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How human catabolism processes relate to the combustion of liquid fuels regarding oxygen consumption and carbon dioxide emissions in Hungary

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Abstract— In connection with road vehicles and their internal combustion engines, their effects on our environment are being dealt with more and more. Plenty of parameters could be listed, but human catabolism and combustion of liquid fuels probably have not been examined together. Carbon dioxide has the most priority as a greenhouse gas in environmental change and metrology, thus it is a constant topic. Oxygen consumption has been examined rarely or never in such a context. In this article, calculations have been carried out from different points of view regarding these two parameters. The results of total-quantity calculations show, that the oxygen demand for the combustion of fuels used for road transport in 2019 in Hungary is the same as the 6-year oxygen demand of the Hungarian population, and the amount of the carbon dioxide emitted by the combustion of fuel used in road transport in Hungary is the same as the amount emitted by the Hungarian population during 5.2 years. The results might be worth examining on a larger scale.

Key-words: oxygen consumption, carbon dioxide emission, human population, transport emission, catabolism, environmental change

1. Introduction

Metabolism is a medical, biochemical term refers to the flow of matter, energy, and information in living organisms. One of the basic processes of metabolism is called catabolism. During catabolism, more complex materials, i.e., food which can be treated as hydrocarbon fuels for humans are broken down into simpler materials, releasing energy. This catabolic energy is converted into work in cells and reserve energy, and some of it is released as thermal energy. The main function of catabolism is to convert high-energy compounds into low-energy oxidized compounds. O_2 (oxygen) is needed to perform this process and CO_2 (carbon dioxide) is generated meanwhile (*Hawkins* and *Mans*, 1983). Oxygen enters the bloodstream through the lungs, and carbon dioxide escapes from the human body through the lungs as well (*Askanazi et al.,* 1980).

In internal combustion engines and fuel cells, metabolic processes are analogous to that of respiratory metabolism in a human body. Hydrocarbons are introduced into the engine in liquid or gaseous form. The oxygen required for oxidation comes from the ambient air. Oxidation of hydrocarbons releases heat that is utilized by the engine. In the case of theoretical and perfect combustion, CO_2 and H_2O (water) are formed. In reality, combustion is never perfect, but the volume ratio of pollutants generated is very small compared to CO_2 (*Heywood,* 1988).

There are rankings for what the number one problem is in the world today that will affect us in the next years, but scientists do not have the answer. It is also certain that everything is connected to everything. Climate change, ozone hole, pollution of waters, grounds, and pathogenic mutations that we are currently suffering from. Many attribute the reason for these to human intervention, among other the overpopulation and the human activity upsetting the environmental balance (*Businessinseider*, 2011; *Gallup International*, 2020; *Ipsos*, 2020).

Anthropogenic is an adjective that refers to an effect that depends on a person or human activity, or an effect caused by a person or human activity (*Fuge*, 2013). Nowadays, first and foremost, impact is nothing more than pollution. Let us go along this line, because the motor vehicle, as such, in its full reality, is a human creation from the conception of a man-made source of pollution, through its life, to the complete cessation of being a car. We can already see that financially the most expensive consequence for mitigating climate change can be found in automotive technology, and therefore, this sector is forced to work hard.

The anthropogenic ratio in emissions of combustion exhaust is 14–15%, from which 7–8% is due to the combined effect of water vapor + gases (e.g., CO_2, CH_4 (methane)). How can it affect the atmospheric warming / cooling to such an extent to guide the fight against carbon dioxide as a primary / most important aspect of energy supply, energy strategy? Global population growth of nearly fifty percent over the next thirsty years, which means, humanity of nine billion people is expected in 2050, to cause an order of magnitude greater change in the hydrological cycle and in water management as climate change is expected over the same thirsty years (*Kovács* and *Tompa*, 2012).

"It could easily be that we have reached a stage where facts, reason and truth are already helpless against propaganda." The greenhouse effect, rioting with the danger of global warming, the purpose of the forcible spread of so-called renewable energies is no different from the aspiration of the (research, business) lobbies interested in the issue to tap the central (state) budget (*Jacobsen*, 2011).

