. From the worldwide production of motor vehicles
2. From the price of oil
3. From the monthly production of passenger cars
4. From the German car data
5. From the Entropy Balance Equation for Open Systems[2]

Determination of an Inflation independent Oil Price

Peroleum (Crude Oil) production and the price of oil are linked. Oil prices are quoted on the stock exchange in USD/barrel. They are subject to inflation. As a result, a price from 2010 is not directly comparable to the price of 2020, you have to take inflation into account. Inflation levels fluctuate from year to year and have been particularly high since 2021. If you want to compare prices of different years, you have to assume a reference year. Use of a reference year has two disadvantages: 1. It is not standardized, each author uses his own reference year. 2. It is outdated: Who is still interested in the prices related to the year 2000?

An independent frame of reference is needed. For this purpose, the Global Domestic Product (GDP) is used. Dividing GDP by world primary energy consumption results in energy productivity. It is shown in figure 1. With the help of energy productivity, the price of a barrel of crude oil can be converted into the energy content of the barrel and given as a percentage.

The primary energy content of a barrel of oil equivalent (BOE) is 1 BOE or 1628.2 kWh. BOE is a unit of energy commonly used in the oil industry.

1 Details and Thermodynamic Calculations : Berndt Warm, „Die kurze Endphase des Ölzeitalters: Erdöl, Autoproduktion und Thermodynamik“, ISBN-13 : 978-3347487307

2 As soon as entropy and exergy come into play, the statements become incomprehensible to many readers. So far, I don't have a solution for it. I'm sorry.

The price of a barrel of petroleum, expressed in U.S. dollars, can be converted into a percentage of the barrel's energy. The conversion factor for this is energy productivity figure 1. The percentage is calculated by:

$$\%\,BOE = \frac{Price\,(USD/bbl) * 100}{EP(t) * 1628.2\,kWh}$$

with:
Price(USD/bbl) : the price of crude oil in US dollars per barrel
EP(t) : the value of energy productivity EP from figure 1 for the year under consideration.
% BOE : indicates what percentage of the energy content is paid per barrel. Another term for % BOE is "Specific energy content in percent".

Example: Let’s assume. a barrel of Brent oil has cost $60 in 2020. EP(2020) has been 0.55 USD/kWh. In %BOE we get:

$$cost\ per\ barrel = \frac{60 * 100}{0{,}55 * 1628{,}2} = 6{,}7\ \%BOE$$

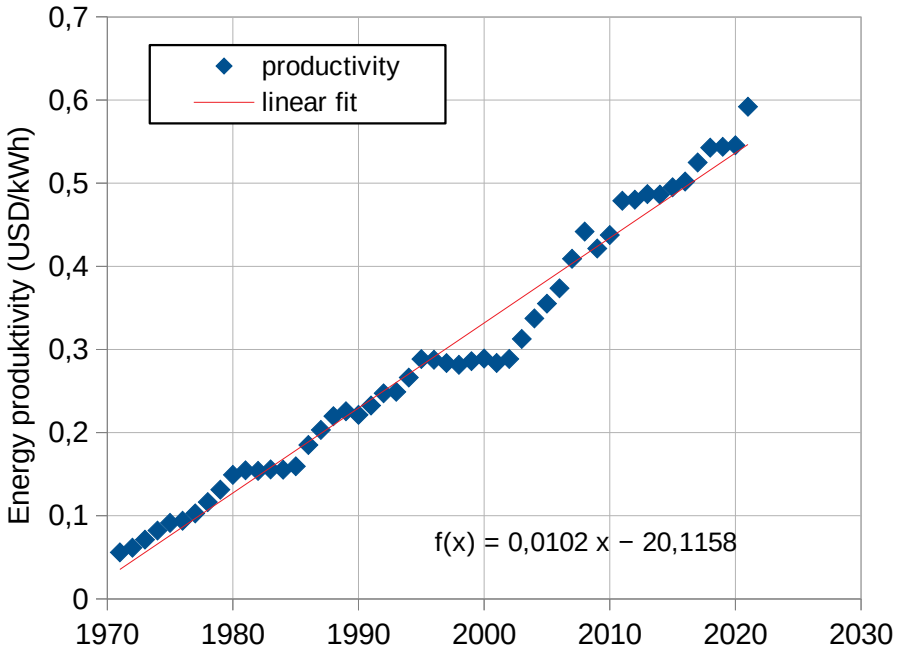

Figure 1: Energy productivity EP(t). The value EP(t) indicates how many dollars the world economy has generated per kWh of primary energy. The chart's 2020 data and before comes from the World Bank. The 2021 value is based on data from BP, Statista and other sources. For 2022, the curve is be extrapolated using the 2020 and 2021 data.

The advantage of being expressed in %BOE is that the values are not dependent on a reference year. The disadvantage is that values for EP(t) of the last two years have to be estimated and are only inaccurately known because the World Bank publishes the data with a delay.

Energy productivity makes it easy to convert money into energy. This is important, because the economy runs on energy, not money. This difference seems trivial, but is always overlooked. Crude oil is extracted with energy, not money. Money is printed by central banks, and can be produced in any quantity. Energy is finite.

