Climate Action Article
Reduce CO_2 Emission or Die
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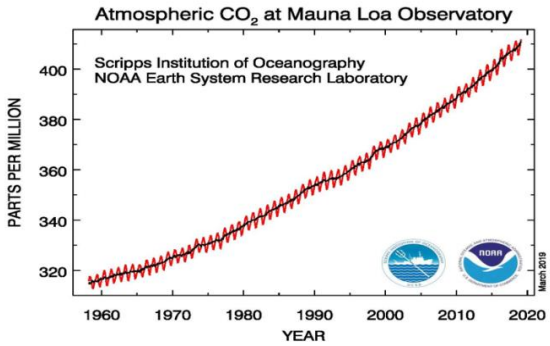
Did you know that the average person worldwide is responsible for 5 tons of CO2 emissions annually? Did you know that our planet Earth is dying? Did you know that we are on the verge being extinct?

One of the main issues causing climate change is the high CO2 emission rate.
The CO2 emission rate consists of factors such as the pollution in the inner cities; this is mainly due to traffic.

It is important to understand that in order to face the problem, we have to change our consumer behaviour and the way we use energy in our daily lives.

As a matter of fact, the energy we use cannot be produced without any environmental



consequences in our current stage of technology, so we have to work on finding the most efficient ways to use our available resources in a sustainable way. The diagram above shows how much the CO2 emissions has exponentially increased in the past 60 years.

The rise of temperature in the atmosphere and oceans causes huge problems, not only for us humans, but for the whole environment.

Results of the rising temperatures are natural disasters for example forest fires (Australia 2019, Turkey 2021), higher sea levels, floods all over the world, extreme heat waves (currently in southern Europe), melting of permafrost which leads to extinction and results in the release of carbon dioxide and methane into the atmosphere.

The IPCC climate report claims that the earth is warmer than it has ever been in 125,000 years.

Furthermore, the earth's global surface temperature has increased by around 1.1°C.
In order to maintain the earth's natural temperature we have to actively decrease human CO2 emissions, the goal would be to bring them near zero.

The beginning of humans having a significant impact on the earth's climate began with industrialisation and was further accelerated by broad use of personal vehicles and technical innovation leading to a huge demand for electricity.

With the increasing demand for electricity it became much more attractive to generate a large amount of usable energy. Due to the increasing supply of electricity, it rapidly became more affordable to the broad society, which in turn led to more electric devices being developed for everyday use, such as washing machines, refrigerators or stoves. Just like this, the usage of electricity grew exponentially up to this day. These huge amounts of energy have to be produced, which was mainly done by burning fossil fuels like coal. This is a huge problem, because not only do we only have a limited amount of it on earth, it also pollutes the atmosphere with a lot of CO2, nitrogen oxides and other environment-harming gases.

These factors combined lead to the global human caused CO2 emissions rising from 0 in 1850 to 26 billion tons a year in 2020, the significantly biggest part coming from western and other developed countries. The amount of global CO2 emissions is the product of the following factors.

$CO_2 = P*S*E*C$

To understand the above equation, we have to look at the single components:
P stands for the human population on earth, S stands for the services per person, this is the amount of CO2 causing actions the average person uses, E equals the amount of energy being used for one service for example the energy needed to run a light bulb for one hour. Last but and not least C stands for the amount of CO2 emitted per a certain amount of energy.

An increase or decrease in each of these factors has an effect on the whole equation, so in order to achieve a lower total CO2 Level; we have to work on decreasing these components.

The factor P (World Population) cannot really be influenced, it is constantly and almost exponentially rising, which is a different problem.

The next factor is S (Services per person) and can be reduced, if we start leaving out unnecessary energy consumption or CO2 emitting services, such as short-distance-flights, unnecessary car rides or cruise ship rides. This can be achieved, if the people get more conscious about their consuming behaviour and actively work on themselves.

The next factor is E (Energy per service), it can be reduced by technical innovation, a good example are LED lights. They only use a fraction of energy vs a conventional light bulb, yet are even more attractive to customers, because they are not overly expensive, nor do they lack in performance and endurance. Similar innovations in different areas would help to decrease this factor and the overall CO2 emissions with it.

The last factor is C (CO2 per Energy unit) and it can be reduced by finding more efficient and environmentally friendly ways to produce the electricity that is being used for the services that require it. This can be achieved by optimizing the technologies we already have, like fixing the storage problems with wind energy by using the inertia coil or twin bladed wind turbine developed by Professor Reza or fixing transmission issues with solar energy.