If the combustion of hydrocarbon-fuelled internal combustion engines were perfect and N_2 (nitrogen) was not oxidized, or hydrocarbons did not form particles, there would not be pollutants in the exhaust gas. However, there are some reasons in connection with combustion of any kinds of hydrocarbons, but especially with internal combustion engine why we may be in trouble (not to mention other pollutants such as NO_x and particulate matter):

– it removes a lot of oxygen from the air from the living being, and
– it emits carbon dioxide and water (water vapor) causing climate change (although this has not yet been fully proven).

The aim of this study is dual. Our first aim is to perform a triple comparative analysis by calculation, regarding vehicles with Otto-engine powered by gasoline, Diesel-engine with diesel, and fuel cell vehicles with fuel of hydrogen, where the investigated parameters are the oxygen consumption and the emission of CO_2. On the other hand, total-quantities have been calculated and compared as far as the fuels' combustion and human function regarding oxygen and carbon dioxide are concerned. This second aim is regarding only Hungary and its transport sector. Hopefully, it can make the readership curious to see how some of the rarely discussed metabolic processes evolve in the processes in terms of exact figures.

2. Calculation methodology and chosen propulsions

2.1. Theoretical combustion processes

Theoretical combustion calculations are being carried out to quantify how many O_2 needed for and CO_2 produced during the processes. For different fuel compositions, these parameters vary. The three investigated kind of fuels are gasoline, diesel, and hydrogen.

2.2. Development of parameters during a type approval test cycle of passenger cars

For a triple comparison, three different propulsions have been chosen. The first subject is a Toyota-branded Yaris vehicle powered by an Otto-engine with a rated power output of 51 kW (*Kraftfahrt Bundesamt*, 2020). The second is a hydrogen-fueled fuel cell of Toyota Mirai. The drive has a rated power of 55 kW (*Kraftfahrt*

Bundesamt, 2020). A diesel-powered Hyundai i20 in the same performance category would be the third one. It has a rated power of 55 kW (*Kraftfahrt Bundesamt*, 2020). Each of these cars has a fuel consumption value which is determined with the help of the standardized WLTC (worldwide harmonized light duty test cycle) cycle in every case. The make of the selected vehicles has no role in this study. An important consideration in the selection of vehicles was that the rated propulsion power should be similar to each other as much as it can be. The other important aspect was that the values of fuel consumption should be the result of testing vehicles for the same purpose. This was fulfilled, because the results come from the same cycle, which is WLTC, that is a part of the emission type approval process prescribed in the regulations used mainly in Europe or in the countries of the United Nations (*Official Journal of the European Union*, 2018; *UNECE*, 2021). The results available with each powertrain will be compared regarding the two investigated gaseous parameters.

2.3. Calculation method of total quantities

To compare the amounts of oxygen needed to burn fuels with humans' oxygen demand, the following calculation method has been used. Calculations have been conducted for the year 2019. As for the oxygen:

- To quantify the total oxygen demand for combusting the fuels used in the road transportation sector, theoretically two parameters are needed. The first one is the quantity of consumed fuels in Hungary in 2019 (*MÁSZ*, 2020), and the second one is the later calculated O_2 factors separately for each fuel (Eqs.(8),(15),(21)). Simple multiplication of these parameters would be the calculation method to get the result.
- For the calculation of humans' O_2 consumption, more parameters are needed. Firstly, the amount of oxygen consumed by a person in room conditions in one day is needed (*ELTE*, 2020). The standard density of the oxygen (at 1 bar, 15 °C) is also necessary (*Messer Hungarogáz Kft*., 2021a), with which the daily oxygen consumption can be determined on a mass base. A value is generated with a measurement unit of g O_2 / (person*day). If it is multiplied by the number of people in the population of Hungary in 2019 (*KSH*, 2020), we will get the oxygen consumption of the population per day. To get the consumption per year, it will be multiplied by the number of days in a year.

As for the carbon dioxide:

- The total carbon dioxide emission produced by combusting the fuels used in the road transportation sector can be calculated theoretically with the help of two parameters. The first one is the quantity of consumed fuels in Hungary (*MÁSZ*, 2020), and the second one would be the later calculated CO_2 factors, separately for each fuel (Eqs.(9),(16)). Simple multiplication of these parameters would be the calculation method.