1. Lifespan Determination from the worldwide Production of Motor Vehicles

This method uses the number of motor vehicles built worldwide since 1900. The number is shown graphically in figure 2. The data comes from https://de.wikipedia.org/wiki/Wirtschaftszahlen_zum_Automobil. The value for 2022 is estimated on the basis of sales figures for the first eight months of 2022.

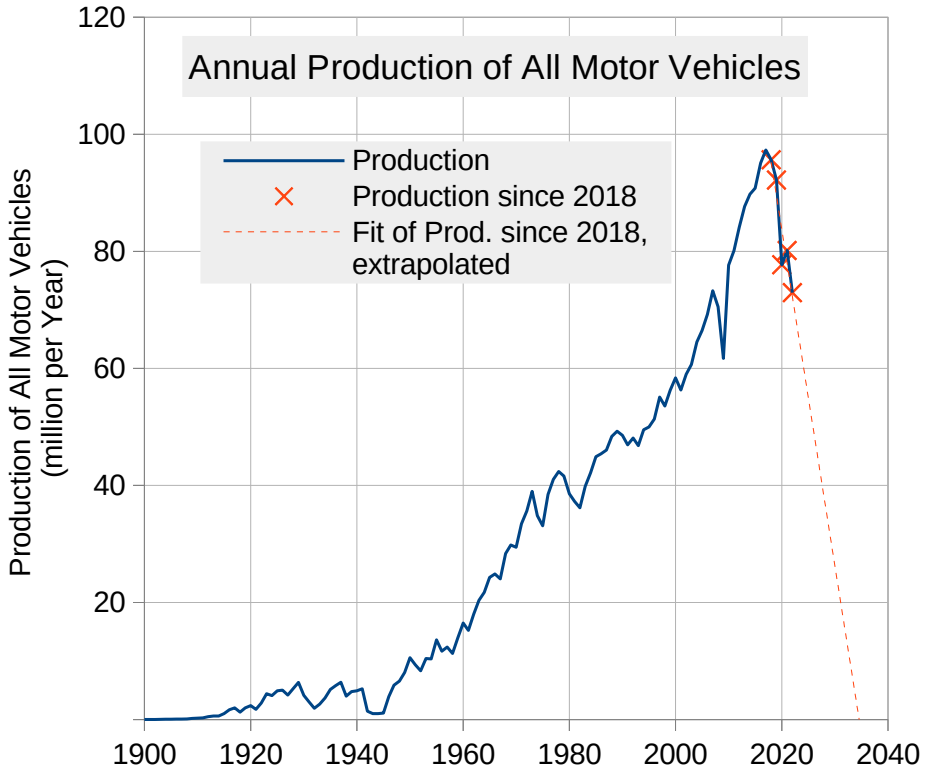

Figure 2: Worldwide annual production of motor vehicles, including cars, trucks and buses. Data from Wikipedia and OICA.

The maximum production was in 2017, since then it has been declining. A linear fit to the last five points hits the zero line around 2034. This means that if the previous trends continue, vehicle production will end in 2034.

One method for estimating the production that will still be possible in the future from previous production data is Hubbert linearization. It is used in mining to predict the expected future residual production of a mine or oil well. For this purpose, the previous summed up production is taken for the x-axis. For the y-axis, the current annual production is taken for each year, divided by the previous total production. If the last data is approximately on a straight line, its cutting axis with the x-axis is the total expected production.

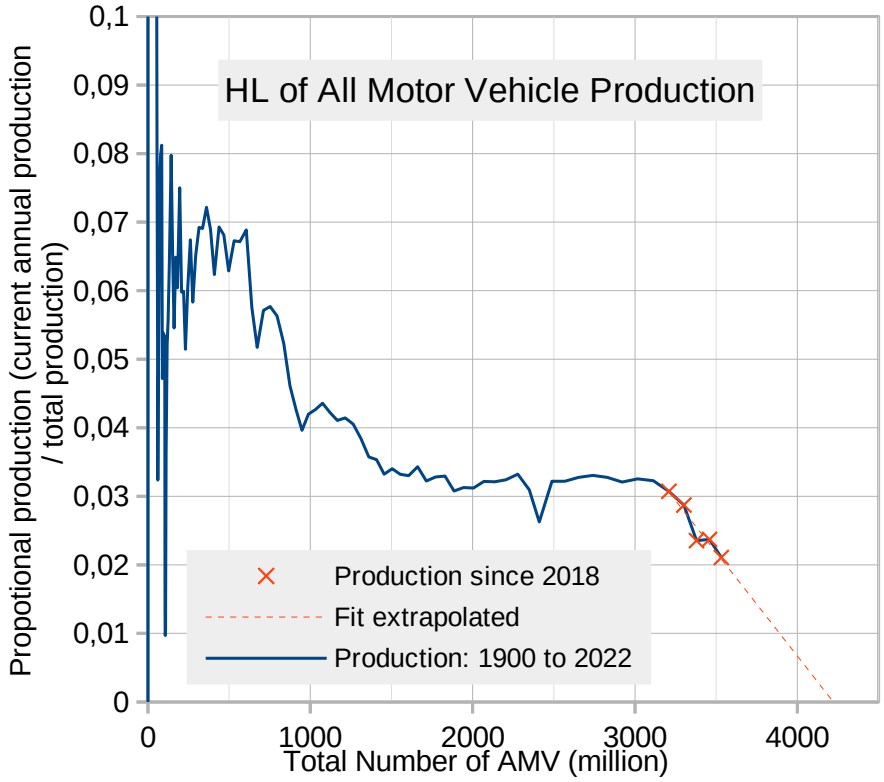

Figure 3: Hubbert Linearization of the production of all motor vehicles.

