

# Fuels summary

A fuel is any substance that can burn to release heat to generate power.

A **renewable fuel** is one that can be replenished through natural processes in a short period of time so that it does not become depleted.

Know your equations:

- Photosynthesis  $6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g})$
- Fermentation  $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) \rightarrow 2\text{CH}_3\text{CH}_2\text{OH}(\text{aq}) + 2\text{CO}_2(\text{g})$
- Complete combustion  $\text{Fuel} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$  ( $\text{CO}_2$  is produced as a product)
- Incomplete combustion  $\text{Fuel} + \text{O}_2 \rightarrow \text{CO} + \text{H}_2\text{O}$  ( $\text{CO}$  or  $\text{C}$  is produced as a product)

Fuel	Source	Renewable? Environmentally friendly?	Energy density kJ/g	Advantages	Disadvantages
Biogas	Usually consists of methane, $\text{CH}_4$ and $\text{CO}_2$ in a ratio of about 70% to 30% respectively. Produced by decomposition of organic material by anaerobic digestion.	Yes, it is renewable  Yes, it is environmentally friendly as it does not contribute to a net increase in atmospheric $\text{CO}_2$	26	It is renewable, does not contribute to a net increase in atmospheric $\text{CO}_2$ and in small scale usage reliable in its supply.	No large scale commercial usage as yet and there is no likelihood that this source of energy can supply the fuel needed to provide base-load power.
<a href="#">Coal seam gas</a>	Methane trapped on the surface of coal. It is formed during the natural formation of coal and often adheres to the surface of coal under the influence of high water pressure	No it is not renewable  No, it is not environmentally friendly as it contributes to a net increase in atmospheric $\text{CO}_2$	54	Accessible and relatively cheap to source. Reliable in large scale supply.	It is a fossil fuel and farmers argue the potential to contaminate underground water supplies is real and ever present.
Natural gas or LPG(liquid petroleum gas)	Usually consists of methane ( $\text{CH}_4$ ) 90% and 5% $\text{CO}_2$ with small fraction of ethane and propane. Is found in fossil fuel deposits of coal or oil	No it is not renewable  No, it is not environmentally friendly as it contributes to a net increase in atmospheric $\text{CO}_2$	54	It is relatively cheap and a cleaner fossil fuel than brown or black coal. Power stations that run on gas can come online in a relatively short period of	It is a fossil fuel and produces greenhouse gases.

				time to boost supply during critical periods of high energy demand. Reliable in large scale supply.	
Syngas (synthesised gas)	Is a mixture of CO and H <sub>2</sub> gases. Can be formed via steam reformation of hydrocarbons $\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2$ Or by an Anion Permeable Membrane (APM) electrolyser $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2 + \text{O}_2$	Renewable if the feedstock does not come from fossil fuels. Use of CO <sub>2</sub> as feedstock can be beneficial for the environment	10-15 MJ/kg Depending on ratio of CO <sub>2</sub> and H <sub>2</sub> .	Can be used to recycle CO <sub>2</sub> from the atmosphere making this type of fuel sustainable and environmentally friendly.	Expensive infrastructure. Impurities such as CO <sub>2</sub> and N <sub>2</sub> reduce the energy density.
Methane	Pure methane, CH <sub>4</sub>	Depending on its source. If it comes from a fossil fuel source, then it is not renewable and is not environmentally friendly as it contributes to a net increase in atmospheric CO <sub>2</sub> If it comes from bio-gas then Yes, it is renewable and no, it is not environmentally friendly as it contributes to a net increase in atmospheric CO <sub>2</sub>	56	See biogas above.	See biogas above.
Ethanol	<a href="#">Bioethanol</a> is produced from <a href="#">fermentation</a> of plant matter such as corn, potatoes, grain (wheat, barley and rye) or sugar.  Ethanol is also commercially produced by steam	Yes, it is renewable and environmentally friendly as the CO <sub>2</sub> produced during combustion does not contribute to a net increase in atmospheric CO <sub>2</sub> as the CO <sub>2</sub> expelled during	30	Its net contribution to atmospheric CO <sub>2</sub> is relatively small depending on where it is sourced. Reliable in large scale supply. Bioethanol is renewable and does not	Crops must be grown and when harvested can be fermented to produce ethanol. Ethanol is recovered through distillation.