– Similarly to the oxygen, the carbon dioxide emission of a population can be determined in a simplified way as follows: the CO_2 emission value under room conditions for a person daily would be the first parameter (*ELTE*, 2020). Using a standard density of the CO_2 (at 1 bar, 15 °C) (*Messer Hungarogáz Kft.*, 2021b), the emission result can be got on a mass base with a measurement unit g CO_2/(person*day). It will be multiplied by the number of people in the population (*KSH*, 2020), and the total CO_2 emission value is obtained for a day which will be multiplied by the number of days in a year.

The calculations have been made with simplification, and its method has been greatly simplified. But the aim was not to give exact numerical values, only to show the magnitudes and to draw attention.

3. Calculations

3.1. Otto-engine vehicle with gasoline

Liquid fuels used in vehicles of road transportations are built up of hydrocarbons. The theoretical oxidation process of these hydrocarbons can be described as follows (*Hartmann* and *Braun*, 1973):

$$C_nH_m + \left(n + \frac{m}{4}\right) O_2 \rightarrow nCO_2 + \frac{m}{2} H_2O + Q\,, \qquad (1)$$

where Q is heat (not relevant here).

That is, combustion of a hydrocarbon containing a given amount of carbon and hydrogen requires a certain amount of oxygen. The oxidation process also generates a certain amount of carbon dioxide, water, and heat. According to *Mollenhauer* and *Tschoke* (2010), commercially available gasoline consists of -2–300 kinds of hydrocarbons. It has to be simplified, thus octane is used for our calculations as a surrogate for real gasoline (*Heywood*, 1988). With the help of Eq.(1) the octane's oxidations process is the following:

$$C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O\,. \qquad (2)$$

As Eq.(2) is based on a unit of amount of substance (mol, kmol), a transition of the equation is needed to get a mass base equation. Molecular weights of chemical elements are used like C=12 kg/kmol, H = 1 kg/kmol, O =16 kg/kmol for the conversation (*Hartmann* and *Braun*, 1973). The mass based chemical equation develops:

$$8\ \text{kmol} * 12\frac{\text{kg}}{\text{kmol}}\ (\text{C}) + 18\ \text{kmol} * 1\frac{\text{kg}}{\text{kmol}}\ (\text{H}) + 12.5\ \text{kmol} * 32\frac{\text{kg}}{\text{kmol}}\ (\text{O}_2) \rightarrow$$

$$\rightarrow 8\ \text{kmol} * \left(12\frac{\text{kg}}{\text{kmol}} + 32\frac{\text{kg}}{\text{kmol}}\right)(\text{CO}_2) + 9\ \text{kmol} * \left(2\frac{\text{kg}}{\text{kmol}} + 16\frac{\text{kg}}{\text{kmol}}\right)(\text{H}_2\text{O})\,. \quad (3)$$

After multiplying and merging Eq.(3), Eq.(4) arises:

$$114\ \text{kg}\ (\text{C}_8\text{H}_{18}) + 400\ \text{kg}\ (\text{O}_2) \rightarrow 352\ \text{kg}\ (\text{CO}_2) + 162\ \text{kg}\ (\text{H}_2\text{O}). \quad (4)$$

Two specific factors per unit mass of fuel can already be determined, from which the first would be the oxygen consumption. For combusting one unit of mass of octane, 3.51 kg of O_2 is needed:

$$\frac{400\ \text{kg}\ (\text{O}_2)}{114\ \text{kg}\ (\text{C}_8\text{H}_{18})} = \mathbf{3.51}\,\frac{\mathbf{kg\ (O_2)}}{\mathbf{kg\ (C_8H_{18})}}\,. \quad (5)$$

To determine the second parameter, which is the mass related CO_2 emission, Eq.(4) is used as well. The result in terms of per unit mass of fuel is the following:

$$\frac{352\ \text{kg}\ (\text{CO}_2)}{114\ \text{kg}\ (\text{C}_8\text{H}_{18})} = \mathbf{3.09}\ \frac{\mathbf{kg\ (CO_2)}}{\mathbf{kg\ (C_8H_{18})}}\,. \quad (6)$$

The specific fuel consumption related to distance traveled of the Otto-engine vehicle measured during a WLTC cycle is $B_{gasoline}$ (volume) = 5.4 liters gasoline/100km (*Kraftfahrt Bundesamt*, 2020). That should be converted to a value containing fuel mass related to distance. To do so, an average density of the gasoline is needed, which is $\rho = 0.75$ kg/liter (*European Committee for Standardization*, 2008). We get the next equation:

$$B_{\text{gasoline}}(\text{mass}) = 5.4\frac{\text{liters}}{100\text{km}} * 0.75\frac{\text{kg}}{\text{liter}} = 4.05\frac{\text{kg}}{100\text{km}}. \quad (7)$$