For motor vehicles, the total production to date is about 3550 million vehicles, the expected total production is about 4200 million vehicles. So about 650 million vehicles can still be built.

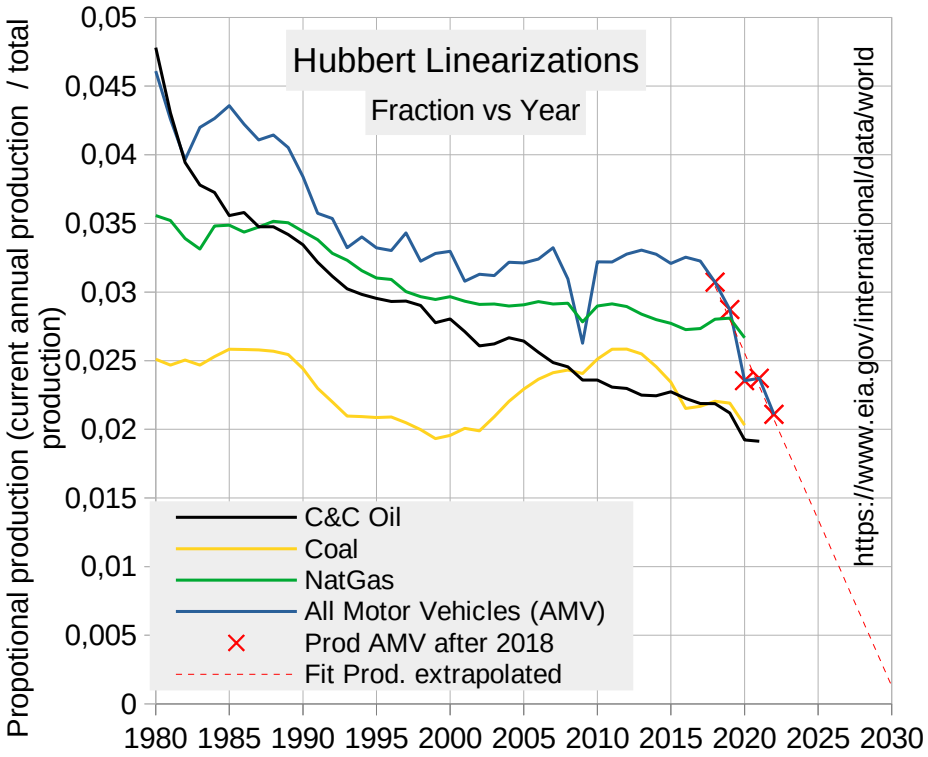

Figure 4: Hubbert linearizations for crude oil, coal, natural gas and motor vehicles. Here, the fit for motor vehicles will reach the zero line as early as 2031.

If one applies the Hubbert linearizations against time and summarizes energy raw materials and motor vehicles in a diagram for the fossils, the steep drop in production is only recognizable in the case of motor vehicles. The energy raw materials fall off much more slowly.

The most likely cause of the difference between the behavior of motor vehicles and fossil energy raw materials is: Gross is still a lot of raw materials extracted, but the net energy of the raw materials is running out. The production effort is becoming too high. The number of vehicles is determined by the net energy, not the amount of raw materials.

Result: The extrapolation of the production data of motor vehicles shows that from about 2031 to 2034 no more vehicles will be produced worldwide.

2. Lifespan Determination using the Oil Price

Figure 5: Oil price (Brent) converted into the energy content of a barrel. (Prices: https://www.finanzen.net/rohstoffe/oelpreis)

At the end of 2018, the author made the observation that the peaks of oil prices are pretty much on a straight line (dashed green line in figure 5). The straight started in 2008 and lasted until 2021, thirteen years. The straight line falls by 1.1%BOE/year.

It was not until the beginning of 2021 that the oil price came back above the straight line and has continued to rise ever since. Just as there was an upward limiting line, there was one that limited the price of oil downwards (dashed dark yellow line in figure 5). It started in early 2016 and has been on the rise ever since. Both lines crossed in mid-2020.

The author interprets the line of maxima as the oil price that the industrialized countries can afford to the maximum while maintaining their lifestyle. He interprets the line of minima as the price of oil that the producing countries need to keep their economies running. In mid-2019, the author noticed this crossroads and expected a crisis in 2020, although he was completely unclear what kind of crisis it would be. He didn't expect Corona.

The price of oil has been somewhat since 2021, well above the green line since 2022. First, OPEC raised prices because its countries' economies needed the money. Then the war in Ukraine caused a further increase. On 05.09.2022, OPEC decided to cut production because the oil price became too low for them.

The inhabitants of the industrialized countries are now realizing that their lifestyle is at risk. The line of the maxima will reach the zero line (0%BOE) around mid-2027. From then on, the inhabitants of the industrialized countries can no longer afford oil without giving up many things of daily life. The demand of the oil producers is then 13-14 %BOE. These two values are incompatible.

