



## ENVIRONMENTAL SUSTAINABILITY: NEW PERSPECTIVES AND PARADIGMS

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### Abstract

Over dependence on fossil fuels is a worldwide problem, currently the uncontrolled use of fossil fuel is harming the earth and emptying the resources. We have just been through the hottest decade ever recorded and besides climate change, combustion engines spit out pollution that causes millions of deaths each year. Hence the world needs rapid transition away from fossil fuels. Due to this the pressure is on to develop new technologies, one of which is e-fuels. It is a sustainable alternative carbon-based fuel where inside the container's hydrogen and air captured carbon dioxide are turned into gaseous hydrocarbons, further processing turns them into liquid synthetic fuels. This syn fuel can be almost carbon neutral as long as the entire production process is powered only by excess electricity from renewable sources. So, while e-fuels might have their use cases this doesn't marks end of combustion engines yet, it will be around for another few years but there will also be electric cars and new technologies.

**Keywords:** e-fuel, carbon dioxide, hydrogen, electricity, synthetic fuel, fossil fuels and climate.

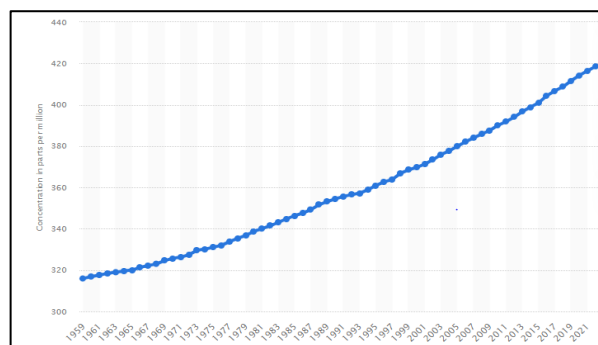
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### 1. Introduction

There was a discussion on e-fuels with the Germany, Italy, Bulgaria and polish government tussling for their identification in the EU parliament and approved the prohibition of new petrol and diesel car sales from 2035. These countries were pointing that e-fuels are feasible alternative to incomplete combustion engine fuels which helps in reduction of CO<sub>2</sub> emissions across Europe.

Obviously, the usage of fossil fuels, being so foundational to world's economy, produces harmful particulate matter emissions. Fossil fuels are hydrocarbons and formed from hydrogen and carbon dioxide which is used to produce energy and also to power engines. Energy like heat and electricity, fossil fuels are burned to produce heat in home and electricity in large power stations. Burning of fossil fuels builds up carbon dioxide and other green house gases in the atmosphere which causes the earth's atmosphere warm resulting in climate change.

Climate change usually disrupts the equilibrium of the nature which also increases many risks to human beings and all other different forms of life on earth. Hence, finding climate neutral source of energy to power engines is an alternative to reduce carbon emissions. Electric vehicles, biofuels, natural gas are few alternatives where e-fuels are one possible mechanical standpoint for a sustainable transformation of the transport sector.



**Figure: 1** Gradual increase in world's carbon emissions concerned from 1959 – 2021.

### 2. Objectives

- Reduce outpouring of chemicals which are deleterious to environment as well as one's wellbeing.
- Decreasing the reliance on mineral oil.
- Safeguarding the security of supply.
- Complete combustion engines.
- Automotive decarbonization.

### 3. How do vehicles contribute to pollution?

Combustion is the protagonist here, a chemical reaction where a substance reacts with oxygen and produces heat. Particularly, in case of vehicles hydrocarbons are building blocks of fossil fuels, which reacts with oxygen and produces carbon dioxide and water. Specifically incomplete combustion contributes to pollution where hydrocarbons doesn't burn completely due to insufficient amount of oxygen.

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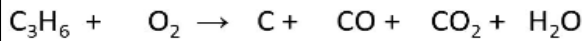
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#### 4. A new epoch for e-fuels?

Most of the attention is on Automotive Decarbonization is currently focused on battery electric vehicles and hydrogen fuel cell electric vehicles. There was once a great hope on biofuels which is now dissipating because of insufficient agricultural land for both food and biofuels. But attention is now moving towards e-fuels, which uses renewable power to produce hydrocarbon fuels without using any plants or other biological processes.