Hereinafter the distance-related (100 km) O_2 consumption and CO_2 emission can be calculated for the Otto-engine vehicle:

$$4.05\frac{\text{kg (gasoline)}}{100\text{km}} * 3.51\frac{\text{kg}\ (\text{O}_2)}{\text{kg}\ (\text{C}_8\text{H}_{18})} = \mathbf{14.18}\frac{\mathbf{kg\ (O_2)}}{\mathbf{100km}}, \quad (8)$$

$$4.05\,\frac{\text{kg (gasoline)}}{100\text{km}} * 3.09\,\frac{\text{kg }(CO_2)}{\text{kg }(C_8H_{18})} = \mathbf{12.51}\,\frac{\mathbf{kg\ (CO_2)}}{\mathbf{100km}}\,. \tag{9}$$

3.2. Diesel-engine vehicle with diesel

According to the scientific literature (*Mollenhauer* and *Tschoke*, 2010), diesel consists of several more types of different hydrocarbons than it is in the case of gasoline. For theoretical calculation it must be simplified, which means a surrogate has to be chosen. This surrogate will be the cetane (hexadecane) (*Heywood,* 1988). Based on Eq.(1), the theoretical oxidation process of hexadecane is the following:

$$C_{16}H_{34} + 24.5O_2 \rightarrow 16\ CO_2 + 17\ H_2O\ . \tag{10}$$

After converting Eq.(10) to a mass base equation, which is followed by multiplying and merging, Eq.(11) arises:

$$226\text{ kg }(C_{16}H_{34}) + 784\text{ kg }(O_2) \rightarrow 704\text{ kg }(CO_2) + 306\text{ kg }(H_2O)\ . \tag{11}$$

Two specific factors per unit mass of fuel can already be determined, from which the first would be the oxygen consumption. For combusting one unit of mass of cetane, 3.12 kg of O_2 is needed as indicated in the following equation:

$$\frac{704\text{ kg }(O_2)}{226\text{ kg }(C_{16}H_{34})} = \mathbf{3.12}\,\frac{\mathbf{kg\ (O_2)}}{\mathbf{kg\ (C_{16}H_{34})}}\,. \tag{12}$$

To determine the CO_2 emission, Eq.(11) can be used as well. The result in terms of per unit mass of cetane is the following:

$$\frac{704\text{ kg }(CO_2)}{226\text{ kg }(C_{16}H_{34})} = \mathbf{3.16}\,\frac{\mathbf{kg\ (CO_2)}}{\mathbf{kg\ (C_{16}H_{34})}}. \tag{13}$$

The chosen Diesel-engine vehicle has a distance-related fuel consumption value which is B_{diesel} (volume) = 5.2 liters diesel/100 km (*Kraftfahrt Bundesamt*, 2020). With the help of an average density value of 0.85 kg/liter of diesel (*European Committee for Standardization*, 2005), fuel mass consumed can be calculated:

B_{diesel} (mass) = 5.2 liters/100km * 0.85 kg/liter = 4.42 kg/100km . (14)

Using Eqs. (12),(13), and (14), the distance-related oxygen consumption and the carbon dioxide emission can be quantified. These are shown in the following equations:

$$4.42 \frac{\text{kg (diesel)}}{100\text{km}} * 3.12 \frac{\text{kg } (O_2)}{\text{kg } (C_{16}H_{34})} = \mathbf{13.79} \frac{\mathbf{kg\ (O_2)}}{\mathbf{100km}}, \tag{15}$$

$$4.42 \frac{\text{kg (diesel)}}{100\text{km}} * 3.16 \frac{\text{kg } (CO_2)}{\text{kg } (C_{16}H_{34})} = \mathbf{13.97} \frac{\mathbf{kg\ (CO_2)}}{\mathbf{100km}}. \tag{16}$$

