An overview of clean and sustainable transport fuels for the future

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An opening caveat

- in a report to the US Navy dated 10th June, 1940, a committee of the US National Academy of Sciences said

  "In its present state, and even considering the improvements possible … the gas turbine could hardly be considered a feasible application to airplanes"

  M. Mason, T. von Karman, L.S. Marks, A.G. Christie, C. F Kettering, R.A. Millikan

- by this date, the first German aircraft flight with the von Ohain jet engine had already taken place and Whittle's first successful jet engine was under construction.

- moral: don't trust so called 'experts', especially when considering the future.

- with this in mind, my talk is intended to give an overview that hopefully stimulates discussion rather than attempts to give answers.

Outline

- National CO2-e emissions
- Road transport emissions
- Alternative transport fuels and pathways
- Powerplant performance
- Summary

Road vehicles the issue –the rest important?

(source: National Greenhouse Gas Inventory, 2007)

Table 2: Energy sector CO_2-e emissions, 2007

Greenhouse gas source and sink categories	CO_2-e emissions (Mt)			
	CO_2	CH_4	N_2O	Total
1 ENERGY	372.1	33.3	2.7	408.2
A. Fuel combustion activities	366.0	1.9	2.7	370.5
1 Energy industries	221.0	0.2	0.6	221.8
A Electricity generation	198.7	0.2	0.6	199.5
B Petroleum refining	5.7	0.002	0.01	5.7
C Manufacture of solid fuels	16.5	0.04	0.02	16.6
2 Manufacturing industries and construction	48.3	0.05	0.3	48.7
3 Transport	76.5	0.59	1.7	78.8
A Civil aviation	5.3	0.001	0.05	5.3
B Road transportation	66.4	0.5	1.6	68.5
C Railways	1.9	0.002	0.02	1.9
D Navigation (domestic)	2.8	0.1	0.02	2.9
E Other transportation	0.04	0.0004	0.0002	0.0
4 Other sectors	18.6	1.0	0.07	19.7
5 Other	1.5	0.002	0.01	1.6
A Lubricants	0.5	NA	NA	0.5
B Mobile (military)	1.1	0.002	0.010	1.1
B. Fugitive emissions from fuels	6.2	31.5	0.03	37.7
1 Solid fuels	NE	26.8	NA	26.8
2 Oil and natural gas	6.2	4.6	0.03	10.8

86.9%

Vehicles on Australia's roads

	2002	2006	Change	Average annual growth
	no.	no.	%	%
Passenger vehicles	10 101 441	11 188 880	10.8	2.6
Campervans	35 164	41 520	18.1	4.2
Light commercial vehicles	1 819 993	2 114 333	16.2	3.8
Rigid trucks	341 483	383 546	12.3	2.9
Articulated trucks	63 905	71 680	12.2	2.9
Non-freight carrying trucks	18 797	20 293	8.0	1.9
Buses	70 196	75 375	7.4	1.8
Motor cycles	370 982	463 057	24.8	5.7
Total motor vehicles	**12 821 961**	**14 358 684**	**12.0**	**2.9**

Source: ABS

Main current and potential fuels

current conventional	main current alternatives	main future alternatives	notes
diesel	biodiesel, CNG, LPG, LNG	DME, electric, H2	not electric or H2 for MDV/HDVs. CNG range limiting for HDV.
gasoline	CNG, LPG, EtOH	electric, H2	LNG not for LCV