Is public transport systems part of the long-term solutions to CO2 Emissions?

Since the beginning of industrialisation the technology developed had a huge impact on the infrastructures. However there were some attempts made to reduce the vehicle exhaust emissions especially with regards to the transport systems.

The urban air pollution was and still is a national concern.

In Professor Dr Reza's article from 1995 he states the problems and offers futuristic solutions in order to achieve a long lasting change for good. One of the solutions was to aim for a well planned public transport system in which the infrastructure should be well designed to have a positive effect on the environment. In addition to that it is important to reduce the journey times and vehicle numbers.

However, the design of the transport vehicles have been primarily influenced by the customers' desires and their wish has been incorporated in legislative measures and controls.

The Scientific communities in Europe and the developed world were concerned that the emissions legislation timetable is too aggressive, because the cost would have been too high to develop the ULEV (Ultra Low Emissions Vehicle) and ZEV (Zero Emissions Vehicle). Besides the significantly higher costs, the amount of effort would not have paid off in the vehicle's performance. As a matter of fact it is important that the bus fleets are in a good condition, also are appealing to the society.

Furthermore, advanced technology is playing a part in that as well. The goal is to create it as sustainable as possible. One way to create a sustainable public transport system is by using a hybrid vehicle. The Scientific community has found three solutions to the problems that were faced by the public. At first there is a short solution that requires a balance between performance and emission. Secondly there is a medium solution that is based on hybrid vehicle technology. It is a combination of an electric motor generator and a natural gas diesel or possibly any other types of engine. Moreover these hybrid vehicles are less damaging to our environment and help to keep the air in our towns and cities cleaner. In

addition to that the performance is being accepted by the public. Not only are the hybrid vehicles better for our environment, but also beneficial to use as a customer, because the hybrid vehicles are strong and have enough power for urban transportation and as well for rural travel.

The last solution would be a long-term solution. It is about using electric power drives. Although the idea remained well, society was not satisfied with measures to reduce pollution levels in the inner cities. The solutions so far have been focusing on the improvement of conventional powertrain design. One of the reasons for that is the financial risk that is given to the companies, shareholders and investors when working on a completely new technology, like full electric cars, rather than conventional gas-powered cars. That is why hybrid vehicles, as a mid-term solution are a good step into the right direction, without scaring away the industry and capital. Although the electrical transport systems are the most feasible solutions to the problems of pollution lack of infrastructure and access to sufficient sources of Lithium and Cobalt have impeded the more rapid implementation of electric battery car development.

Is Hybrid that successful?

The fact that almost all major and progressive auto manufacturers are producing hybrid cars, some 25 years after Professor Ziarati promoted the idea, is proof that hybrid vehicles have a major role to play in the overall plan for cleaner air and reduced emissions of harmful pollutants.

A hybrid car consists of an internal combustion engine, an internal electric engine and a well suited battery. The battery cannot only be charged on an electric charging station, but is also automatically charged while braking and driving with the combustion engine. That means hybrid cars are capable of driving electrically, without needing to charge them. Furthermore, ability to charge hybrid cars over night at home has helped in increasing the number of hybrid cars on the road. Almost all major auto manufactures while mastering the development of electric vehicles are producing hybrid vehicles a suggestion offered by Professor Ziarati in the early 1990s. In the event of accidents hybrid cars are safer than full electric cars due to their much smaller battery sizes. Recent accidents have shown that in the event of accidents the entire car could explode and emit very toxic fumes for miles around it.

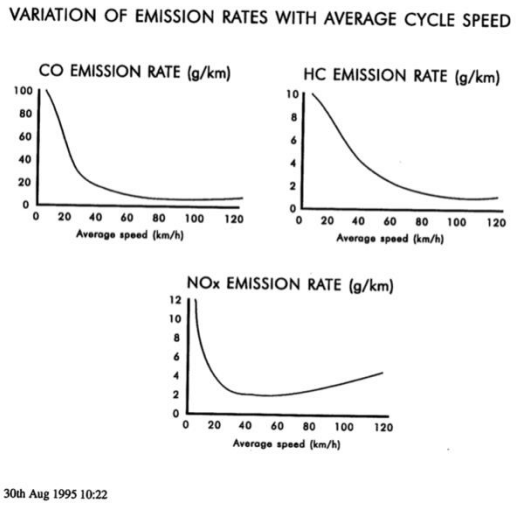
Also hybrid cars can offer a huge benefit over electric motors which is having the ability to control the torque on each of the wheels because of distributed single wheel engines. This leads to better stability, responsiveness and agility while driving the car.