3.3. Hydrogen fuel-cell vehicle

In the fuel cell, which generates electricity using hydrogen, the following chemical process takes place (*Eichlseder* and *Klell,* 2010):

$$H_2 + ½\ O_2 \rightarrow H_2O + Q, \tag{17}$$

that is, hydrogen is oxidized by oxygen from the air to form water. In this case, heat, indiced by Q, is also generated, but in our case, it is not relevant now. Using the molecular weights, we bring the equation on a mass basis:

$$2\text{kmol} * 1 \frac{\text{kg}}{\text{kmol}} \text{ (H)} + \frac{1}{2}\text{kmol} * 2 * 16 \frac{\text{kg}}{\text{kmol}} \text{ (O)} \rightarrow 1\text{kmol} * \left(2 \frac{\text{kg}}{\text{kmol}} + 16 \frac{\text{kg}}{\text{kmol}}\right) (H_2O). \tag{18}$$

By multiplying in Eq.(18), it will be:

$$2 \text{ kg } (H_2) + 16 \text{ kg } (O_2) \rightarrow 18 \text{ kg } (H_2O). \tag{19}$$

Two specific factors per unit mass of fuel can already be determined. The result is shown in the following equation for e O_2, while CO_2 emission does not appear:

$$\frac{16 \text{ kg } (O_2)}{2 \text{ kg } (H_2)} = \mathbf{8} \frac{\mathbf{kg\ (O_2)}}{\mathbf{kg\ (H_2)}}. \tag{20}$$

Calculation of distance-related O_2 consumption of a hydrogen fuel-cell vehicle happens as follows. Firstly, fuel consumption is needed. It was determined in this case as well during a WLTC driving cycle: $B_{hydrogen}$ (mass)=0.8 kg hydrogen/100 km (*Kraftfahrt Bundesamt*, 2020). Using the above formula, we can calculate the specific oxygen consumption for the distance traveled (100 km):

$$0.8\frac{\text{kg}\,(\text{H}_2)}{100\text{km}} * 8\frac{\text{kg}\,(\text{O}_2)}{\text{kg}\,(\text{H}_2)} = \mathbf{6.40}\,\frac{\mathbf{kg}\,(\mathbf{O_2})}{\mathbf{100km}}\,. \tag{21}$$

3.4. Calculation of human properties and characteristic of fuel combustion – total quantities

Calculations have been conducted with the help of the method described in Subsection 2.3. The amount of oxygen consumed by combusting fuels is

$$\text{m}_{\text{O}_2\text{ consumed (gasoline)}} = \text{m}_{\text{gasoline consumed}} \times \text{O}_2\text{ factor}_{\text{gasoline}} =$$
$$= 1\,114\,907\,107\text{ kg} \times 3.51\,\frac{\text{kg}\,(\text{O}_2)}{\text{kg gasoline}} = 3\,902\,174\,874\text{ kg}\,, \tag{22}$$

$$\text{m}_{\text{O}_2\text{ consumed (diesel)}} = \text{m}_{\text{diesel consumed}} \times \text{O}_2\text{ factor}_{\text{diesel}} =$$
$$= 2\,068\,402\,409\text{ kg} \times 3.12\,\frac{\text{kg}\,(\text{O}_2)}{\text{kg diesel}} = 6\,412\,047\,468\text{ kg}\,, \tag{23}$$

$$\text{m}_{\text{O}_2\text{ consumed (total)}} = \text{m}_{\text{O}_2\text{ consumed (gasoline)}} + \text{m}_{\text{O}_2\text{ consumed (diesel)}} =$$
$$= 3\,902\,174\,874\text{ kg} + 6\,412\,047\,468\text{ kg} = 10\,314\,222\,342\text{ kg}\,. \tag{24}$$

Oxygen consumed by population:

$$\text{m}_{\text{O}_2\text{ consumed (population)}} = \text{V}_{\frac{\text{O}_2\text{ consumed}}{\text{person}\times\text{day}}} \times \rho_{\text{O}_2\text{ standard}} \times \text{population} \times \text{days} =$$
$$= 360\text{ dm}^3 \times 1.337\,\frac{\text{g}}{\text{dm}^3} \times 9\,778\,371 \times 365 = 1\,717\,881\,818\text{ kg}\,. \tag{25}$$