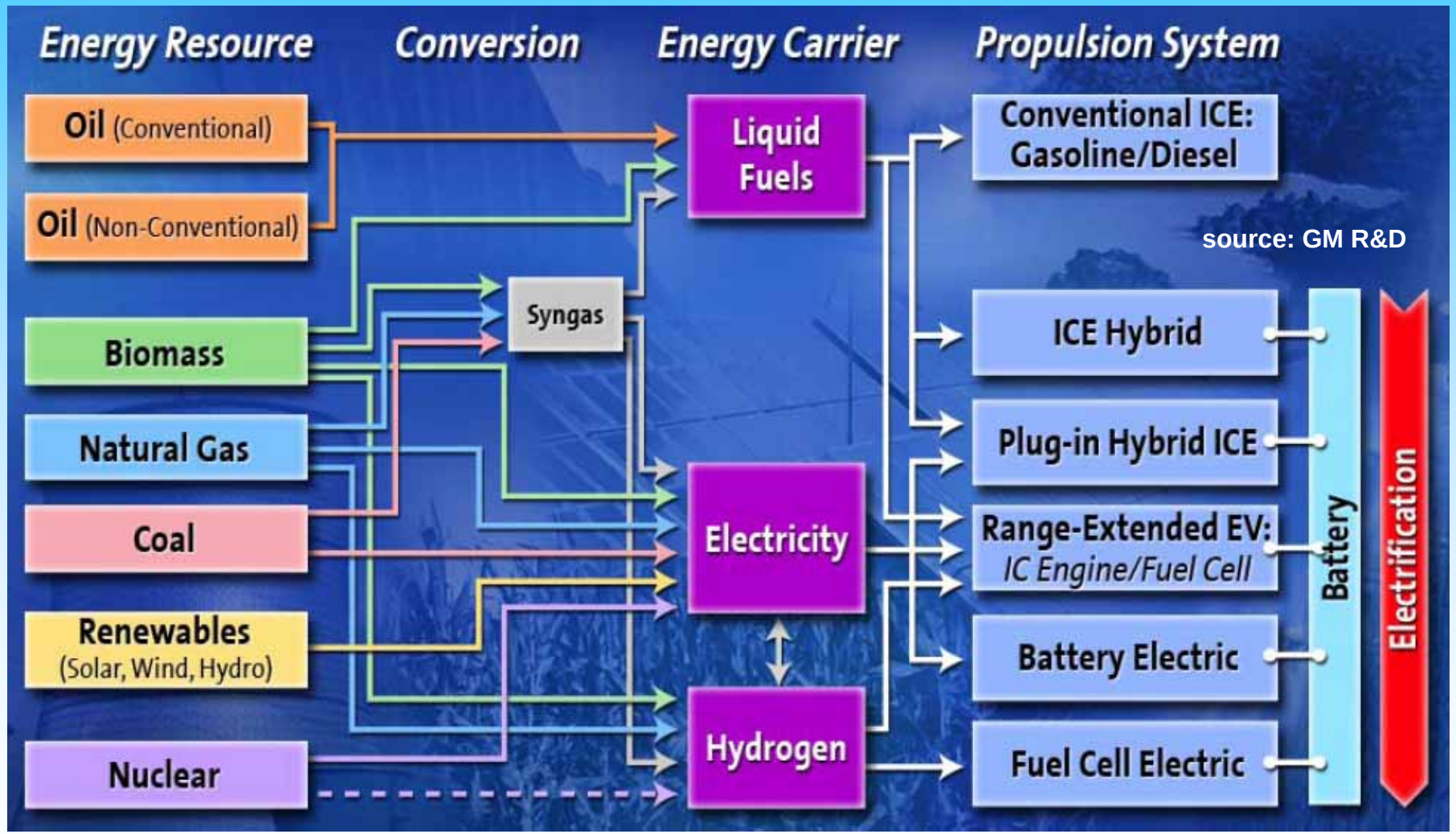
- all current and future alternative fuels listed offer the *potential* of improved pollutant and GHG emissions relative to their conventional equivalents.

Fuel production and distribution

fuel	current production at scale?	future production at scale?	current distribution infrastructure?	notes
gasoline	yes	yes	yes	
CNG	yes	yes	sort of	Gas network in place, bowsers not.
LPG	yes	yes	yes	
hydrogen	no	maybe	no	Might come back via CCS, nuclear, etc.
ethanol	sort of	maybe	yes	Small current local production. Could be imported.
electricity	sort of	maybe	yes	Needs to be mirrored by renewables growth.
diesel	yes	yes	yes	
LNG	yes	yes	sort of	LNG industry is growing rapidly.
biodiesel	no	maybe	yes	What is the future biodiesel production capacity?
DME	no	maybe	no	

