



Melbourne
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How safe is Hydrogen?

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What do we mean by ‘safe’?

- The *Cambridge English Dictionary* defines ‘safe’ as:
 - “not in danger or likely to be harmed”
 - “not harmed or damaged”
- Whilst these definitions make sense, we need greater precision when *assessing* whether something is ‘safe’.
- Typically, we turn to ‘risk’, where we define the risk of some adverse outcome as:

$$\text{Risk} = (\text{Consequence}) \times (\text{Likelihood})$$

- Here, the ‘likelihood’ is the chances of that outcome happening, and the ‘consequence’ might be measured in \$, lives or other things.
- We might then consider a risk as ‘acceptable’ if it is below some accepted threshold, since nothing is without risk.



What do we mean by ‘safe’?

- But, unfortunately, life isn’t that simple. How do we quantify ‘consequences’, ‘likelihoods’ and ‘acceptable thresholds’?
- We also have to be very mindful about our differing perceptions of all aspects of risk, and what informs these perceptions.
- Is riding a motorcycle ‘safe’?

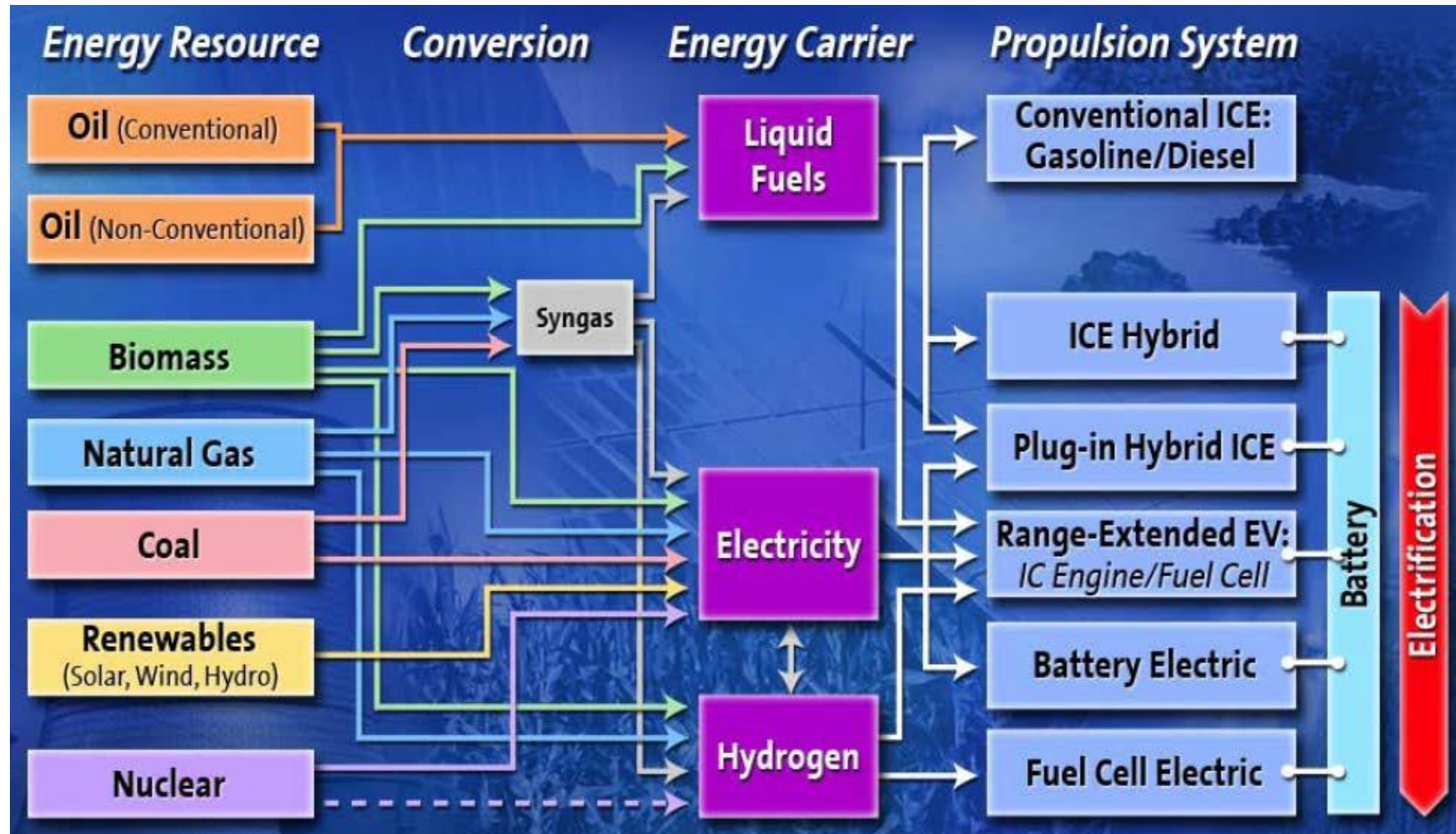
In Australia, almost 1 in 5 road deaths are motorcyclists, and a motorcyclist is about 30 times more likely to be killed than other road users per km travelled.