Variation of Emission Rates with average Cycle Speed

The following graphs show the average travelling speed compared to the emission rate of different pollutants such as Carbon Monoxide, Hydrocarbon and Nitrogen Oxides. All of them have significantly higher emissions per kilometre at lower travelling speeds, such as in inner city traffic and other low-distance rides. This is why hybrid vehicles have such a huge advantage in our modern, urbanized world. The electric motor can be used in inner city traffic, for rides under 60 km/h and the combustion engine could be used for longer

distances and higher travelling speeds, which automatically charges the battery for the electric engine again.

Another benefit of hybrid powertrains is the extraordinary high energy efficiency.
Energy efficiency is measured in percent, so 100% equals the amount of energy that's being



put into an engine, no matter if it's coming out of a battery or out of Diesel, gasoline and CNG. The percentage of this amount being transformed into kinetic energy to spin the axis and wheels is indicated by the Efficiency in the following comparison.

Powertrain System	Efficiency %	NOx + HC	CO	CO_2
Battery Electric	37.9	0.02	0.06	52.3
CNG Hybrid	30.1	0.03	0.08	68.8
Developed CNG Hybrid	39.5	0.01	0.02	50.2
Typical Gasoline 3-way Cat	11.5	0.44	2.20	227.5
Typical IDI Diesel	15.4	0.50	1.00	179.8
ECE 15 Limits		0.97	2.72	

As it is shown in the table above, the developed CNG hybrid provides the highest efficiency of all listed powertrain systems. This is due to the combination of the highly efficient electric motor, of which one of the lesser weaknesses is the significantly higher rate of consumption at higher travelling speeds and a natural gas combustion engine, which emits a lot less pollutants than a conventional gasoline or diesel engine.
With an energy efficiency of 39.5, it is almost four times as efficient as a typical gasoline engine and about 2.5 times as efficient as a diesel powertrain. What also may be surprising is that the developed CNG hybrid is even more eco-friendly than a full battery electric vehicle, when the production emissions are considered in the calculation. This shows that the developed CNG hybrid is the best powertrain option in the comparison.

How can the Hybrid gain popularity?

One option would be to show people how great the hybrid technology is by using it in public transportation such as buses. Through this way, people can find out how it's beneficial to the inner city air quality and sound environment and maybe get attracted to buy a hybrid car for their personal use. Since particulates have proven to cause lung and heart disease (medical experts), it is very important to reduce any further air pollution. Another important step would be to establish a network of scientists and car companies to create a vision for the future of auto mobility with hybrid cars.
Furthermore it's important to take risks and invest into innovative projects to ensure a sustainable future.

To create more public attention it would also be important to be present at international technology and automobile trade fairs, where the benefits of hybrid transportation could be presented and explained. To ensure a positive public image it would also be beneficial if scientists from different countries would publish papers with accurate scientific comparisons between hybrids and conventional combustion engine cars. If these moves turn out to be effective and popularity of hybrid cars improves in society the demand on hybrid cars will automatically increase and innovation projects could raise more funds from companies and investors to achieve their goals. Moreover the vehicle HX3 Hybrid developed by General Motors in the form of a five-seat family vehicle proved how important and efficient a hybrid car is. Due to both technologies combined, the hybrid car is capable of driving 700 miles without recharging the battery or the fuel, which is about ten times the maximum range of a fully electric vehicle. In addition to that, the front wheels get the vehicle and electric range of about 80 miles. This kind of technology was developed by many Industry groups and manufactures in order to develop similar vehicles.

A Network formed so called Friendly Low Energy Efficient Transport System has suggested a range of hybrid systems under two major headings first the shuffle for replacement of diesel driven buses and the "Phaser" as a small van and taxi or private family car.
There are actually no further problems besides the production costs; the real problem would be the acceptance from the public.

What possible problems could there be with a hybrid?

Possible problems of a hybrid car could be either that the customers have to pay for the high technical solutions or must be able to draw on subsidies and form of tax concessions.

In order to overcome these problems it is up to all of society if it is willing to pay for the benefit of energy efficient transportation systems in the cities.

What positive impact can the hybrid have for the future?