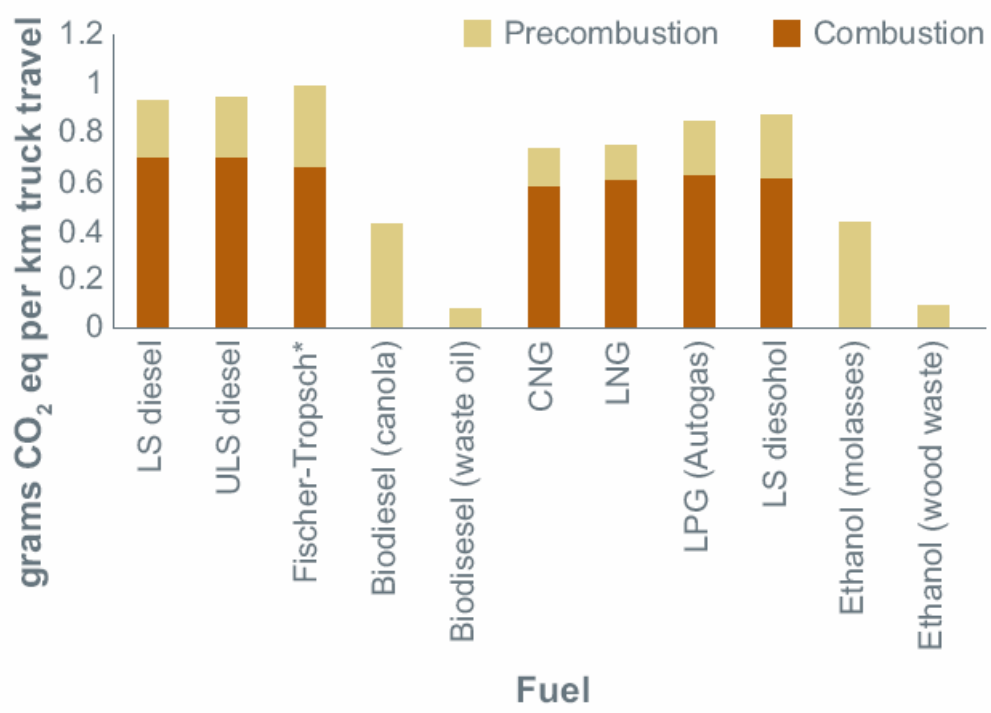
An example of fuel pathways

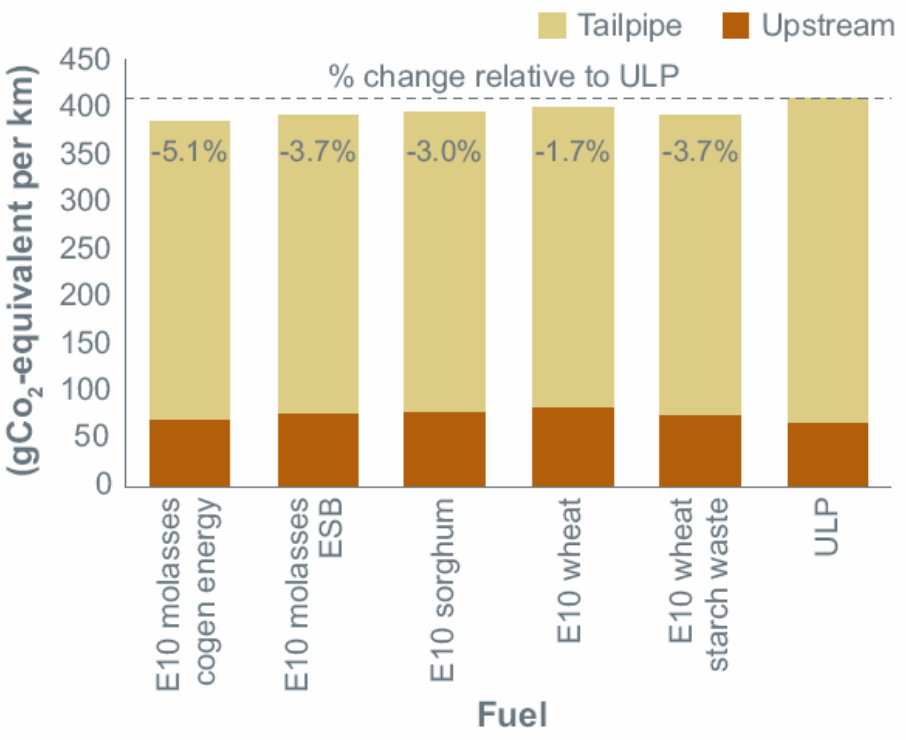
Many ways to skin a cat



Estimate GHG performance by fuel

Source: CSIRO





Why not hydrogen?

- there are critics and admirers of hydrogen. Critics rightly point out the issues of its production, distribution and storage. However,

1) H_2 rich fuels were used widely

- we called it ‘town gas’, ‘producer gas’, etc. It had a distribution infrastructure which we are currently using. Some of us ran our cars on it during WWII.

- the Germans and Japanese used it in Fisher Tropsch - CTL to power their war effort.

2) H_2 ICEs are similar to CNG and LPG designs

- e.g. injection systems, octane rating, control

- an end point in the ‘progressive decarbonisation’ of fuels.