Result: The extrapolation of oil prices shows that from 2022 the lifestyle in the industrialized countries will degrade, and that after 2027 the inhabitants of the industrialized countries will hardly be able to pay for oil or its products.

3. Lifespan Determination from the Monthly Production of Passenger Cars

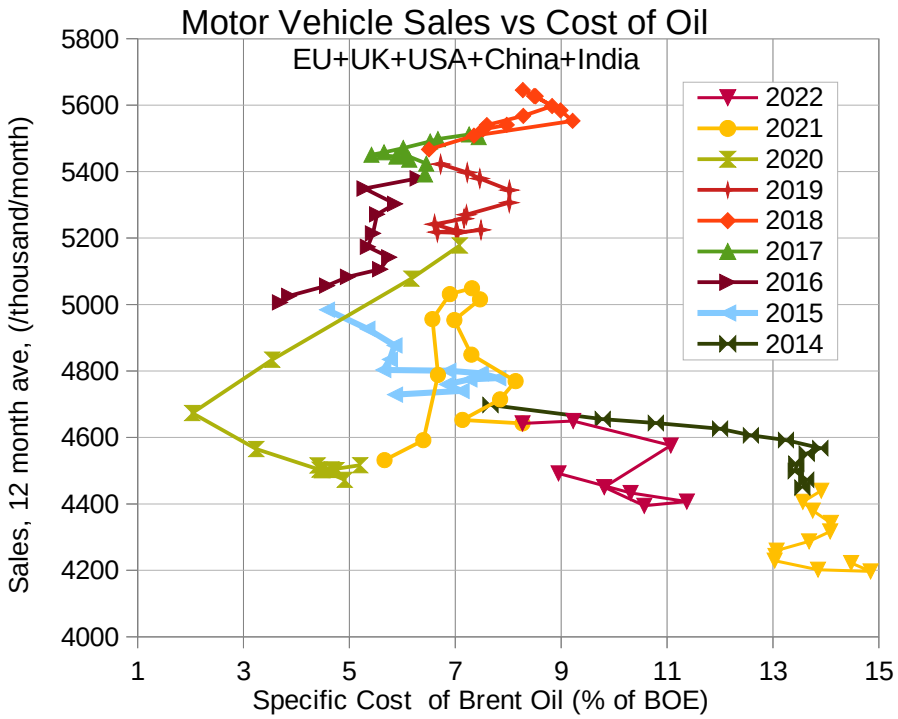

Figure 6: Monthly sales figures of cars, sum of 5 sales regions. The sales figures shown are the average values of the previous 12 months. Data from: ACEA, SMMT, FRED, CAAM, FADA, as well as CEICDATA.

Figure 6 contains several prominent areas:

- In 2013 and 2014, car sales increased at approximately 14%BOE of oil prices.
- In 2018, sales began to fall at 8-9%BOE.
- In 2021, car sales did increase at oil prices of 5%BOE to 6%BOE
- In 2021, at 7%BOE oil price sales numbers collapse and then, almost to this day, fall.

While in 2013 the relatively high price of 14 %BOE was conducive to the desire to buy, in 2021 an increase was possible at only 6 %BOE. In 8 years, the "beneficial price" decreased by 8%BOE, i.e. one percent BOE per year.

In 2018, car sales fell at 8-9%BOE, in 2021 at 7%BOE. Here, the "limiting oil price" fell by 2%BOE in 3 years, just under one point in one year.

The extrapolation of the trend means that in 2027 the "conducive price" will be 0 %BOE, i.e. hardly anyone can afford a car anymore. Electric vehicles are usually more expensive than comparable cars, so the transition to electric vehicles will not slow down this trend.

Result: The extrapolation of sales data relative to the oil price shows that in 2027 and later hardly any cars will be sold.

4. Lifespan Determination from German Car Production Data

Car production and the export of passenger cars from Germany have been declining since 2018. The 2020 corona crisis, the semiconductor supply crisis and the Ukraine war are often cited in the press as the culprits. However, since the decline began in 2018, the explanation is incomplete.

