

# Transport and Infrastructure Net Zero Consultation Roadmap

## Take the survey

Department of Climate Change, Energy, Environment and Water

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9 Who are you answering on behalf of?

Organisation

10 Organisation name

Stralis Aircraft

11 What best describes you or your organisation?

Industry

12 What sector do you represent?

Other: "Air transport"

13 What state or territory do you live in?

Queensland

14 Postcode

4008

15 What area best describes where you live?

City

16 1. Do you support the proposed guiding principles?

Yes

17 1.1 Please add details to your response.

Yes subject to the feedback raised in this submission and the following recommendations:

1. The necessity of a diversified approach to aviation decarbonisation due to the varied needs across different aviation segments and aircraft types. We need a combination of solutions tailored to specific applications, rather than a one-size-fits-all approach.
2. Recognise advancements in hydrogen-electric and battery-powered aircraft technologies, and their potential for achieving true net zero emissions and operational

efficiencies in domestic aviation services. Leverage hydrogen-electric propulsion systems and new fuels like liquid hydrogen in the roadmap from 2030.

3. Prioritise zero greenhouse gas liquid fuels and technologies to achieve substantial emissions reductions. This includes recognition of green liquid hydrogen as a viable and emissions-free aviation fuel.
4. Urge the inclusion of liquid hydrogen as an official low carbon liquid fuel, supported by infrastructure investments and policy frameworks to spur its development and adoption.
5. Propose a thorough analysis of decarbonisation technologies and fuels and their economic, social, and environmental costs and benefits, to clarify the potential for different options to significantly reduce aviation costs and emissions, across different aircraft segments and services.
6. Fast-track support for emerging technology that decarbonises and electrifies the harder to abate transport modes like aviation in line with the Future Made in Australia plan.
7. Support innovators and invest in Australian manufacturing and skills development for emerging solutions and technology demonstration.
8. Collaborate with industry stakeholders and international alliances to drive innovation, support technology trials, and accelerate the adoption of zero emission aviation solutions.
9. Enable transport infrastructure readiness through demonstrator projects of emerging technologies like hydrogen-electric aircraft and maximising renewable energy generation and integration at airports.
10. Develop robust metrics to measure emissions reductions and technology uptake across all the different transport sectors, setting clear interim targets out to 2050.

**18** 2. Do you support the use of the avoid-shift-improve framework as a tool to identify opportunities for abatement?

Yes

**19** 2.1 Please add details to your response.

Recognising technological 'improvements' to certain transport modes could and will make some poor performing existing modes a better 'shift' option in the future than current 'more sustainable transport modes'. For example, a hydrogen-electric aircraft could provide a far better emissions and cost option than rail or car. Application of the framework and what solutions align to what aspects, should have regular review over time.

**20** 3. Do you agree the development of a national policy framework for

active and public transport will support emissions reduction?

Yes

21 3.1 Please add details to your response.

Not answered

22 4. What should be included in a national policy framework for active and public transport and how should it be developed?

Recognise some areas do not have good active or public transport access, nor would it necessarily be suitable of cost effective e.g. remote, regional, and rural areas.

23 5. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure the movement of people contributes to transport emissions reduction?

Support new and clean transport technology development, demonstrations and roll out in Australia. Promote and facilitate higher value travel and trips, reducing unnecessary travel costs and impact. Facilitate and incentivise shifts to cleaner transport technology and modes, through transparency in information and benefits - low or zero carbon, is not the same as low or zero greenhouse gas emissions per se. Manage and minimise greenwashing.

24 6.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure that the movement of goods contributes to transport emissions reduction?

Embrace, develop and support production and use of new emerging clean transport technologies, including CTOL aircraft, and e-VTOLs; as well as clean energy and fuels that can be produced, supplied, and used locally e.g. green electricity and green liquid hydrogen. Incentivise buy-local and buy-Australian and reduce the distances travelled for goods processing. Facilitate and maximise efficiencies in distribution and logistics around freight and supply chains.

25 6.2. How would these actions address the identified challenges and opportunities for emissions reduction in the movement of goods?

New low emission transport solutions, such as AAM, electric aircraft and eVTOL's could

be especially useful for movement of goods and critical services in remote, rural and regional communities.

26 7. Do you agree with the proposed net zero pathway for light road vehicles?

Yes

27 7.1 Please add details to your response.

Not answered

28 8. The Australian Government is currently developing an Australian New Vehicle Efficiency Standard and has already begun to implement actions in the National Electric Vehicle Strategy.8.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce light vehicle emissions?

Integrate electric charging stations into development plans and building codes, including minimum requirements for all transport infrastructure upgrades and improvements. This includes airports where a large proportion of scope 3 emissions result from people driving to the airport. Standardise EV charging stations and plugs.

29 8.2 How would these actions address the identified challenges and opportunities to reduce light vehicle emissions?

Not answered

30 9. Do you agree with the proposed net zero pathway for heavy road vehicles?

Yes

31 9.1 Please add details to your response

Not answered

32 10. The proposed pathway for heavy road vehicles relies on a mix of

battery electric, hydrogen fuel-cell and low carbon liquid fuels. Rank from 1 to 3, the order in which these should be prioritised for emissions reduction.

1: Battery electric

2: Hydrogen fuel cell

3: Low carbon liquid fuels

**33** 10.1 Please add details to your response. Why did you rank them in that order?

As this is a zero-emission roadmap, they should be ranked in line with their emission reduction potential, alongside consideration of broader sustainability and social credentials. Ranking LCLF is difficult due to limited clarity on what LCLF includes and excludes e.g. is liquid hydrogen included or not? The science and technology is developing rapidly but the emissions reduction potential varies considerably for different types of LCLF, and take-up and infrastructure investment are not fully understood.

**34** 11. What role should low carbon liquid fuels play in the heavy vehicle decarbonisation?

It is not clear if LCLF includes liquid hydrogen. This needs clarity, but assuming it will as it presents a significant opportunity to truly decarbonise heavy haulage, maritime and aviation.

**35** 12. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce heavy vehicle emissions?

Investment in R&D and demonstration projects for new clean technology, and infrastructure, including green liquid hydrogen. Efficiency and maximising logistics and movements, reducing empty vehicles on the roads through incentives and controls.

**36** 13. Do you agree with the proposed net zero pathway for rail?

Yes

**37** 13.1 Please add details to your response.

Not answered

- 38 14. The proposed pathway for rail relies on a mix of battery electric, hydrogen fuel-cell and low carbon liquid fuels. Rank from 1 to 3, the order in which these should be prioritised for emissions reduction.
- 1: Battery electric
  - 2: Hydrogen fuel cell
  - 3: Low carbon liquid fuels
- 39 14.1 Please add details to your response. Why did you rank them in that order?
- As this is a zero-emission roadmap, they should be ranked in line with their emission reduction potential, alongside consideration of broader sustainability and social credentials. Ranking LCLF is difficult due to limited clarity on what LCLF includes and excludes e.g. is liquid hydrogen included or not? The science and technology is developing rapidly but the emissions reduction potential varies considerably for different types of LCLF, and take-up and infrastructure investment are not fully understood.
- 40 15. What role should low carbon liquid fuels play in rail decarbonisation?
- It is not clear if LCLF includes liquid hydrogen. This needs clarity, but assuming it will as it presents a significant opportunity to truly decarbonise heavy haulage, maritime and aviation.
- 41 16. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce rail emissions?
- Not answered
- 42 16.1 How would these actions address the identified challenges and opportunities to reduce rail emissions?
- Not answered
- 43 17. Do you agree with the proposed net zero pathway for maritime?
- Yes

44 17.1 Please add details to your response.