- Is nuclear electricity ‘safe’?

James Hansen, a famous climate scientist, argues that nuclear electricity currently saves about 70-80k lives pa globally compared to the hypothetical case of generating that electricity from fossil fuels, even taking into account disasters like Chernobyl and Fukushima.

So what about Hydrogen ... relative to other fuels?

source: GM





How safe is Hydrogen? Depends on how its used.

Fuel	Flammable	Density as std. gas.	Ignitability	Energy release	Peak temp.	Toxicity	'Storability'	
Electricity	n/a	n/a	n/a	+/-	n/a	+/-	-	+ = comparable to or better than gasoline/diesel
Ethanol	+	+	+	+	+	+	+	
Hydrogen	-	+	-	-	-	+	-	
LPG	-	-	-	+	+	+	+	- = worse than gasoline/diesel
Methanol/DME	+	+	+	+	+	+	+	
Ammonia	+	+/-	+	+	+	-	-	+/- = means 'it depends'
Natural gas	+	+	+	+	+	+	-	

- Note that these metrics are judged by their safety, and only some of them may be relevant to a particular case.
- These judgements are often the *opposite* of what we desire of a good fuel, meaning that we have to make trade-offs.

How *good* is Hydrogen relative to other fuels?

Fuel	W-to-W GHG reduction	Other env. and health impacts	Cost effective	Scale of resource	Ease of integration	Consumer utility
Electricity	+/-	+	-	+	-	-
Ethanol	+/-	+	+/-	+/-	+	+
Hydrogen	+/-	+	+/-	+	-	-
LPG	5-15%	+	+	-	+	+
Methanol/DME	+/-	+	+	+	+	+
Ammonia	+/-	-	+/-	+	-	-
Natural gas	0-25%	+	+	+	-	-

+ = comparable to or better than gasoline/diesel

- = worse than gasoline/diesel

+/- = means 'it depends'

- We must evaluate alternative fuels using several, important metrics in order to assess their likelihood of uptake.
- **None** of these alternative fuels are comparable to or better than gasoline/diesel in all respects. All face significant challenges.



Closing thoughts

- Hydrogen is commonly used already.
 - Particularly in industry.
 - Hydrogen was also used in our homes and workplaces (in town gas), prior to the uptake of natural gas heating.
 - Safety standards already exist for many aspects of the hydrogen supply chain.
- As such, we should not view hydrogen as inherently more or less safe than many other industrial fluids and fuels.
- The *relative risk* of switching from an incumbent fuel to hydrogen (or any other fuel) is the key concern.

Will we have fewer injuries or fatalities, or lose less money, etc. through the greater use of hydrogen?

- The answer to such questions is *application specific*, and depends on many factors.



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