	<p>reformation  <math>\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{C}_2\text{H}_6\text{O}</math>.  <a href="#">Click</a> to see the organic pathways that can be used to produce ethanol</p>	<p>combustion was trapped from the atmosphere during photosynthesis. Emissions of <math>\text{CO}_2</math>, however, during transport and manufacture(distillation) of ethanol should be taken into account and can contribute, albeit a small, to a net atmospheric increase in <math>\text{CO}_2</math> levels.</p>		<p>contribute to a net increase in atmospheric <math>\text{CO}_2</math></p>	<p>This process competes with limited land with which to grow food. Production and transport of ethanol is energy consuming and this energy often comes from fossil fuels.</p>
<a href="#">Biodiesel</a>	<p>Fatty acids obtained from plants or animal matter.</p>	<p>Yes it is renewable and environmentally friendly as the <math>\text{CO}_2</math> produced during combustion does not significantly contribute to a net increase in atmospheric <math>\text{CO}_2</math> as the <math>\text{CO}_2</math> produced during combustion was trapped from the atmosphere during photosynthesis. Emissions of <math>\text{CO}_2</math>, however, during transport and manufacture(distillation) of biodiesel should be taken into account and can contribute, albeit a small, to a net atmospheric increase in <math>\text{CO}_2</math> levels.</p>	42	<p>Similar to ethanol above. Reliable in large scale supply. Biodegradable and non-toxic.</p>	<p>Similar to ethanol above. + Biodiesel is hygroscopic due to polar ester groups.</p>
Petrodiesel	<p>Obtained from fossil fuel reservoirs.</p>	<p>No it is a mixture of hydrocarbons (fossil fuel) of</p>	45	<p>It is cheap and relatively easy to source.</p>	<p>It is a fossil fuel and contributes</p>

		chain length of 8 to 21 carbon atoms		Reliable in large scale supply.	significantly to a net increase in atmospheric CO <sub>2</sub> .
Hydrogen gas (green and blue hydrogen) - Green hydrogen is produced from renewable sources and energy via the electrolysis of water. - Brown hydrogen is produced from non-renewable sources, such as fossil fuels with carbon capture and storage technology employed.	Hydrogen gas can be produced in a number of ways. Some are: - Electrolysis of water (green hydrogen), - Steam reformation (blue hydrogen) - gasification of brown coal (blue hydrogen)	Depends on how it is produced. Yes it is renewable if it is produced through the electrolysis of water using renewable energy sources No it is not if it is produced via steam reformation $\text{CH}_4 + 2\text{H}_2\text{O} \rightarrow 4\text{H}_2 + \text{CO}_2$ or gasification of brown coal.  It is also environmentally friendly as its burning as a fuel does not contribute to a net increase in atmospheric CO <sub>2</sub> . Transport and storage is a big problem for H <sub>2</sub> and requires a great deal of energy both to store and to produce and as such this factors must also be taken into account if we are to label H <sub>2</sub> as an environmentally friendly fuel.	141	Reliable in large scale supply and although most of our industrial quantities currently, as of 2022, come from steam reformation using methane gas, great advances are currently being made other ways of producing renewable supplies of H <sub>2</sub> gas with minimal environmental impacts. It is one of the most promising and environmentally friendly fuels.	Expensive to store and transport. Infrastructure is currently, as of 2022, not available for widespread usage of H <sub>2</sub> gas as a fuel in transport or industry. The nature of the H <sub>2</sub> molecule makes it hard to store and transport. It must be liquefied and stored at - 253°C and up to 7.0 X 10 <sup>4</sup> kPa. Such extreme conditions require expensive infrastructure is hard to maintain.
Brown coal	Obtained from fossil fuel reservoirs.	No, it is not renewable nor environmentally friendly it is a fossil fuel whose combustion causes a net	16	Reliable in large scale supply. Since it is very close to the surface, only a metre or two, it is relatively cheap to dig out	It is a fossil fuel and as such contributes to global warming. It is also a dirtier form of coal.

		increase in atmospheric CO <sub>2</sub> .		from the ground and as of 2022 Victoria has enough supply, at current usage, for the next 200 years.	Dirtier in the sense that brown coal contains up to 60% water and must first be dried before it can be used. This requires more energy that is supplied from the burning of further fossil fuels which contribute even more to global warming. Mining of brown coal causes land degradation so the land on which the mine exists needs to be rehabilitated after the mine has ceased operations.
Black coal	Obtained from fossil fuel reservoirs.	No, it is not renewable nor environmentally friendly it is a fossil fuel whose combustion causes a net increase in atmospheric CO <sub>2</sub> .	34	It is a more refined form of coal that contains very little water. This fact alone makes it environmentally better than brown coal, because energy is not used to dry the coal as happens with brown coal. It is found in large deposits in Australia and is relatively easy	Like brown coal it is a fossil fuel and contributes to global warming. Mining of black coal causes land degradation so the land on which the mine exists needs to be rehabilitated after the mine has ceased operations.

				to dig out from the ground.	
LPG (Liquid propane gas)	Obtained from fossil fuel reservoirs.	No, it is not renewable nor environmentally friendly. It is a fossil fuel whose combustion causes a net increase in atmospheric CO <sub>2</sub> .	51	It is relatively cheap and readily available to use in small scale such as BBQ or heating.	See methane above.