There seems to be a focus on LCLF as the solution for every transport mode without providing transparent information to aid understanding of the different types, emission reduction limitations and capacity/production limits. It would seem to be flagged as the solution for every mode, but practically this will be very challenging if not impossible. What transport modes lend themselves more easily to shift to alternatives such as electric and/or hydrogen and makes sense on emissions, social, economic and sovereign resilience aspects? Some practical production and economic analysis is needed on all the options (existing and emerging) for all transport modes. This will help inform the transport modes or sub-segments where available LCLF should be targeted toward.

45 18. The Australian Government is engaging in consultation as part of the development of the Maritime Emissions Reduction National Action Plan and those consultations will also inform the final Roadmap and Action Plan. 18.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce maritime emissions?

Investment in R&D and demonstration projects for new clean technology, and infrastructure, including hydrogen-electric powertrains and green liquid hydrogen. Aligning with similar demonstrations and infrastructure for other transport modes.

46 18.2 How would these actions address the identified challenges and opportunities to reduce maritime emissions?

Not answered

47 19. Do you agree with the proposed net zero pathway for aviation?

In short, we don't. The focus on SAF as the primary decarbonisation pathway and solution is narrow and short-term, and seems to be driven by lobby groups and incumbent industry players. It is widely known there is no one decarbonisation solution for aviation, and we need a mix of options that are most appropriate for different aircraft and aviation service segments. This should be a foundational piece of work undertaken by the government to understand the range of decarbonisation opportunities and where they are best applied and directed.

There are many challenges with SAF, not just lack of supply and high expense, and wide-ranging emission reduction potential which in some cases questions viability and validity,

amongst other social, economic and environmental limitations. New technologies including electric aircraft powered by batteries and hydrogen, can work towards true net zero outcomes, be quieter, and generate operational savings. Green hydrogen has been identified as a key pathway for decarbonising the aviation sector, see Airbus Zero-e program amongst others. In its liquid form it can be directly used with fuel cells and can also be directly combusted, covering useful ranges and payloads - with the potential to service all domestic routes. Australia has abundant renewables to produce green hydrogen and it can be produced from seawater and provides sovereign fuel security. However, despite this, there does not seem to be adequate policy, strategy, investment, or support for innovative and emerging hydrogen-electric aviation technology or liquid hydrogen production and supply.

The pathway to 2050 depicted in Figure 18 seems very unambitious for anything other than SAF, and fails to recognise the performance and potential of electric, hydrogen, hybrid and potentially ammonia technology under development and in flight testing for commercial application from 2030. By 2050, which is over 25 years away, there will be significant steps made in new and emerging technology. It is a concerning government proposition that by 2040-2050 the "Majority of aviation fuel used in Australia is SAF", as this assertion will NOT get aviation to net zero. It is also worrying that the roadmap limits hydrogen and electric flights to only serving 'short range' by 2040-50 when there are already commitments from big players like Airbus with their ZEROe program, to have hydrogen-powered commercial aircraft entering service by 2035 to complete distances of up to 2000+ nm (3700km) and <200 passengers. Stralis Aircraft in Australia are anticipating ranges of 3000km from their SA1 aircraft. These expected distances cover all existing domestic Australian flights. There are multiple Australian and international outfits, small and large, looking to trial and certify battery and hydrogen electric aircraft from 2030, and they will continue to advance and develop the technology alongside others right out to 2050.

#### 48 19.1 Please add details to your response.

New technologies including electric aircraft powered by batteries and hydrogen, can work towards true net zero outcomes, be quieter and generate operational savings.

The pathway to 2050 depicted in Figure 18 of the roadmap seems unambitious for anything other than SAF, and fails to recognise the variety of electric, hydrogen, hybrid, and emerging ammonia technology and aircraft projects currently under development. There will be significant steps made in new and emerging technologies between now and 2050.

It is a narrow and limiting proposition to suggest by 2040-2050 the "majority of aviation fuel used in Australia will be SAF", as this assertion limits and restricts other viable net zero technologies and options that could potentially service domestic routes. This strategy will not get domestic aviation to net zero which is the focus of the net zero transport roadmap.

The roadmap limits hydrogen and electric flights to only serving "short range" flights in Australia by 2040-50 without qualifying what "short range" alludes to. One of the longest domestic flight routes in Australia is between Perth and Brisbane at 3,614km (1,952 NM) and approximately 4.45 hours flight duration. There are commitments from big aircraft manufacturers like Airbus with their ZEROe program, working to have hydrogen-powered commercial aircraft entering service from 2035 to complete distances of up to 2000+ nm (3700km) and <200 passengers. This would suggest ALL commuter, regional and domestic flights in Australia could be served by hydrogen powered aircraft by 2040-2050.

Closer to home, Stralis Aircraft in Australia is similarly anticipating ranges of around 3000km from its 50-seater SA1 aircraft. There are multiple Australian and international outfits, small and large, looking to trial and certify battery and hydrogen electric aircraft from 2030, and they will continue to advance and develop the technology alongside others right out to 2050. Australia with its renewable energy and hydrogen commitments, has a significant opportunity to demonstrate leadership and transition the Australian aircraft fleet and drive manufacturing of new clean technology and aircraft of the future.

Key insights from mapping a range of different emerging aircraft technology include:

- a. Green Hydrogen is an essential technology for the decarbonisation of domestic aviation in Australia i.e. no-regrets - useful distances and largest decarbonisation lever (also input for e-fuel which could provide energy for international missions).
- b. Battery electric offers early adoption options and smaller distance opportunities, although battery technology is also advancing.
- c. Most current technology companies are based offshore but there is Australian presence and capability working to develop and manufacture aircraft technology.
- d. Useful range of options covering different numbers of passengers and distances, with different levels of maturity and Technology Readiness Level (TRL).
- e. Entry Into Service dates can add 5 years for scalable deployment.

On 24 Jun 24, Joby flew 523 miles in California with an aircraft powered by liquid hydrogen and a fuel cell. The market capitalisation of the company increased by US \$1

billion (30%) – a testament to confidence in the market (medium range hydrogen-electric planes) and in the technology (liquid hydrogen and fuel cells).

The data and information on decarbonisation options and technology, including batteries, seems to be outdated and misleading in the roadmap. Small battery powered electric aircraft are already certified, and are flying in Australia, and Europe is conducting its first international flight trial with electric aircraft (albeit small at this stage). This technology is not only being developed and used by eVTOL aircraft but also CTOL (Conventional Take Off and Landing) aircraft.

It would be interesting to see what mapping the government has done of different emerging aviation technology and investigation into the routes and services that can be serviced by different options, and the economic and emission savings and benefits arising for Australia, airlines and customers.

A foundational piece of work may be needed to understand the different decarbonisation technologies and fuel options and opportunities for aviation sub-sectors and services across Australia, and where they are best applied and directed. Incorporating a thorough analysis of technical specifications against current and projected domestic aviation activity to help the sector and decision makers understand what is anticipated to be available and when, and for what segments. A cost-benefit analysis of different options would be beneficial, on economic, social, and environmental grounds.

The roadmap references legacy aircraft and fleet renewal as a potential inhibitor to transition, however it could make financial sense for airlines to retrofit or procure new hydrogen-electric aircraft that can be flown using less expensive zero-emission fuels, such as liquid hydrogen. Note that companies advancing hydrogen-electric aircraft such as Stralis Aircraft, ZeroAvia and Dovetail, have business plans that incorporate or target aircraft retrofits which enable legacy aircraft to transition.