O_2 consumption values are shown in *Table 2.* and will be discussed in the next section. The amount of carbon dioxide emitted by fuel combustion is

$$\text{m}_{\text{CO}_2\text{ emitted (gasoline)}} = \text{m}_{\text{gasoline consumed}} \times \text{CO}_2\text{ factor}_{\text{gasoline}} =$$
$$= 1\,114\,907\,107\text{ kg} \times 3.09\,\frac{\text{kg}\,(\text{CO}_2)}{\text{kg gasoline}} = 3\,456\,212\,031\text{ kg}\,, \tag{26}$$

$$m_{CO_2\ \text{emitted (diesel)}} = m_{\text{diesel consumed}} \times CO_2\ \text{factor}_{\text{diesel}} =$$

$$= 2\ 068\ 402\ 409\ \text{kg} \times 3.16\ \frac{\text{kg }(CO_2)}{\text{kg diesel}} = 6\ 412\ 047\ 468\ \text{kg}\ , \qquad (27)$$

$$m_{CO_2\ \text{emitted (total)}} = m_{CO_2\ \text{emitted (gasoline)}} + m_{CO_2\ \text{emitted (diesel)}} =$$

$$= 3\ 456\ 212\ 031\ \text{kg} + 6\ 412\ 047\ 468\ \text{kg} = 9\ 868\ 259\ 499\ \text{kg}\ . \qquad (28)$$

The amount of carbon dioxide emitted by population is

$$m_{CO_2\ \text{emitted (population)}} = V_{\frac{CO_2\ \text{emitted}}{\text{person} \times \text{day}}} \times \rho_{CO_2\ \text{standard}} \times \text{population} \times \text{days}$$

$$= 288\ \text{dm}^3 \times 1.8474\ \frac{\text{g}}{\text{dm}^3} \times 9\ 778\ 371 \times 365 = 1\ 898\ 946\ 819\ \text{kg}\ . \qquad (29)$$

CO_2 emission values are shown in *Table 3* and will be discussed in the next section.

4. Results and discussion

4.1. Comparison of propulsions

The results of comparison of propulsions are shown in *Table 1.* This table consists of three table-sections. The top table-section summarizes the results regarding the oxidation of different fuels. The smaller the molecule which is oxidized, the more oxygen needed for the oxidation. Accordingly, the oxidation of hydrogen needs the most amount of oxygen, it is followed by the oxidation of gasoline, and the least is for diesel. As for the CO_2 formation, it is not produced during the combustion of hydrogen, because there is no carbon in the molecule. Octane which has carbon in its molecule formats CO_2 during oxidation, but this amount is less than in case of diesel, which has the most carbon in molecule.

In the middle table-section, the table deals with results realized during a WLTC cycle. Values of oxygen consumption show another tendency among fuels compared to the results of simple oxidation. This is because of the different energy content of fuels and the different efficiency of the propulsion calculated from heat power of fuel to the power of vehicle's wheel. The hydrogen fuel-cell vehicle has the lowest O_2 consumption, and the highest one belongs to the Otto-engine vehicle. In case of a Diesel-engine vehicle it is a bit lower compared to the vehicle using gasoline during a WLTC cycle. CO_2 emission is proportional to the carbon content of the fuel. Fuel-cell vehicle has zero emission. Diesel-engine vehicle has the highest CO_2 emission, while that is a bit lower for the Otto-engine vehicle compared to the diesel.

The lowest section of the table represents the results derived from the middle section's WLTC results. This sums up what has been said so far. There is a slight difference between Otto and Diesel. Oxygen consumption of fuel-cell vehicle is the half of those the two other propulsion conception. As far as the CO_2 emission is concerned it is not produced from the process of the fuel cell while diesel's value is slightly higher than that of the Otto-engine vehicle.