CALIFORNIAN EMISSION STANDARDS

Exhaust Standards, g/mile

	HC	CO	NOx
(1991) US Federal Standards	0.41	3.4	1.0
1991 California	0.39	7.0	0.4
1993 California	0.25	3.4	0.4
1994 Transitional Low Emission Vehicle (TLEV)	0.125	3.4	0.4
1997 Low Emission Vehicle (LEV)	0.075	3.4	0.2
1997 Ultra Low Emission Vehicle (ULEV)	0.040	1.7	0.2
1998 Zero Emission Vehicle (ZEV)	0.00	0.0	0.0
OTHER REQUIREMENTS: On-board diagnostics phase 2 (1994) Low evaporative emissions (1995)			

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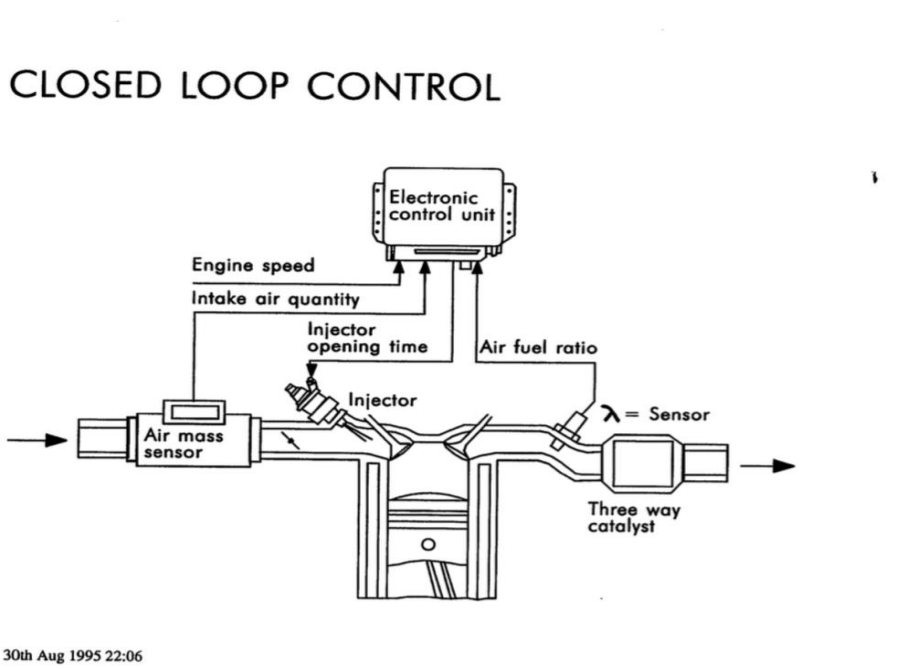
Because of the Californian emission guidelines automobile producers were forced to rapidly develop new technical solutions for their powertrain systems. Not only was it necessary to change because of environmental reasons but also it has been a key factor of the industries economic survival. The industry has already invested an enormous amount into the concepts that is why the industry had to stop at some point and create a concept which was efficient enough to invest without any further losses. The illustration shows different emission criteria and the matching emission limits by gram per mile of NOx, CO and HC.

It can be observed that the limits get lower each year, in order to put pressure on the industry to further reduce the emissions of their engines. Besides that, there are defined criteria for the classes of Transitional low emission vehicles (TLEV), low emission vehicles (LEV), ultra low emission vehicles (ULEV) and zero emission vehicles (ZEV). With this overview, it's possible to classify cars into different emission classes, the lowest being Zero Emission Vehicles, which are only fully electric vehicles such as hydrogen powered vehicles; followed by Ultra Low Emission Vehicles, which are highly efficient hybrid cars.

Results of this pressure that has been put on the industry have already been shown. One of the most successful design innovations is the 3-way catalyst, which is coated with platinum and other metallic compounds and can filter out up to 90% of the pollutants. To properly work, it needs a fuel to air ratio that's near to the chemical optimum, which can be achieved significantly better with an Electronic fuel injection (EFI) system, as it can portion the fuel injections more accurately and reacts faster to changes of the airflow due to its sensors.



The line graph clearly shows that before using the catalyst the hydrocarbon emissions (gm/mile) rises linearly per every minute at 32 minutes of running time.
It rises around 2.4g/m and reaches a temperature of more than 700°C.
In contrast touching the catalyst it only increases up to a temperature of 200°C in addition to that the hydrocarbon emissions stagnate after 6 minutes and cause about 0,3g/m Hydrocarbon emissions. With that being said the catalyst is an essential centre piece to reduce the environmental pollution. In order to understand the impact the catalyst has on our technology, it is important to have a look at how the three way catalyst works.

