

# Comparison of Energy Sources

Andrew Lorimer

Energy source	Energy content	Renewability	Environmental impacts of extraction	Environmental impacts of combustion	Key combustion equation/s
Coal (brown/black)	Black: 34 kJ/g; Brown: 16 kJ/g	Non-renewable - produced by fossilised plant material (millions of years)	Destruction of vegetation, pollution due to mine waste, greenhouse emissions from transport & mining machinery	Acid rain (SO <sub>2</sub> ), greenhouse gas emissions (accelerates climate change), air pollution (e.g. smog)	Complete: $C(s) + O_2(g) \longrightarrow CO_2(g)$ Incomplete: $2C(s) + O_2(g) \longrightarrow 2CO(g)$
Crude oil	30 kJ/g	Non-renewable - organisms fossilised over millions of years. Limited worldwide supply	Transport by road & sea releases greenhouse gases.	Toxic CO with incomplete combustion, produces CO <sub>2</sub> contributing to climate change.	Complete: $2C_{16}H_{34}(l) + 49O_2(g) \longrightarrow 32CO_2(g) + 34H_2O(g)$ Incomplete: $2C_{16}H_{34}(l) + 17O_2(g) \longrightarrow 32C(s) + 34H_2O(g)$
Petroleum gas	48 kJ/g	Non-renewable (derived from crude oil)	Refinement causes hydrocarbon pollution of air	Uncombusted hydrocarbons may be released (CO(g)), causing photochemical smog.	Complete: $2C_8H_{18}(l) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(g)$ ; $\Delta H = 5.51$ MJ/mol octane Incomplete: $2C_8H_{18}(l) + 17O_2(g) \longrightarrow 16CO(g) + 18H_2O(g)$
Coal seam gas	≈ 54 kJ/g (nat. gas)	Non-renewable (byproduct of natural coal production)	Destruction of vegetation & geology (drilling), pollution of aquifers	Greenhouse gas emissions	Methane (complete): $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$
Biogas	26 kJ/g	Very renewable - sourced from anaerobically decaying organic waste (e.g. manure). Currently low worldwide supply.	Relief of landfill. Reduces air pollution from waste. May require damaging boring & trenching.	Low odour & smoke. Produces greenhouse gases like other methane-based fuels.	Methane (complete): $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$
Bioethanol	30 kJ/g	Very renewable - sourced from fermented sugars (e.g. wheat starch, molasses). Combining with E10 reduces renewability.	Consumption of agricultural waste (landfill reduction). More land dedicated to bioethanol sources, less for food agriculture.	Produces CO(g) and hydrocarbons (greenhouse gases) without E10. Produces CO <sub>2</sub> (g) with E10. Can corrode engines (high water retention).	$C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$ ; $\Delta H = 1370$ kJ/mol
Biodiesel	42 kJ/g	Very renewable - sourced from used cooking oil, tallow, oil seed crops	Consumption of waste (landfill reduction). Less space for agriculture & forests. Biodegradable. Byproducts (glycerol) can be used elsewhere.	Similar to petrodiesel - produces CO <sub>2</sub> (g) (greenhouse gas), contributing to air pollution & climate change	$C_{17}H_{29}COOCH_3(l) + 26O_2(g) \longrightarrow 19CO_2(g) + 16H_2O(g)$

Fuel type	Acquired from	Chemical structures	Combustion products	Fuel line flow	Environmental impacts
Petrodiesel	Refined crude oil (decaying marine life)	Alkanes ( $C_n H_{2n+1}$ ) - 12-24 C atoms / molecule	Complete: $CO_2(g), H_2O(g)$ Incomplete: $C(s), H_2O(g)$ Minor products: $SO_2, NO_x, CO$	Freezes at $\approx -8^\circ C$ . Viscosity $\propto 1 /$ temperature. Gels at $-19^\circ C$ due to viscosity. Vaporises at $\approx 370^\circ C$ . Not significantly hygroscopic - inconducive to bacteria & corrosion.	Extraction: destruction of marine environment, transport emissions, oil spills. Refinement: hydrocarbon byproducts pollute air. Combustion: greenhouse effect (climate change), air pollution e.g. photochemical smog, noise pollution.
Biodiesel	Fatty acids from plants & animals - byproducts e.g. cooking oil, tallow, oil seed crops	Alcohol esters ( $C_n H_{2n+1} OH$ ). Fats (esters between fatty acids & glycerol) react with an alcohol e.g. methanol with a catalyst (transesterification).	Same emissions as petrodiesel, but $n[CO_2(g)]$ and $n[H_2O(g)]$ are lower. Higher $NO_x$ emission.	Freezes at $2^\circ C$ . Hygroscopic - gels at a higher temperature than petrodiesel (causes engine blockages) and accelerates growth & rust.	Lower greenhouse gas emissions than petrodiesel. Biodegradable. Consumes waste. May consume land for agriculture or natural heritage (deforestation).

## References

- [1] Diesel fuel — Wikipedia. [https://en.wikipedia.org/wiki/Diesel\\_fuel](https://en.wikipedia.org/wiki/Diesel_fuel), 2019. [Online; accessed 08-Jan-2019].
- [2] Taylor et. al. *Chemistry 2: VCE units 3&4*. 2017.