The roadmap suggests "there is also some uncertainty on the commercial viability of hydrogen and electric propulsion aircraft", however this is the same, if not more so for LCLF and SAF. Hydrogen-electric propulsion systems are technically viable and save on one of the biggest cost areas for airlines - maintenance. Cost forecasts on different energy/fuel types also suggests electricity and hydrogen will be significantly cheaper than fossil fuel and SAF.

Using a well-known metric in the aviation sector (CASK – Cost of Available Seat Kilometre), analysis undertaken by Stralis Aircraft for 2035 suggests that hydrogen-electric technologies could be more commercially viable than battery-electric, fossil fuel

or SAF.

Carbon markets and credits should be further developed to clearly differentiate beyond just 'offsetting', to include 'insetting' programs that can spur investment in Australian low and zero carbon powertrain technologies and aircraft demonstrator programs, to advance and enable a net-zero transition.

This is a 'net zero' transport roadmap and not business-as-usual, so it is going to require a change to the status quo, including innovative technology and new ways of operating in aviation. Note there appears to be little if anything in the roadmap acknowledging and stressing the need for significant operational change, appropriately managing this change and transition, and facilitating sustainable behaviour change and reducing low-value and unnecessary flights and travel, going beyond modal shift.

- 49 20. The Australian Government has already engaged in consultation on aviation decarbonisation through the development of the Aviation White Paper and those consultations will also inform final Roadmap and Action Plan.

Is liquid hydrogen included and recognised as a LCLF, or treated separately? If it is treated separately, where is it recognised and supported in existing or emerging policy frameworks?

- 50 20.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce aviation emissions?

International aviation and shipping emissions should also be considered and factored in to the policy framework, even if they are separated out.

- 51 21. Do you agree with the proposed net zero pathway for transport infrastructure?

Yes

- 52 21.1 Please add details to your response.

The proposed net zero pathway for transport infrastructure is currently quite limited, with the focus on data collection, operational emissions, and investment in low and zero carbon materials. These are all important, but there would seem to be additional key

strategic pathway opportunities not garnered in the document, such as maximising renewable energy generation through existing and new transport infrastructure - to generate the renewable energy to power transport and its operations into the future.

- 53 22. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce transport infrastructure emissions and ensure that transport infrastructure is ready for and enables low-emission transport modes? The proposed net zero pathway for transport infrastructure focuses on data collection, operational emissions, and investment in low and zero carbon materials. These are all important, but additional strategic opportunities are to help airports prepare for new and emerging technology and fuels, such as hydrogen-electric aircraft and liquid hydrogen. In addition, there is an opportunity to incorporate renewable energy generation as part of existing and new transport infrastructure such as airports, including production of new fuels such as green hydrogen to power transport operations into the future. As an example, see Christchurch Airports Kowhai Park.

The three priorities identified for the Commonwealth's investment of productivity, liveability and sustainability provide a good framework for assessing future transport infrastructure investments. There is not much detail on how different types of transport infrastructure should best respond and prioritise, such as airports, ports, and railways. Airports and ports, have a critical opportunity to help enable and facilitate aircraft and ships to transition to zero emission energy and fuels, and to inform and integrate with broader sustainable travel and transport network planning. Airports and ports may well need to produce and distribute cleaner energy and fuels and prepare themselves to service alternative technologies.

The impacts of climate change and extreme weather that are mentioned in the roadmap, such as flooding and bush fires on roads and access, are particularly evident for rural and remote communities. For example, for parts of FNQ flooding prevents fuel getting through by road to enable continued air operations which is the alternative in times of disaster. With clean new aircraft technologies such as battery and hydrogen electric aircraft, the renewable energy required to power these could be produced locally with investment in appropriate infrastructure and does not need to rely on transportation of (mostly imported) fuels to these communities to enable consistent services and supplies (some critical). This increases environmental, social, economic, and sovereign resilience of these communities.

Schemes that help drive and track infrastructure improvements such as the 'Airport

Carbon Accreditation Scheme' should be actively promoted, encouraged, and facilitated as a framework for airports in Australia, encouraging them to work through the levels towards net zero.

54 22.1 How would these actions address the identified challenges and opportunities to reduce transport infrastructure emissions?

Not answered

55 23. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure the energy mix is ready to support transport emissions reduction?

Work to ensure existing and new transport infrastructure and associated investment facilitates and supports generation of renewable energy and fuels where practicable and possible, deploying the energy hub concept like Christchurch Airport in New Zealand.

Will the Future Made in Australia plan, also fast-track support for emerging technology that helps to electrify the harder to abate transport modes like aviation, as electrification has been identified as the primary method for reducing emissions in the transport sector? Even transport modes that are hard to electrify such as aviation, have been electrified – but the technology needs development and deployment in Australia.

We encourage the government to undertake some thorough research work and analysis on what transport modes and vehicles can be serviced by the different alternative technologies such as electrification and hydrogen-electric powertrain systems, not just on emissions, but energy efficiency, economics, and social resilience. Much of Australia's domestic aviation services could for example, be serviced by electric and hydrogen-electric aircraft, but the airlines and industry will need to transition and either retrofit or replace their fleet. It will also require investment and the willingness and foresight to change and move away from BAU. SAF might contribute to emissions reduction for legacy aircraft that cannot be retrofitted but, in most cases, especially short and medium journeys (all of Australian domestic routes), SAF does not deliver the best overall outcome. Hydrogen electric aircraft are anticipated to be significantly cheaper to operate (>50%) which makes the economics attractive too, alongside the true environmental net-zero credentials.

We hope and expect the governments support of a LCLF industry will include liquid hydrogen, as it's such a promising fuel for the hard to abate sectors of aviation, shipping,

and heavy haulage. Despite national policy efforts to support a green hydrogen industry, we understand there is currently no commercial production of liquid hydrogen anywhere in Australia, which sets us behind other advanced, industrialised countries.

## 56 24. How should the use of low carbon liquid fuels (LCLFs) be prioritised across different transport modes over time to achieve maximum abatement?

It is widely known there is no one decarbonisation solution, and we need a mix of options that are most appropriate for different transport sectors and sub-segments.

There is more than one LCLF and Australia should differentiate between them based on their environmental credentials and their suitability for different aviation applications.

As a starting point, the Australian aviation community should aim for and include zero greenhouse gas liquid fuels not just zero or low carbon liquid fuels.

Even if some forms of LCLF and SAF achieve net zero carbon emissions by using natural sources of carbon, combustion will still generate other greenhouse gas emissions.

There is general agreement in the literature that the use of SAF in an existing jet engine means that the engine will operate under the same conditions as for kerosene since equivalent thrust and energy output will be required for the aircraft to operate. The consequence is that even though SAF might reasonably claim to achieve net zero carbon emissions, it will not neutralise the other emissions associated with carbon fuel combustion such as carbon monoxide, volatile organic compounds, and NO<sub>x</sub>. For example, the amount of NO<sub>x</sub> released by SAF fuelled engines is largely unchanged since emissions are dependent on the temperature of combustion rather than the formulation of the fuel itself. A conventional engine will also make the same level of noise, whereas hydrogen electric propulsion systems have the potential to reduce noise levels.

Green liquid hydrogen emits zero greenhouse gases when consumed in a fuel cell and the government should recognise green liquid hydrogen as an official low carbon liquid fuel.

The answer to the question which asked to rank decarbonisation options for transport modes, should be ranked in line with their emission reduction potential and broader sustainability credentials (economic, social, and broader environmental impacts) as this is a net zero transport roadmap.