#### 5.E-Fuels

All mobility can't be electrified with the help of batteries and fuel cells. Because aero planes, ships, and even trucks will often be powered by combustion engines as well. Hence new fuels are being researched worldwide which ensure that even combustion Engines operate CO<sub>2</sub> neutral which are synthetic fuels or so-called e-fuels. These are based on simple ideas; they are produced exclusively with renewable energy where hydrogen is initially extracted from water. But for a liquid fuel, carbon is still needed where carbon dioxide is captured as a source. Then we obtain e-fuel from merging carbon dioxide and hydrogen. We can also get artificial gasoline, diesel or kerosene which helps vehicles includes aero plane, ships, cars and trucks drive CO<sub>2</sub> neutral with a combustion engine which makes significant contribution to reduce global warming.

#### 6.Technology of E-fuels

Porsche and several partners have started production of a climate neutral e-fuel, aimed at replacing gasoline in vehicles with traditional internal combustion engines.

- a) Chemistry behind production of fuels: elements can have different oxidation states, when an atom receives electron, it is called reduction and when it loses its electron then it is oxidation. The reaction which incorporates oxidation and reduction is redox reaction.
- b) Redox reactions can be used to store energy in some fuel. And the central element for this is oxygen, it has 2 major oxidation states, we need to invest energy from a renewable source to take away electrons from oxygen atoms and transfer them on to some other atoms. This way it can form some sort of fuel. Then we can transfer back electrons to oxygen which rereleases the energy. This is the basic principle behind any sort of fuel.
- c) Hydrogen as a fuel: energy investment is required to split water (H<sub>2</sub>O) into hydrogen (H<sub>2</sub>) and oxygen (O<sub>2</sub>). The hydrogen is then stored in a vehicle, finally when the vehicle is powered hydrogen and oxygen reacts to form water again and releases energy.
- d) E-FUEL: same idea has been implemented in e-fuels, it starts with electron rich oxygen atoms in water, then transfer them on to carbon atoms forming hydrocarbons and oxygen gas. During the combustion electrons are transferred back and energy is released. [carbon dioxide reduction]

#### 7.Technology of E-fuels

Production is based on reduction of carbon dioxide. There are 2 main techniques to reduce carbon atoms: Thermal and Electrochemical.

##### a) Thermal technique

Initially energy is invested to produce hydrogen atom from water then hydrogen atom brought together with carbon atom with high pressure (100bars) and temperature (250 degree Celsius) with metal surfaces as catalyst to produce hydrocarbon.

##### b) Electrochemical technique

Here, two electrodes are connected through the circuits with water at the anode and carbon molecules containing carbon at the cathode. Then invest energy by applying voltage, this will cause electrons to be transferred from oxygen directly to the carbon atoms to produce e-fuels.

##### c) For e-fuels will now have two distinct pathways:

1. Initially carbon dioxide is converted to carbon monoxide then by Fischer-tropsch process mixture of different hydrocarbons are produced, can be called as artificial crude oil.



2. Another pathway where we electrochemically convert CO<sub>2</sub> into small alcohols and aldehydes with utmost 3 carbon atoms. Then we combine these molecules together to produce large alcohols and aldehydes. Some of these can already used as fuel but we can further enlarge via functional group containing oxygen.



##### d) Various kinds of e-fuels:

- a) e-methane
- b) e-hydrogen
- c) e-ammonia
- d) e-methanol
- e) e-DME
- f) e-gasoline
- g) e-diesel
- h) e-jet

##### e) Cost of e-fuel:

Currently the cost of e-fuel is high because expenditure of electricity in huge amount but are expected to be decrease over time.

#### 8.Demand of e-fuels

They are not expected to play a significant role in the transport sector in short term 2030. By 2050, literature sources claim that the e-fuel contribution to the transport sector could range from 0 to 30% and will mainly focused on the aviation, maritime and long-haul road transport segments.

##### a) Drawbacks:

Barriers of these low-carbon fuels are:

1. Efficiency marks the main drawback, e-fuels has very less efficiency than battery electric vehicles (BEVs) and fuel cell vehicle.
2. where efficiency of battery electric vehicles are 4-6 times higher than e-fuels i.e., around 69%. Fuel cell vehicle has an efficiency of around 26-35%, and a liquid e-fuel car has an efficiency of around 13-15%.
3. Required huge amount of electricity.
4. Production costs for e-fuels remains high.

### **9. Conclusion:**

Transport sector contributes major amount of CO<sub>2</sub> emissions which warms up mother earth and leads to global warming. In order to reduce the pollution and save mother earth all have to come up with alternatives. Where, e-fuels- sustainable fuel expected to replace conventional fuel. It cannot be carbon free, but can reduce carbon emissions. Also, we can notice that emptying of minerals hence fossil fuels cannot feed us for long time. Currently, Porsche companies hiring in production of large amount of e-fuels and trying to make it more efficient.

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