The following Illustration resembles how the catalyst works. At first the air gets sucked into the engine and flows through the air mass sensor, which transmits the intake air quantity to the Electronic control unit. Depending on the quantity of air, the Electric Control Unit measures the time of the electronic signals to the fuel injector to spray the fuel inside; the more air comes inside, the higher is the frequency of the fuel sprays. As the next step, the air flows into the combustion chamber, where the air fuel mixture gets compressed and explodes. Then it flows past the air/fuel ratio sensor and further into the three-way-catalyst.

What about electric cars?

Electric cars have significant advantages within the inner-city areas, because of the zero emission capabilities and the low noise which is a major contribution to the environment.

What could be possible problems?

One problem would be that in 1995 the consumer did not like the idea of an electrical vehicle. Even nowadays this is still a problem for instance. Toyota claims that the world is not yet ready to support a fully electric auto fleet, also there is only 2% electric cars at the moment. For example in the United States there are 289,5 million cars on the roads and around 98%of them are gas-powered. In addition to that Toyota is selling 81% of its cars in the United States. Besides that, a study found out that the United States would need 8500 strategically charging stations to support a fleet of 7 million electric cars, which is six times

the amount of electric cars right now. Toyota warns that the Grid and Infrastructure are not there yet to support the electrification of the private car fleet.

What about a sustainable and achievable future perspective?
In order to achieve a future perspective with only electrical vehicles we would need 300 million electrical cars within 20 years to prevent any further CO2 emissions, especially in the urban areas.

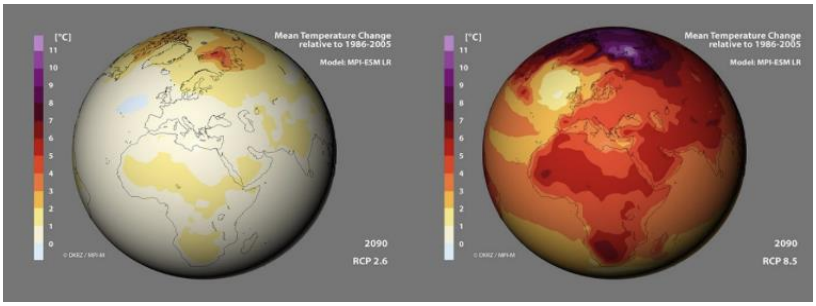
It could be possible if all manufacturers would follow GM and stop making ICE cars. Nevertheless we have to electrify the auto fleet, which requires a massive expansion of the power grid and an enormous increase in power generation.

What could a sustainable future look like?

After hearing about all of the problems the climate change has caused us, it is important to comprehend that we as a society have to take the responsibility for the harm we caused our world through using our resources and leaving an ecological footprint behind.

In order to reduce the C02 emissions we need to start changing.
However car pollution is a serious problem which is also a factor in causing asthma (Dr John More-Gillian, British Lung Assoc.). The technology is given to change our current situation. It is important to understand that we as human beings can change a lot if we do it together step by step. 75% of the journeys in the UK are less than 5 miles away. Instead of taking the car, Great Britain could expand their infrastructure in order to increase the rail use, this way the car use could be minimized.

We need to focus on reducing the quantity of cars in order to achieve a sustainable world. It is important to reduce our caused emissions because they affect the entire environment and if we don't change anything now, we will be living in constant danger due to major natural catastrophes. Besides that, animals will become extinct, for example the polar bear's habitat is about to disappear, if we do not take actions now. Another fact is that the climate cannot be changed by only one country, it is important to face it together so everyone can live peacefully on our beloved earth. Especially the western countries have to reduce their CO2 emissions drastically, to achieve any results. In order to change the urban air pollution, hybrids or electrical vehicles can reduce the transport pollution in the inner city areas. Because we have learned that energy cannot be produced nor destroyed, we need to use it as efficiently as possible so it will not get to waste. As a matter of fact, industries need to start taking action if they still create massive tons of CO2 because we live in an age of globalization and urbanization, so that's why we have to work on building a sustainable future for humanity and planet earth.



Sources:
Emerging Transport Systems by Professor Dr. Reza Ziarati (http://www.c4ff.co.uk/history/papers/Emerging_transportation_system.pdf), and Environmental Impact of New Transport System, (http://www.c4ff.co.uk/history/papers/Impact_of_new_transport_system.pdf.

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