Therefore, if Australia is to address climate change responsibly, it should adopt zero greenhouse gas liquid fuels or technologies as a priority, then zero carbon liquid fuels and technologies, and only if there are no other options, low carbon liquid fuels.

There seems to be no mention of liquid hydrogen in the roadmap, despite this being a key zero-emission fuel for aviation, heavy haulage and maritime.

IATA's Energy and New Fuels Infrastructure Net Zero Roadmap recognises liquid hydrogen as a key aviation fuel and sets out the need for investment into hydrogen infrastructure now, not later.

Many Australian and international aviation companies such as Airbus, ZeroAvia, Joby, Stralis Aircraft, AMSL Aero, Hypersonix and Dovetail are in the process of developing aircraft that will be powered by liquid hydrogen on the basis of its environmental credentials and its eminent suitability as an aviation fuel.

Green liquid hydrogen has been identified as a key pathway for decarbonising the aviation sector, for example see the Airbus Zero-e program. It can be used with fuel cells in aircraft and produces no emissions other than water vapour and covers useful ranges and payloads.

Australia has abundant renewables to produce green hydrogen and it can be produced from seawater - providing sovereign fuel security. However, despite this, there does not seem to be adequate policy, strategy, investment, or support for liquid hydrogen production and supply.

The round-trip efficiency of liquid hydrogen (LH2) is more efficient than SAF.

Approximately 10% of the renewable energy produced makes it to propulsion via SAF in comparison to 25% of the renewable energy making it to propulsion via LH2.

LCLF doesn't seem to encompass liquid hydrogen in documentation and references, and we urge the government to include liquid hydrogen as an official low carbon liquid fuel for aviation, maritime and heavy vehicle applications and to recognise it as a key opportunity in the roadmap.

57 25. What are the best ways for the Australian Government to work collaboratively with industry, business, governments and communities to implement the proposed pathways?

Engage with a wide range of industry bodies and alliances regularly, in general design and delivery, as well as specific consultations. Seek views from a wide range of players, including innovators and disruptors, not just the long-standing incumbents. Innovation and systems change are often spurred and realised by the former, rarely the latter.

The Australian Jet Zero Council is a great initiative but seems to be lacking representation from clean tech innovators and universities that are progressing innovations beyond SAF.

58 25.1 What are good domestic or international examples of partnership and collaboration on transport and transport infrastructure emissions reduction that could inform the final Roadmap and Action Plan?

47. Good partnership examples include:

- a. The Hydrogen Flight Alliance, progressing Australia's first aircraft flights on green liquid hydrogen from 2025.

- b. Alliance for Zero-Emission Aviation (AZEA) see: [https://defence-industry-space.ec.europa.eu/eu-aeronautics-industry/alliance-zero-emission-aviation\\_en](https://defence-industry-space.ec.europa.eu/eu-aeronautics-industry/alliance-zero-emission-aviation_en)
- c. The New Zealand Hydrogen Aviation Consortium launched in March 2023 and brought together six world leaders in sustainability.
- d. UK Hydrogen in Aviation Alliance formed to establish the UK as a global leader in hydrogen-powered flight.
- e. Clean Aviation Europe and Clean Aviation Joint Undertaking in Europe. Comprising the European Commission, the aeronautics industry (including small and medium businesses), research centres, and academia. European Union's leading research and innovation programme for transforming aviation towards a sustainable and climate neutral future.

**59 25.2 What opportunities can Government leverage to show leadership in Australia and internationally?**

Invest in and support innovators and innovative players and partnerships, and actively support Australian manufacturing and skills development surrounding the solutions and technology demonstrations. For example, those looking to produce liquid hydrogen and hydrogen-electric powertrains and aircraft in Australia, support airports that want to trial new aircraft technologies or produce their own liquid hydrogen due to their remote or regional locations.

The roadmap should incorporate training and skills development and building the capability of Australian engineers and aviation sector staff for production, handling, and use of new aircraft technologies and fuels. Education providers and Universities are key enablers in this regard and help derisk the challenges of new technology implementation such as new fuel storage, transport, and assembly with aircraft.

Other opportunities to show leadership is to use government procurement and service operations to help finance and support new technology and trials e.g. government subsidised or regulated flight routes and aircraft services in Australia.

**60 26. What measures and metrics should be used to evaluate the final Transport and Infrastructure Net Zero Roadmap and Action Plan?**

An absolute measure of reduction in greenhouse gas emissions from Australia's different transport sectors and sub sectors is important in addition to a percentage reduction.

Tracking the availability and uptake of different zero and low emission technologies by the different transport sub sectors, to include electric, hydrogen electric fuel cell, and

hydrogen combustion.

Tracking the production, supply and sale of new low carbon energy and fuels such as green liquid hydrogen, used by different transport modes including aviation.

Charging and refuelling infrastructure for new technology by transport mode e.g. for aviation could monitor electric aircraft charging and liquid hydrogen refuelling by airport.

Identify transport sector specific measures that are most relevant and useful, for example CASK is a key and common measure in aviation and by airlines, this should easily be monitored now and into the future for services operated by different energy and fuel types. This helps to monitor effective investment, and inclusivity and equity. It is expected that electric and hydrogen-electric aircraft would seem to be more favourable for CASK into the future, especially in relation to fossil fuel and SAF.

Set clear interim emission reduction targets for different transport sectors out to 2050, similar to those suggested in the Framework for an Australian Clean Transport Strategy (FACTS produced by the iMOVE CRC).

**61** 26.1 What other data and evidence could governments use and how could this offer further insights on the pace, scale and location of transport emissions reduction pathways?

A Framework for an Australian Clean Transport Strategy (FACTS) that was funded with government funds through the iMOVE CRC: <https://transportfacts.org/> and <https://imoveaustralia.com/project/project-outcomes/facts-a-framework-for-an-australian-clean-transport-strategy/> (it sets out the framework for all modes and has clear policy recommendations for all levels of government in Australia which is helpful and would benefit the national transport emissions reduction pathways).

**62** 27. Do you have any feedback on the proposed review process?

It would be useful to hold specific workshop and consultation sessions, or invite presentations from a wide range of innovators and those developing emerging technology that will decarbonise transport. To learn from international leadership and advancements.

**63** 28. Do you have any further feedback on the Consultation Roadmap and proposed pathways?

Stralis Aircraft fully endorses the submission from the Hydrogen Flight Alliance.

64 28.1 Is there anything missing? Are the sections appropriately integrated? Is the Roadmap appropriately ambitious?

Green liquid hydrogen seems absent and is a critical net zero fuel for hard to abate transport modes.

65 29. Is there any further information or documentation that you wish to be considered with your submission?

Aerospace Technology Institute FlyZero Reports – present a route for a new generation of zero-carbon emission aircraft, airlines, airports and infrastructure.

Hydrogen in Aviation - Launching Hydrogen Powered Aviation Report

Launching Green Hydrogen Powered Aviation in Aotearoa New Zealand

ARUP & MBIE: Pilot Hydrogen Hubs for Trialling Advanced Aviation in New Zealand

AZEA Vision: Flying on electricity and hydrogen in Europe

Simplifying Hydrogen Aviation Powerlist 2023

IATA Net Zero Roadmaps, in particular the aircraft technology and the energy and new fuels infrastructure roadmaps. Liquid hydrogen is clearly recognised as a key future fuel for aviation. The other three roadmaps - operations, finance, and policy - are also useful.

