NZ CLEAN HIGH DUTY CYCLE[1] TRANSPORT: RESEARCH CHALLENGES

	Land		Marine		Aviation			Indicative Challenges[2]		
	Road	Rail	Short eg Waiheke	Coastal +	Short eg drones	Regional	Long-haul			
Supply - Fuel								**Fuel production**	**Storage/ distribution**	**End use**
Coal/NG+CCS → H_2, NH_3 etc[3]	?✓?	?✓?	✓✓?		✓✓?			Conversion mature and sets benchmark for potential gaseous/ liquid fuels. CCS not mature. Cost of conversions to H_2 carriers.	H_2 energy density & containment. H_2 carriers proposed to address H_2's weaknesses.	Conversion cost and efficiency and scale up (incl. carriers)
P → H_2, NH_3 etc[4]	?✓x	✓✓x	✓✓x		✓✓?			Conversion mature, but cost and efficiency issues remain.	Ditto for fossil fuel. [But distributed production an option and likely].	As above for H_2, NH_3 etc from fossil fuel
P → Electric Motor + enhanced charging (incl. gantries etc)	✓✓?	✓✓✓						Mature	Battery energy density and specific energy, charging tech & speed. Distribution mature.	Mature. The addressable market will be defined by the economics of the enhanced charging system.
Bio. → gas (eg CH_4) (Bio → H_2 has potential if H_2 specifically desired)	x✓✓	?✓✓	✓✓✓		✓✓?			Feedstock availability (e.g. waste), dispersed resource, cost and efficiency of pre-processing and upgrading (but both mature).	Mature. Liquid fuels likely to be preferred in the long haul marine and aviation applications.	Mature (bio methane in ICE). Challenges in other gas/motor combinations.
Bio → liquid	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓?	✓✓x	✓✓x	Land use, dispersed resource, cost etc. of pre-processing and upgrading (latter not yet mature).	Mature	Mature depending on level of upgrading and nature of motor.
Bio/P → Hybrid ICE EV	✓✓?	✓✓?	✓✓?	✓✓✓	✓✓?	✓✓?		As above for Bio → liquid production	[Addresses battery energy density and specific energy limitations]	Cost of two technologies. Power density in aviation conversions.
H_2/P → Hybrid FC EV	✓✓?	✓✓?	✓✓?					As above for H_2 production	H_2 & P as above but less acute	As above for Bio → Hybrid use
Demand reduction										
Logistics	-✓✓	-✓✓		-✓✓	-✓✓	-✓✓	-✓✓	"Last mile", impact of ICT/AI/embedded intelligence, freight and passenger vehicle efficiency, better sharing		
Telepresence etc	-✓✓	-✓✓				-✓✓	-✓✓	Human acceptability, technologies and local infrastructure, 3D printing		

Ticks etc. are a very initial and subjective assessment of respectively: feedstock availability relative to market; technology maturity by 2030; and approximate 2030 NZ price relative to a baseline of fossil fuel + CO_2-e @ \$100/t. For demand reduction "feedstock" is not applicable. All fuels can achieve some degree of technology maturity at scale by 2030, the challenge is to then reduce the price, although markets will buy on more than price alone. P → Electric Motor will be economic at the margin of many of the markets, defining the low duty cycle boundary, and is not shown.

Sources: "Hydrogen in NZ" (2019) Concept Consulting; "NZ Biofuels Roadmap" (2018) Scion

[1] Limited to high duty cycle assuming battery technology will be used in applications not constrained by storage and recharge time limitations
[2] A very high level initial identification of where the research challenges lie
[3] Various potential hydrogen carriers including synthetic fuels e.g. conversion to methanol.
[4] Ditto re hydrogen carriers.