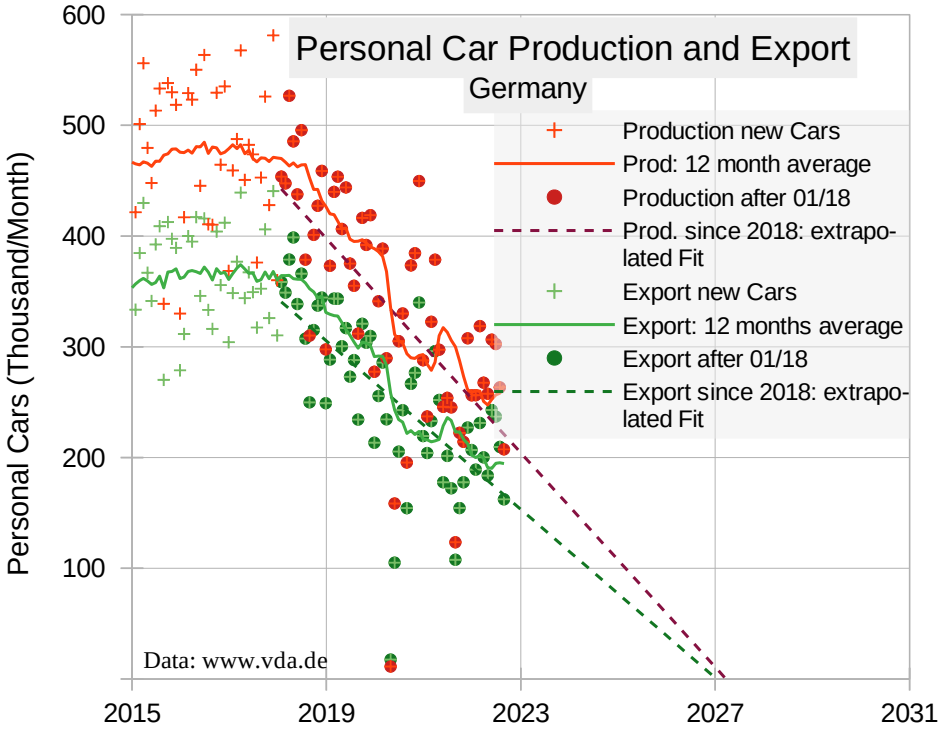

Figure 7: Monthly production and export of cars from Germany. The negative trends since 01.01.2018 are marked by own data sets.

Since the data is very scattered, it takes at least several months before upward and downward tendencies in the curve are recognizable. In figure 7, the data has been projected into the future since 2018 using linear fits. Both fits cut the straight y=0 around 2027 and say that from 2027 no more cars will be produced in Germany.

Result: The extrapolation of the German production data shows that no more cars will be produced in Germany in 2027.

5. Lifespan Determination from the Entropy Balance Rate for Open Systems

The earth's crust is usually in a temperature equilibrium near the oil fields. Oil production transports heat from the Earth's interior to the Earth's surface. The petroleum pumped upwards is replaced by water from the Earth's surface, which cools the Earth's interior.

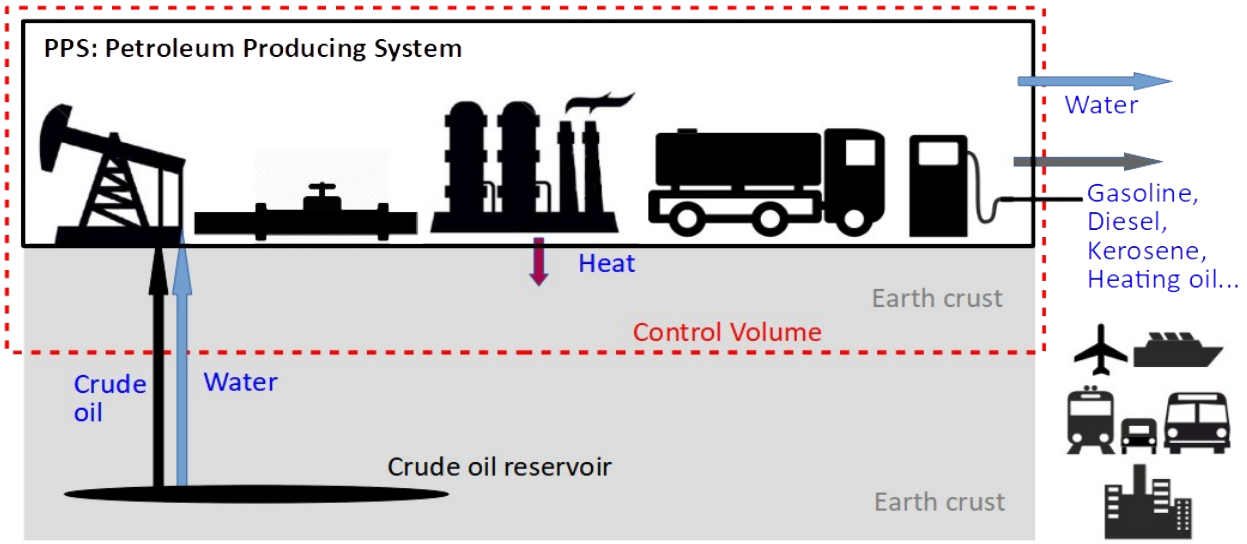

Figure 8: Sketch of the control volume for the thermodynamic calculation of oil production.

The temperature equilibrium of the earth gets disturbed. According to the Second Law of Thermodynamics, the necessary energy is to be applied by the Petroleum Producing System (PPS). The PPS not only consists of the pumping systems of the producers, but also includes refineries, transport systems, filling stations, etc. This also includes the training of the welder who manufactures pipes for oil production somewhere in the world, doctors, military personnel to secure transport routes and much more.

The calculation of the energy expenditure is carried out with the help of the "Steady State Entropy Rate Balance for Control Volumes", a mathematical formulation of the second law of thermodynamics[3] for open systems. This calculation requires the definition of a control volume, which is shown in figure 8.