A Framework for an Australian Clean Transport Strategy sets out a clear framework and policy recommendations for different tiers of government for all transport modes.

66 Would you like to upload a document?

Yes

67 Have you removed any identifying information from your submission?

Yes

68 Upload a submission

HFA Transport and Infrastructure NZE Roadmap Submission.pdf

**69** Upload a submission

Not answered

**70** Upload supporting file

Stralis Intro Deck July 2024.pdf

**71** Upload supporting file

FACTS-A-Framework-for-an-Australian-Clean-Transport-Strategy-2022.pdf



26 July 2024

## HFA Submission for the Transport and Infrastructure Net Zero Consultation Roadmap

The [Hydrogen Flight Alliance \(HFA\)](#) welcomes the opportunity to provide a submission for the Transport and Infrastructure Net Zero Consultation Roadmap. The HFA was officially launched in June 2023 with the attendance of the Hon Mick de Brenni MP, Queensland Minister for Energy, Renewables and Hydrogen, and is working collectively to create a collaborative environment to advance hydrogen electric flight in Australia, using green liquid hydrogen. Our members include:

1. [Stralis Aircraft](#)
2. [Skytrans Airlines](#)
3. [Brisbane Airport](#)
4. [Gladstone Airport](#)
5. [Aviation Australia](#)
6. [AMSL Aero](#)
7. [Royal Flying Doctors Service QLD](#)
8. [Toowoomba Wellcamp Airport](#)
9. [BOC, a Linde Company](#)
10. [H2 Energy Company \(h2ec\)](#)
11. [Griffith University](#)
12. [Central Queensland University](#)
13. [Queensland University of Technology](#)
14. [Hypersonix](#)
15. [Fabrum Liquid Hydrogen Solutions](#)

The focus of the HFA is to enable emission free hydrogen powered propulsion and flight in Australia from mid-2025, working toward commercial flights from 2026. Green liquid hydrogen, produced locally from renewable energy sources in Australia, will be used as fuel, which is converted to electrical power using a hydrogen fuel cell.

Green liquid hydrogen will play a crucial role in aerospace decarbonisation and can be used for direct combustion or with fuel cells to power aircraft. This includes efforts by global leaders such as [Airbus](#). The IATA [Aircraft Technology Net Zero Roadmap](#) clearly identifies liquid hydrogen as a key energy solution, with advanced fuel cell flight tests with liquid hydrogen commencing from 2023.

Closer to home, HFA members Stralis Aircraft, AMSL Aero and Hypersonix are all designing, developing and testing new aerospace technology and powertrain systems that will use liquid hydrogen as fuel. These are all being developed in Australia with a global customer base.

The HFA have provided feedback on the most relevant sections of the Transport and Infrastructure Net Zero Consultation Roadmap based on our work to date and priority action areas in the following pages.

In summary, key recommendations from the HFA include:

1. The necessity of a diversified approach to aviation decarbonisation due to the varied needs across different aviation segments and aircraft types. We need a combination of solutions tailored to specific applications, rather than a one-size-fits-all approach.
2. Recognise advancements in hydrogen-electric and battery-powered aircraft technologies, and their potential for achieving true net zero emissions and operational efficiencies in domestic aviation services. Leverage hydrogen-electric propulsion systems and new fuels like liquid hydrogen in the roadmap from 2030.
3. Prioritise zero greenhouse gas liquid fuels and technologies to achieve substantial emissions reductions. This includes recognition of green liquid hydrogen as a viable and emissions-free aviation fuel.
4. Urge the inclusion of liquid hydrogen as an official low carbon liquid fuel, supported by infrastructure investments and policy frameworks to spur its development and adoption.
5. Propose a thorough analysis of decarbonisation technologies and fuels and their economic, social, and environmental costs and benefits, to clarify the potential for different options to significantly reduce aviation costs and emissions, across different aircraft segments and services.
6. Fast-track support for emerging technology that decarbonises and electrifies the harder to abate transport modes like aviation in line with the Future Made in Australia plan.
7. Support innovators and invest in Australian manufacturing and skills development for emerging solutions and technology demonstration.
8. Collaborate with industry stakeholders and international alliances to drive innovation, support technology trials, and accelerate the adoption of zero emission aviation solutions.
9. Enable transport infrastructure readiness through demonstrator projects of emerging technologies like hydrogen-electric aircraft and maximising renewable energy generation and integration at airports.
10. Develop robust metrics to measure emissions reductions and technology uptake across all the different transport sectors, setting clear interim targets out to 2050.

If you have any queries or would like to follow up, please get in touch.

Best regards,



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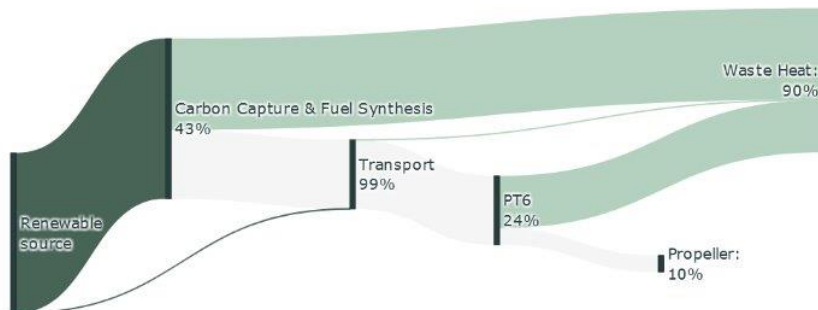
## NET ZERO PATHWAY FOR AVIATION

### Low Carbon Liquid Fuels (LCLF) and Sustainable Aviation Fuels (SAF)

1. It is widely known there is no one decarbonisation solution for aviation, and we need a mix of options that are most appropriate for different aircraft and aviation service segments.
2. There is more than one LCLF and Australia should differentiate between them based on their environmental credentials and their suitability for different aviation applications.
3. As a starting point, the Australian aviation community should aim for and include zero greenhouse gas liquid fuels not just zero or low carbon liquid fuels.
4. Even if some forms of LCLF and SAF achieve net zero carbon emissions by using natural sources of carbon, combustion will still generate other greenhouse gas emissions.
5. There is general agreement in the literature that the use of SAF in an existing jet engine means that the engine will operate under the same conditions as for kerosene since equivalent thrust and energy output will be required for the aircraft to operate. The consequence is that even though SAF might reasonably claim to achieve net zero carbon emissions, it will not neutralise the other emissions associated with carbon fuel combustion such as carbon monoxide, volatile organic compounds, and NOx. For example, the amount of NOx released by SAF fuelled engines is largely unchanged since emissions are dependent on the temperature of combustion rather than the formulation of the fuel itself. A conventional engine will also make the same level of noise, whereas hydrogen electric propulsion systems have the potential to reduce noise levels.
6. Green liquid hydrogen emits zero greenhouse gases when consumed in a fuel cell and the government should recognise green liquid hydrogen as an official low carbon liquid fuel.
7. The question which asked to rank decarbonisation options for other modes such as rail and heavy transport, has not been asked for aviation and maritime transport modes. The answer would be the same, as this is a zero-emission transport roadmap, the options should be ranked in line with their emission reduction potential and broader sustainability credentials (economic, social, and broader environmental impacts).
8. Therefore, if the Australian aviation sector is to address climate change responsibly, it should adopt zero greenhouse gas liquid fuels or technologies as a priority (noting electric aircraft are operating commercially in Australia), then zero carbon liquid fuels and technologies, and only if there are no other options, low carbon liquid fuels.
9. There seems to be no mention of liquid hydrogen in the roadmap, despite this being a key zero-emission fuel for aviation (as well as a key fuel for heavy haulage and maritime).
10. IATA's [Energy and New Fuels Infrastructure Net Zero Roadmap](#) recognises liquid hydrogen as a key aviation fuel and sets out the need for investment into hydrogen infrastructure now, not later.
11. Many Australian and international aviation companies such as Airbus, ZeroAvia, Joby, Stralis Aircraft, AMSL Aero, Hypersonix and Dovetail are in the process of developing aircraft that will be powered by liquid hydrogen on the basis of its environmental credentials and its eminent suitability as an aviation fuel.
12. Green liquid hydrogen has been identified as a key pathway for decarbonising the aviation sector, for example see the [Airbus Zero-e program](#). It can be used with fuel cells in aircraft and produces no emissions other than water vapour and covers useful ranges and payloads.
13. Australia has abundant renewables to produce green hydrogen and it can be produced from seawater - providing sovereign fuel security. However, despite this, there does not seem to be adequate policy, strategy, investment, or support for liquid hydrogen production and supply.