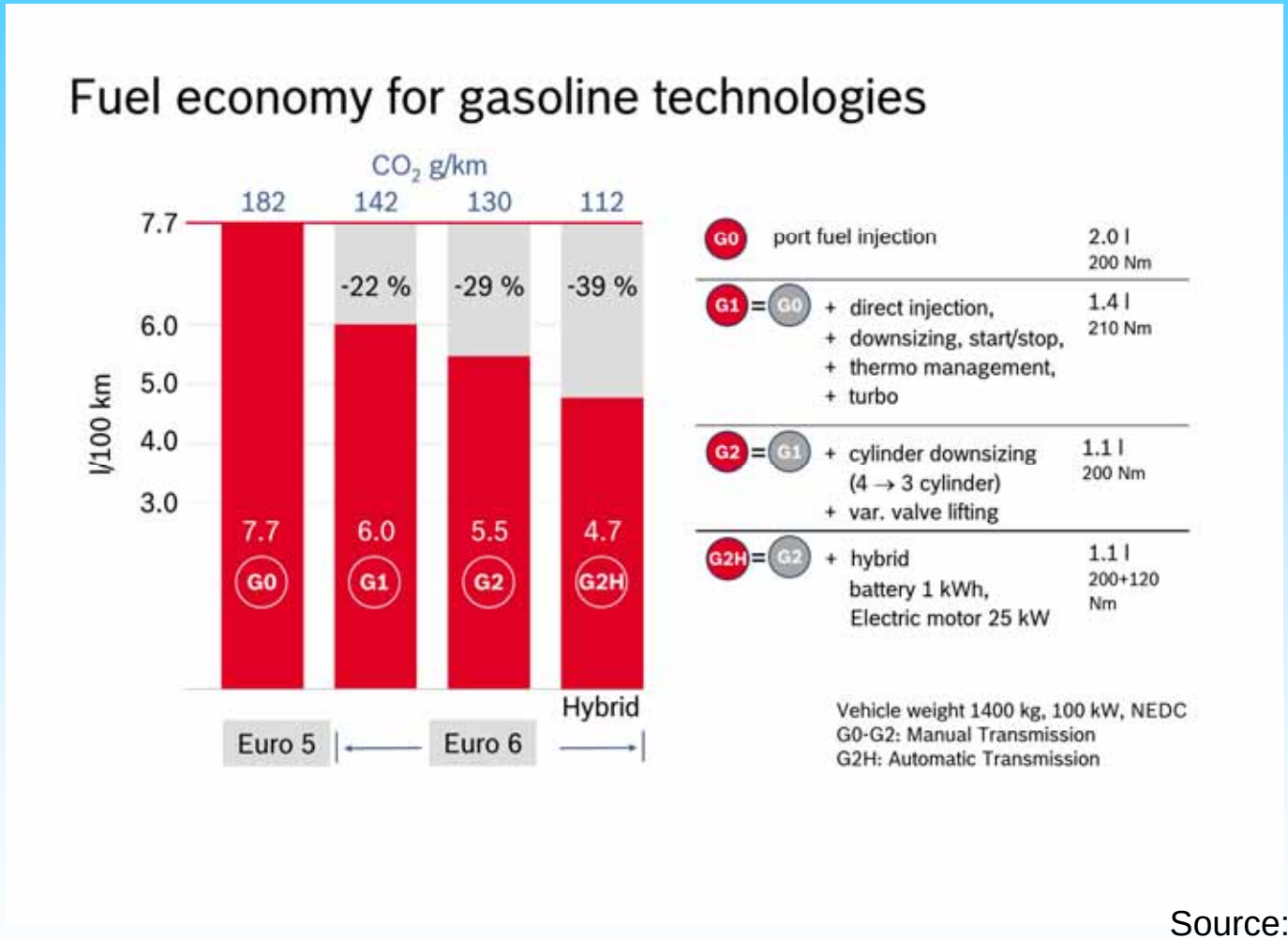
3) H_2 rich fuels may return via several routes

- e.g. IGCC + sequestration, nuclear and biomass derived syngas.

Electric vehicles

- Ferdinand Porsche's first EV was built in 1899. This car won races.
- In 1901, Porsche then added a small IC engine and generator, making the first (series) hybrid.
- Most current EV prototype vehicles feature lithium-ion batteries. The main challenge with these batteries is their price, which ranges over $500-1000 per kWhr. A mid-sized passenger vehicle will have ~20kWhrs of batteries, i.e. $10-20K per vehicle.
- EVs offer very low GHG overall emissions if the electricity is sourced from means other than coal, e.g. renewables, nuclear, etc.

Potential improvements from ICEs



Source: Bosch

Final thoughts and questions

- If fuel cells, batteries and electric motors predate the IC engine, and have been used in vehicles for decades, why aren't they commonly used in production road vehicles?
- Why do ~5% of Australian passenger vehicles run on LPG when conversions are almost free and fuel costs are so low?
- Can we make or import enough biofuel by 2020 to make significant GHG cuts?
- What are the *fastest* and *cheapest* (to both the user and nation) ways to reduce road vehicle GHG emissions?
- Why should transport pay more or less for GHG emissions than other emitters?
- Given all this, which fuels should we support?

What is ACART?

- ACART is a collaborative venture between Ford, the University of Melbourne and the Victorian State Government.
- ACART has advanced facilities and research capabilities for access by external parties, specialising in improved fuel consumption and lower emissions from engines running on conventional and alternative fuels.
- For further information, contact:

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