10 years ago, HillsGroup[4] created the graph (figure 9) resulting from the calculation of the thermodynamically necessary exergy. Transformed into the SI system, figure 10 results. It shows exergy values and anergy values. Exergy is the mechanically usable proportion of energy. Depending on the design, engines use about 20%-60% of the total energy of a fuel and convert this 20%-60% into mechanical work. Anergy is the unusable part of the energy, and is also referred to as waste heat.

The thermodynamically necessary exergy (TNE) for oil production (=temperature equilibrium distortion) increases continuously over time. The distance of this curve to the theoretically or practically usable portion is the remaining exergy for the oil user.

3 The second law is a law of nature that is as impossible to violate as it is to fly faster than light.
4 A former advisory group for the oil industry. The HillsGroup website no longer exists. The report "Report# HC3-433 Depletion: A determination for the world's petroleum reserve" contained this graphic.

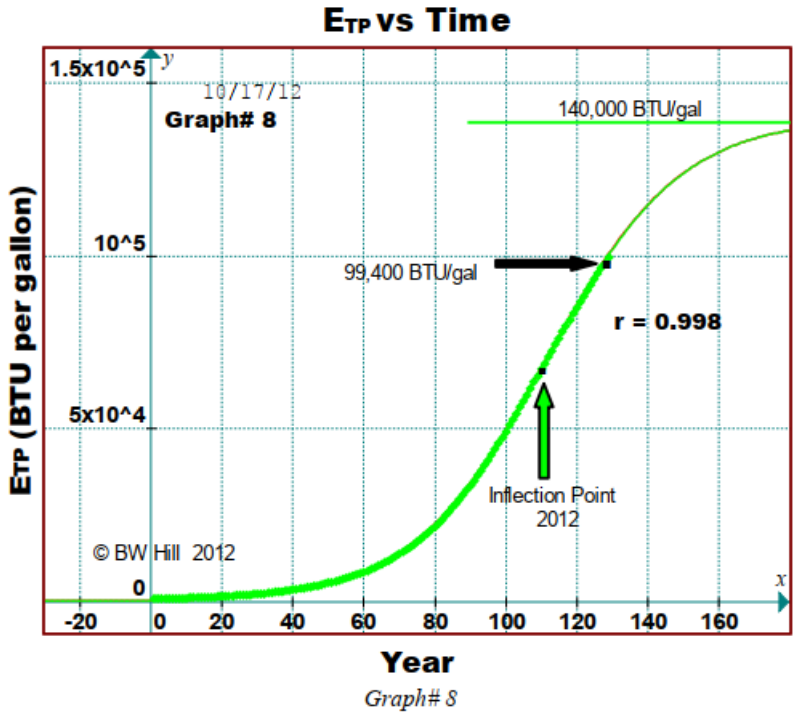

Figure 9: Exergy expenditure of oil production, thermodynamically calculated. ETP stands for Energy Total Production. The units (BTU, gallon) are from the imperial system used by oil production companies. The chart is copied from the original HillsGroup report.

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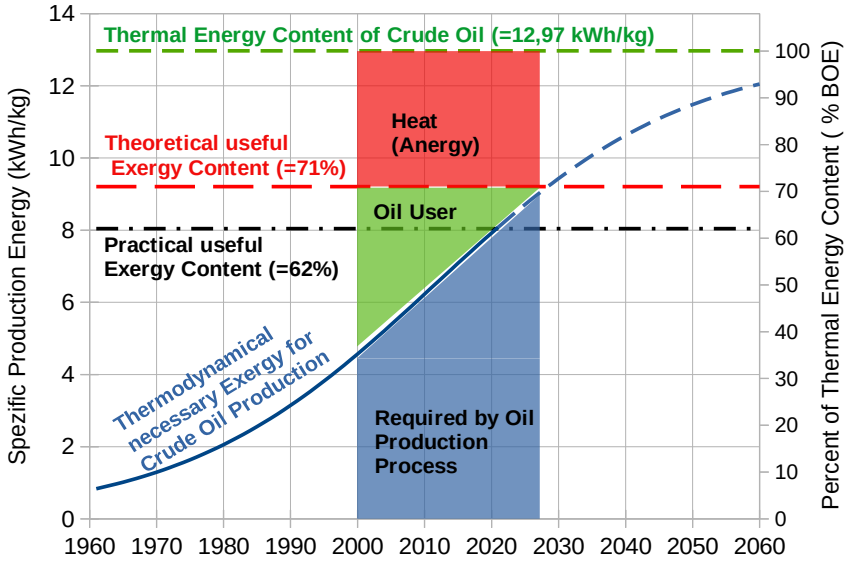

Figure 10: Graphical representation of the thermodynamically determined production experience in the SI system, including the distribution of the exergies of the barrel of crude oil to the overall process of oil production, to oil users and waste heat (anergy). The "smooth" curve was created by the fact that not the real oil production quantities were used, but a fit for these quantities.

The exergy required to change the temperature equilibrium is continuously increasing and will reach the value for the practical exergy content of crude oil in 2021, and the theoretically us-

able exergy content in 2029. The difference in exergy between 2021 and 2029 is 9%, i.e. 1.125%BOE/year.

After deduction of the exergy necessary for the promotion from the theoretical usable exergy, the exergy is obtained, which can be used technically. The green triangle indicates the exergy left for the consumer for the relevant range from 2008 to 2027.