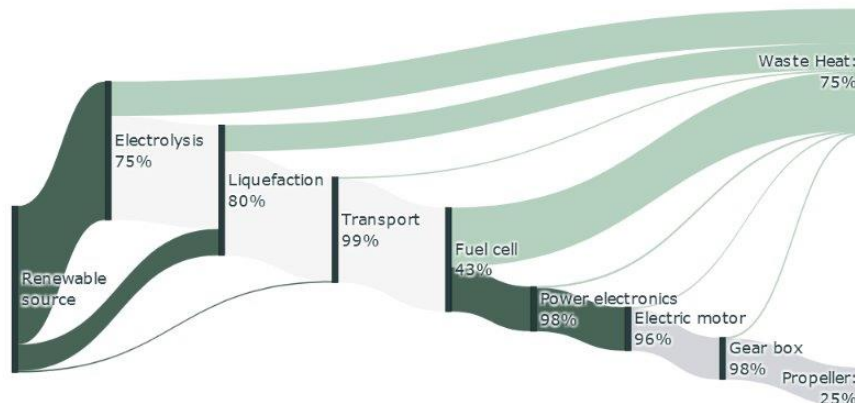
14. The round-trip efficiency of liquid hydrogen (LH2) is more efficient than SAF. Approximately 10% of the renewable energy produced makes it to propulsion via SAF in comparison to 25% of the renewable energy making it to propulsion via LH2. See efficiency cascades below:

Renewable energy source to propeller efficiency cascade: SAF electrofuel by Prometheus.



Source: Stralis Aircraft, Prometheus Fuels and B1900D Operating Handbook

Renewable energy source to propeller efficiency cascade: Green hydrogen.



Source: Stralis Aircraft and US Department of Energy

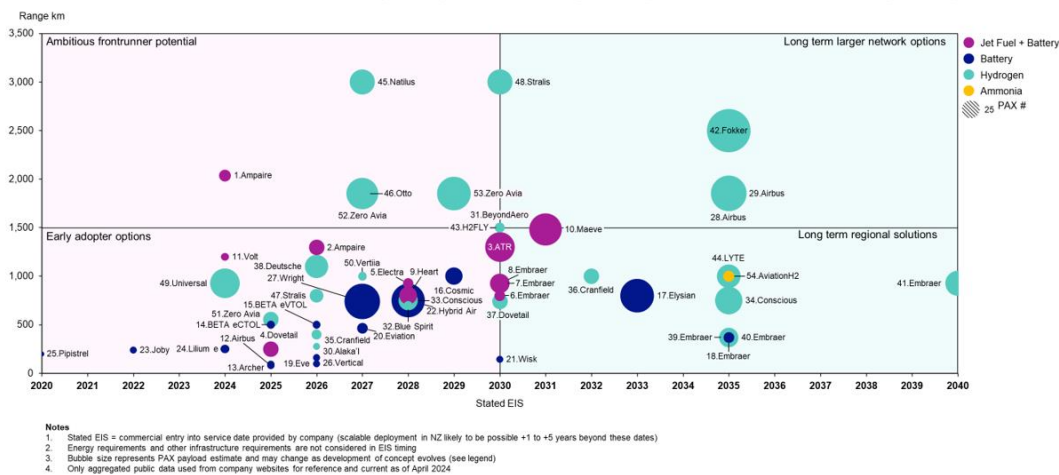
15. LCLF doesn't seem to encompass liquid hydrogen in documentation and references, and we urge the government to include liquid hydrogen as an official low carbon liquid fuel for aviation, maritime and heavy vehicle applications and to recognise it as a key opportunity in the roadmap.

### Clean Hydrogen-Electric Aircraft Technology

16. New technologies including electric aircraft powered by batteries and hydrogen, can work towards true net zero outcomes, be quieter and generate operational savings.
17. The pathway to 2050 depicted in Figure 18 of the roadmap seems unambitious for anything other than SAF, and fails to recognise the variety of electric, hydrogen, hybrid, and emerging ammonia technology and aircraft projects currently under development. There will be significant steps made in new and emerging technologies between now and 2050.
18. It is a narrow and limiting proposition to suggest by 2040-2050 the "majority of aviation fuel used in Australia will be SAF", as this assertion limits and restricts other viable net zero technologies and options that could potentially service domestic routes. This strategy will not get domestic aviation to net zero which is the focus of the net zero transport roadmap.

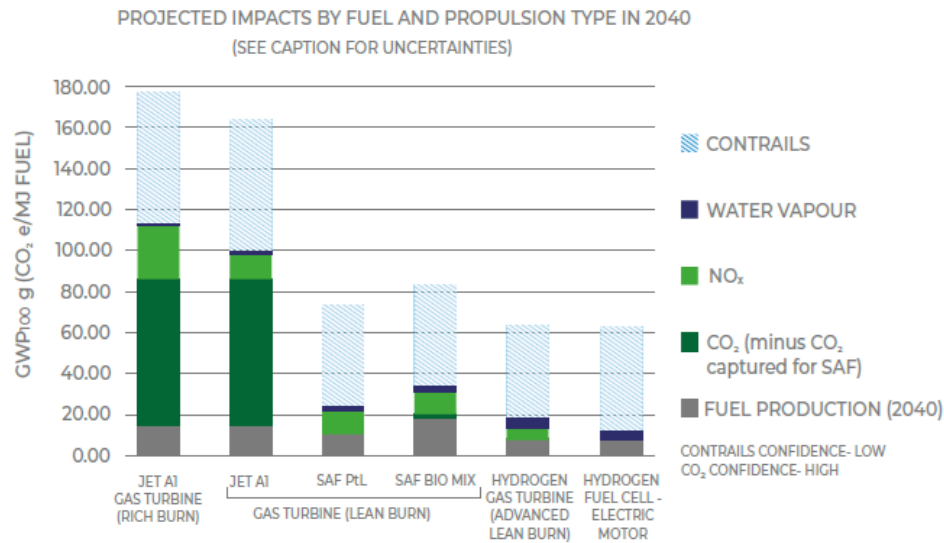
19. The roadmap limits hydrogen and electric flights to only serving “short range” flights in Australia by 2040-50 without qualifying what “short range” alludes to. One of the longest domestic flight routes in Australia is between Perth and Brisbane at 3,614km (1,952 NM) and approximately 4.45 hours flight duration. There are commitments from big aircraft manufacturers like Airbus with their [ZEROe program](#), working to have hydrogen-powered commercial aircraft entering service from 2035 to complete distances of up to 2000+ nm (3700km) and <200 passengers. This would suggest ALL commuter, regional and domestic flights in Australia could be served by hydrogen powered aircraft by 2040-2050.
20. Closer to home, Stralis Aircraft in Australia is similarly anticipating ranges of around 3000km from its 50-seater SA1 aircraft. There are multiple Australian and international outfits, small and large, looking to trial and certify battery and hydrogen electric aircraft from 2030, and they will continue to advance and develop the technology alongside others right out to 2050. Australia with its renewable energy and hydrogen commitments, has a significant opportunity to demonstrate leadership and transition the Australian aircraft fleet and drive manufacturing of new clean technology and aircraft of the future.
21. The figure below developed by Stralis Aircraft working with industry partners, summarises and compares a selection of emerging Next Generation Aircraft Technology for their range and passengers, against entry-into-service dates:

**Aircraft concept comparison of passenger payload capability & range vs proposed availability timing**



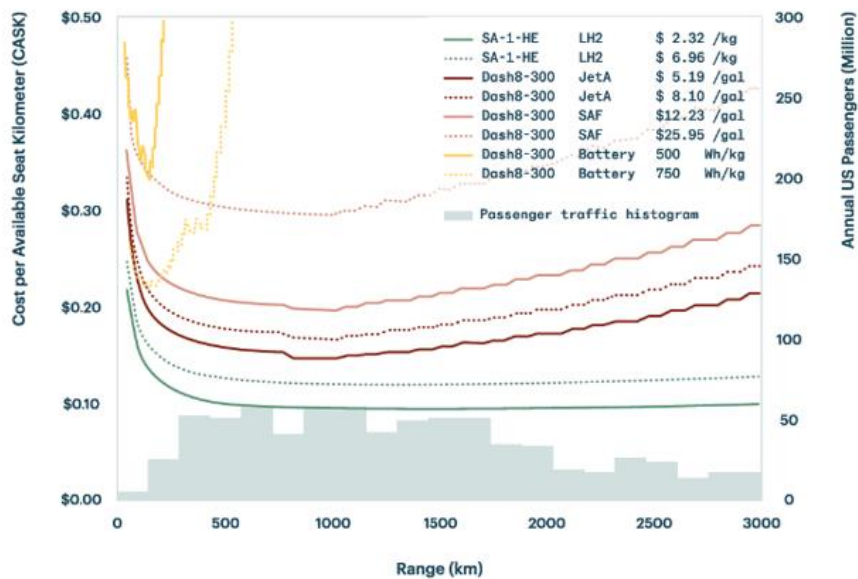
22. Key insights from this mapping include:
  - a. **Green Hydrogen** is an essential technology for the decarbonisation of domestic aviation in Australia i.e. **no-regrets** - useful distances and largest decarbonisation lever (also input for e-fuel which could provide energy for international missions).
  - b. **Battery electric** offers early adoption options and smaller distance opportunities, although battery technology is also advancing.
  - c. **Most current technology** companies are based offshore but there is Australian presence and capability working to develop and manufacture aircraft technology.
  - d. **Useful range** of options covering different numbers of passengers and distances, with different levels of maturity and Technology Readiness Level (TRL).
  - e. **Entry Into Service** dates can add 5 years for scalable deployment.
23. On 24 Jun 24, Joby flew 523 miles in California with an aircraft powered by liquid hydrogen and a fuel cell. The market capitalisation of the company increased by US \$1 billion (30%) – a testament to confidence in the market (medium range hydrogen-electric planes) and in the technology (liquid hydrogen and fuel cells).

24. This figure from ATI's FlyZero Sustainability Report illustrates emissions impact of different options excluding electric which is emission free if running from renewable electricity:



25. The data and information on decarbonisation options and technology, including batteries, seems to be outdated and misleading in the roadmap. Small battery powered electric aircraft are already certified, and are flying in Australia, and Europe is conducting its first international flight trial with electric aircraft (albeit small at this stage). This technology is not only being developed and used by eVTOL aircraft but also CTOL (Conventional Take Off and Landing) aircraft.
26. It would be interesting to see what mapping the government has done of different emerging aviation technology and investigation into the routes and services that can be serviced by different options, and the economic and emission savings and benefits arising for Australia, airlines and customers.
27. A foundational piece of work may be needed to understand the different decarbonisation technologies and fuel options and opportunities for aviation sub-sectors and services across Australia, and where they are best applied and directed. Incorporating a thorough analysis of technical specifications against current and projected domestic aviation activity to help the sector and decision makers understand what is anticipated to be available and when, and for what segments. A cost-benefit analysis of different options would be beneficial, on economic, social, and environmental grounds.
28. The roadmap references legacy aircraft and fleet renewal as a potential inhibitor to transition, however it could make financial sense for airlines to retrofit or procure new hydrogen-electric aircraft that can be flown using less expensive zero-emission fuels, such as liquid hydrogen. Note that companies advancing hydrogen-electric aircraft such as Stralis Aircraft, ZeroAvia and Dovetail, have business plans that incorporate or target aircraft retrofits which enable legacy aircraft to transition.
29. The roadmap suggests "there is also some uncertainty on the commercial viability of hydrogen and electric propulsion aircraft", however this is the same, if not more so for LCLF and SAF. Hydrogen-electric propulsion systems are technically viable and save on one of the biggest cost areas for airlines - maintenance. Cost forecasts on different energy/fuel types also suggests electricity and hydrogen will be significantly cheaper than fossil fuel and SAF.

30. Using a well-known metric in the aviation sector (CASK – Cost of Available Seat Kilometre), analysis undertaken by Stralis Aircraft for 2035 suggests that hydrogen-electric technologies could be more commercially viable than battery-electric, fossil fuel or SAF. See figure below:



Source: Stralis Aircraft using data from IRENA, CEFC and ICF Report for ATAG

31. Carbon markets and credits should be further developed to clearly differentiate beyond just 'offsetting', to include 'insetting' programs that can spur investment in Australian low and zero carbon powertrain technologies and aircraft demonstrator programs, to advance and enable a net-zero transition.
32. This is a 'net zero' transport roadmap and not business-as-usual, so it is going to require a change to the status quo, including innovative technology and new ways of operating in aviation. Note there appears to be little if anything in the roadmap acknowledging and stressing the need for significant operational change, appropriately managing this change and transition, and facilitating sustainable behaviour change and reducing low-value and unnecessary flights and travel, going beyond modal shift.

## TRANSPORT INFRASTRUCTURE

33. The proposed net zero pathway for transport infrastructure focuses on data collection, operational emissions, and investment in low and zero carbon materials. These are all important, but additional strategic opportunities are to help airports prepare for new and emerging technology and fuels, such as hydrogen-electric aircraft and liquid hydrogen. In addition, there is an opportunity to incorporate renewable energy generation as part of existing and new transport infrastructure such as airports, including production of new fuels such as green hydrogen to power transport operations into the future. As an example, see [Christchurch Airports Kowhai Park](#).
34. The three priorities identified for the Commonwealth's investment of productivity, liveability and sustainability provide a good framework for assessing future transport infrastructure investments. There is not much detail on how different types of transport infrastructure should best respond and prioritise, such as airports, ports, and railways. Airports and ports, have a critical opportunity to help enable and facilitate aircraft and ships to transition to

zero emission energy and fuels, and to inform and integrate with broader sustainable travel and transport network planning. Airports and ports may well need to produce and distribute cleaner energy and fuels and prepare themselves to service alternative technologies.