Table 1. Results of propulsions' comparison

O_2 consumption and CO_2 emission	Specific oxygen consumption $[\frac{\text{kg (CO}_2)}{\text{kg (C}_n\text{H}_m \text{ or H}_2)}]$	Specific carbon dioxide emission $[\frac{\text{kg (CO}_2)}{\text{kg (C}_n\text{H}_m \text{ or H}_2)}]$
Oxidation of octane	3.51	3.09
Oxidation of hexadecane	3.12	3.16
Oxidation of hydrogen	8	0
O_2 consumption and CO_2 emission	Specific oxygen consumption during a WLTC cycle $[\frac{\text{kg (O}_2)}{\text{100 km}}]$	Specific carbon dioxide emission during a WLTC cycle $[\frac{\text{kg (CO}_2)}{\text{100 km}}]$
Otto-engine vehicle	14.18	12.51
Diesel- engine vehicle	13.79	13.97
Hydrogen fuel-cell vehicle	6.40	0
Comparison of propulsions	Specific oxygen consumption during a WLTC cycle $[\frac{\text{kg (O}_2)}{\text{100 km}}]$	Specific carbon dioxide emission during a WLTC cycle $[\frac{\text{kg (CO}_2)}{\text{100 km}}]$
Otto-engine vehicle / Diesel-engine vehicle	1.03	0.91
Otto-engine vehicle / Hydrogen fuel-cell vehicle	2.22	NA
Diesel-engine vehicle / Hydrogen fuel-cell vehicle	2.15	NA

4.2. *The relationship between human properties and characteristics of fuel combustion – total quantities*

The results of the comparison with the humans' parameters are shown in *Tables 2* and *3*. Here, too, we would like to emphasize that the calculations have been made with a high degree of simplification, and its method has been greatly simplified. The aim was not to give exact numerical values, but only to show the magnitudes and to draw attention. The oxygen consumption of the combustion of fuels used in the road transportation in Hungary during a year was as much as the amount of oxygen used by the number of people meeting the Hungarian population for 6 years. In the same way, the number of people meeting the Hungarian population for 5.2 years realizes as much CO_2 emission as it is produced by combustion fuels in the road transport in Hungary for a year.

Table 2. O_2 quantities consumed by fuels and population

Fuel	**Fuel amount used [kg/year (2019)]**	**Amount of O_2 consumed by fuel [kg / year (2019)]**
Gasoline	1 114 907 107	3 902 174 874
Diesel	2 068 402 409	6 412 047 468
Total O_2 consumed by fuel		10 314 222 342
Amount of O_2 consumed by population [kg/year (2019)]		1 717 881 818
$\frac{\mathbf{O_2\ consumed\ by\ fuel}}{\mathbf{O_2\ consumed\ by\ population}}$ **[year]**		**6.00**

Table 3. CO_2 quantities emitted by combustion of fuels and population

Fuel	**Fuel amount used [kg / year (2019)]**	**CO_2 emitted by fuel combustion [kg / year (2019)]**
Gasoline	1 114 907 107	3 456 212 031
Diesel	2 068 402 409	6 412 047 468
Total CO_2 emitted by fuel combustion		9 868 259 499
CO_2 emitted by population [kg / year (2019)]		1 898 946 819
$\frac{\mathbf{CO_2\ emitted\ by\ fuel\ combustion}}{\mathbf{CO_2\ emitted\ by\ population}}$ **[year]**		**5.20**

5. Conclusions

In this article, different calculations have been conducted for two very important but together very rarely investigated gas phase components: O_2 and CO_2. First, different propulsions of vehicles were calculated and compared. In order to find the link between the human properties and the properties of the combustion of transportation's fuels regarding the two basic parameters (oxygen consumption and carbon dioxide emission), a second set of calculations were made. The following conclusions can be drawn:

- Comparisons between the propulsion systems during a WLTC cycle:
  - Vehicles with Otto-engine consume the most amount of oxygen. It is followed by the vehicles propelled by a Diesel-engine, and the lowest consumption showed by the fuel-cell vehicles.
  - A fuel-cell vehicle does not emit any CO_2, while the Diesel vehicles have the highest level of CO_2 emission, and the Otto-vehicles' result is in between.
- The O_2 demand for combusting the fuels used in road transport in Hungary is the same as the 6-year demand of a Hungarian population in the year 2019.
- As for the CO_2 emission, combustion of fuels used in road transport in Hungary emits the same as the emission of the Hungarian population during 5.2years.
- Results seem to be serious, although calculations are relating only to the road transport in a small country of the world.

5.1. Additional investigation options

In authors' opinion, the topic has been analyzed and represented above can be further investigated probably in the ways as follows:

- Examining how the real conditions could be approached as far as the combustion of fuels, the function of oxygen consumption, and the carbon dioxide emission in a human body are concerned.
- Investigation could be extended to other sectors (energy, industry, households, agriculture).
- Extensions can be made towards larger population and vehicle fleet.
- Examining the effects that can have this tendency (especially the oxygen) on the humans or living organisms on a long term.

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