Result: In the years 2028 – 2029, the exergy expenditure for oil production will be higher than the exergy content of crude oil[5]. Then oil production no longer makes sense in terms of energy.

Comparison of the Results of Methods 2, 3 and 5

Method 2 (figure 5): The slope of the dashed green line connecting the price maxima is -1.1 %BOE/year. The line will hit the zero line in 2027.
Method 3 (figure 6): The propensity to buy cars decreases by -1%BOE/year. According to this diagram, zero cars will be sold in 2027.
Method 5 (figure 10): The increase in production exergy is currently 1.25 %BOE/year. The theoretically usable exergy content will be achieved in 2029.

The three methods provide almost exactly the same results for the slope and the end date[6]. This accuracy is astonishing, because in method 5 there are two inaccuracies due to the principal reasons:

- Crude oil is largely extracted with other energies, e.g. from natural gas and coal.
- Real efficiencies of gasoline and diesel engines are well below the 71 percent that are theoretically achievable.

The inaccuracies should actually lead to the fact that the real figures from the economy have deviations from the calculation. However, real numbers and calculations are almost identical.

The likely explanation is that consumers pay for the oil at maximum as much money as they can generate with it themselves. And their earnings are proportional to their share of the barrel's exergy. Their share is the theoretically usable exergy minus the exergy used for the extraction (figure 11).

If the thermodynamically necessary exergy (TNE) remaining for consumers for an efficiency of 69% is entered into the oil price curve, figure 12 results. It shows a remarkable agreement of the maximum oil prices with the theoretical curve. The dashed green curve of method 2, which connects the maximum values, is almost exactly on the thermodynamically calculated one. In most cases, however, less is paid than the limit value allows.

The very good agreement between calculation from physics and economic data demonstrates the validity of the thermodynamic calculation. It also provides an explanation of why curves 1,2 and 4 have linear curves: The underlying thermodynamic calculation results in an almost linear course of the conveying energy in the relevant period.

5 The exergy necessary to change the temperature balance is only the minimum of exergy required.
6 And not only that, the 4 methods 1, 2, 4 and 5 show roughly linear progressions.

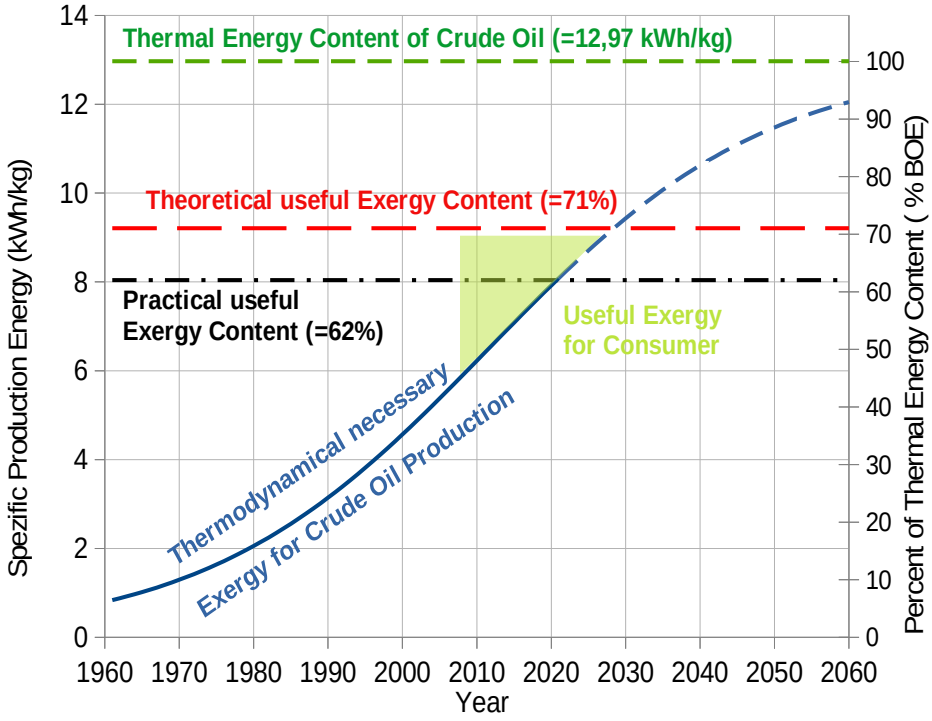

Figure 11: The light green triangle emphasizes the period 2008-2027. It represents the exergy that can be used by the consumer.

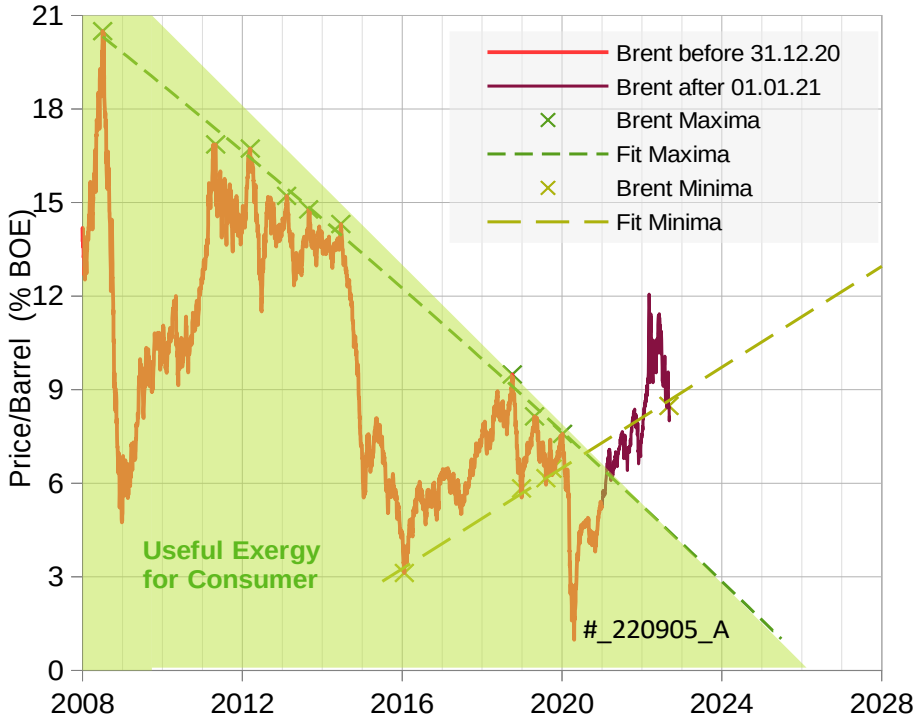

Figure 12: Real oil price Brent with maxima, as well as from the calculated thermodynamically necessary exergy (TNE) for 69 % efficiency for the oil user remaining remnants of exergy. All values in % BOE.

The fall in the price of crude oil from 2008 to 2020 with the extreme price increase since 2021 is an absolute alarm signal! Soon there will be no more crude oil affordable, no matter for which economy in the world!

Prediction of Future Oil Production

Based on the past car sales numbers and the five methods, it is possible to make a prediction for the future C&C oil production. It is to be expected, that the crude oil production will decrease slowly until 2027, because people spent their money on oil products to continue the life style they are used to. They only forgo to buy new cars. After 2027, they will be forced to forgo oil products which get too expensive. Oil production will decrease then very fast.

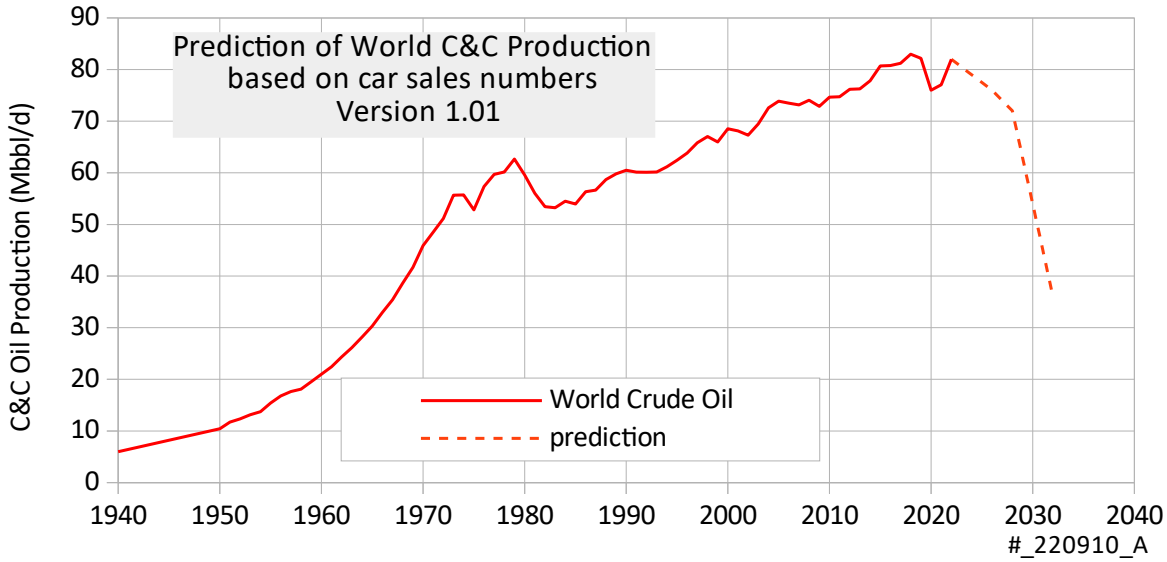

Figure 13: Prediction for Oil Production

Summary

Procedures 1, 2 and 4 are extrapolations of economic data of the past. Method 3 is a link between oil prices and car production. Method 5 is a calculation based on a law of physics.

The five calculation methods result in:
1. End of world motor vehicle production between 2031 and 2034.
2. End of oil production in 2027.
3. End of worldwide sales of motor vehicles in 2027.
4. End of German vehicle production in 2027.
5. End of oil production in 2029.

The results are not the same, but in the end the same thing comes out. All five procedures show that vehicle production and oil production will continue to collapse in the coming years. Vehicle production will disappear first. Oil production later, as the world's existing fleet will continue to consume crude oil, even if no new vehicles are added. It is to be expected, that the crude oil production will decrease slowly until 2027, and after that very fast.

And: Oil will be extremely expensive by 2027 at the latest!