35. The impacts of climate change and extreme weather that are mentioned in the roadmap, such as flooding and bush fires on roads and access, are particularly evident for rural and remote communities. For example, for parts of FNQ flooding prevents fuel getting through by road to enable continued air operations which is the alternative in times of disaster. With clean new aircraft technologies such as battery and hydrogen electric aircraft, the renewable energy required to power these could be produced locally with investment in appropriate infrastructure and does not need to rely on transportation of (mostly imported) fuels to these communities to enable consistent services and supplies (some critical). This increases environmental, social, economic, and sovereign resilience of these communities.
36. Schemes that help drive and track infrastructure improvements such as the 'Airport Carbon Accreditation Scheme' should be actively promoted, encouraged, and facilitated as a framework for airports in Australia, encouraging them to work through the levels towards net zero.

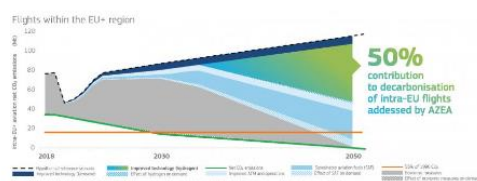
## TRANSPORT ENERGY USE

37. Work to ensure existing and new transport infrastructure and associated investment facilitates and supports generation of renewable energy and fuels where practicable and possible, deploying the energy hub concept like Christchurch Airport in New Zealand.
38. Will the Future Made in Australia plan, also fast-track support for emerging technology that helps to electrify the harder to abate transport modes like aviation, as electrification has been identified as the primary method for reducing emissions in the transport sector? Even transport modes that are hard to electrify such as aviation, have been electrified – but the technology needs development and deployment in Australia.
39. We encourage the government to undertake some thorough research work and analysis on what transport modes and vehicles can be serviced by the different alternative technologies such as electrification and hydrogen-electric powertrain systems, not just on emissions, but energy efficiency, economics, and social resilience. Much of Australia's domestic aviation services could for example, be serviced by electric and hydrogen-electric aircraft, but the airlines and industry will need to transition and either retrofit or replace their fleet. It will also require investment and the willingness and foresight to change and move away from BAU. SAF might contribute to emissions reduction for legacy aircraft that cannot be retrofitted but, in most cases, especially short and medium journeys (all of Australian domestic routes), SAF does not deliver the best overall outcome.
40. Hydrogen electric aircraft are anticipated to be significantly cheaper to operate (>50%) which makes the economics attractive too, alongside the true environmental net-zero credentials.
41. We hope and expect the governments support of a LCLF industry will include liquid hydrogen, as it's such a promising fuel for the hard to abate sectors of aviation, shipping, and heavy haulage. Despite national policy efforts to support a green hydrogen industry, we understand there is currently no commercial production of liquid hydrogen anywhere in Australia, which sets us behind other advanced, industrialised countries.

## TRAVELLING IN PARTNERSHIP

42. Engage with a wide range of industry bodies and alliances regularly, in general design and delivery, as well as specific consultations. Seek views from a wide range of players, including innovators and disrupters, not just the long-standing incumbents. Innovation and systems change are often spurred and realised by the former, rarely the latter.
43. The Australian Jet Zero Council is a great initiative but seems to be lacking representation from clean tech innovators and universities that are progressing innovations beyond SAF.
44. Invest in and support innovators and innovative players and partnerships, and actively support Australian manufacturing and skills development surrounding the solutions and technology demonstrations. For example, those looking to produce liquid hydrogen and hydrogen-electric powertrains and aircraft in Australia, support airports that want to trial new aircraft technologies or produce their own liquid hydrogen due to their remote or regional locations.
45. The roadmap should incorporate training and skills development and building the capability of Australian engineers and aviation sector staff for production, handling, and use of new aircraft technologies and fuels. Education providers and Universities are key enablers in this regard and help derisk the challenges of new technology implementation such as new fuel storage, transport, and assembly with aircraft.
46. Other opportunities to show leadership is to use government procurement and service operations to help finance and support new technology and trials e.g. government subsidised or regulated flight routes and aircraft services in Australia.
47. Good partnership examples include:
  - a. The [Hydrogen Flight Alliance](#), progressing Australia's first aircraft flights on green liquid hydrogen from 2025.
  - b. Alliance for Zero-Emission Aviation (AZE) see: [https://defence-industry-space.ec.europa.eu/eu-aeronautics-industry/alliance-zero-emission-aviation\\_en](https://defence-industry-space.ec.europa.eu/eu-aeronautics-industry/alliance-zero-emission-aviation_en)

- The objective of the Alliance is to **prepare the market for the entry into service of zero-emission aircraft**.
- The novel propulsion technologies used by such aircraft will have a profound impact not only on aircraft design, but also on the fuels and **airport infrastructures** they require and on the way they are operated. Airline business models may also be affected.
- The Alliance will comprehensively **identify and prioritise the challenges** posed by zero-emission aircraft and **propose practical solutions** to overcome these.



Hydrogen (whether used in combustion turbines or fuel cells) and battery electric propulsion will completely eliminate in-flight CO<sub>2</sub> emissions and significantly reduce other emissions.

- c. The [New Zealand Hydrogen Aviation Consortium](#) launched in March 2023 and brought together six world leaders in sustainability.
- d. [UK Hydrogen in Aviation Alliance](#) formed to establish the UK as a global leader in hydrogen-powered flight.
- e. [Clean Aviation Europe](#) and [Clean Aviation Joint Undertaking](#) in Europe. Comprising the European Commission, the aeronautics industry (including small and medium businesses), research centres, and academia. European Union's leading research and innovation programme for transforming aviation towards a sustainable and climate neutral future.

## MEASURING SUCCESS

48. An absolute measure of reduction in greenhouse gas emissions from Australia’s different transport sectors and sub sectors is important in addition to a percentage reduction.
49. Tracking the availability and uptake of different zero and low emission technologies by the different transport sub sectors, to include electric, hydrogen electric fuel cell, and hydrogen combustion.
50. Tracking the production, supply and sale of new low carbon energy and fuels such as green liquid hydrogen, used by different transport modes including aviation.
51. Charging and refuelling infrastructure for new technology by transport mode e.g. for aviation could monitor electric aircraft charging and liquid hydrogen refuelling by airport.
52. Identify transport sector specific measures that are most relevant and useful, for example CASK is a key and common measure in aviation and by airlines, this should easily be monitored now and into the future for services operated by different energy and fuel types. This helps to monitor effective investment, and inclusivity and equity. It is expected that electric and hydrogen-electric aircraft would seem to be more favourable for CASK into the future, especially in relation to fossil fuel and SAF.
53. Set clear emission reduction targets for different transport sectors out to 2050, similar to those suggested in the Framework for an Australian Clean Transport Strategy below:



### Light vehicle targets

A national target of 1 million zero emission light vehicles by 2027

State 2027 zero emission light vehicle targets QLD: 200k, NSW: 300k, VIC 275k, SA: 75k, WA: 100k, TAS: 25k, ACT: 20k, NT: 5k

55% zero emission light vehicle sales by 2030 (a fleet of 2-2.5 million vehicles)

100% zero emission light vehicle sales by 2035

100% zero emission light vehicle fleet by 2045



### Government fleet targets

100% of new government vehicles to be 0g CO<sub>2</sub>/km by 2023 – where fit-for-purpose models are available

100% of government fleet vehicles to be 0g CO<sub>2</sub>/km by 2027 – where fit-for-purpose models are available

100% of service vehicles to be 0g CO<sub>2</sub>/km by 2030 – where fit-for-purpose models are available



### Mode share shift targets

50% active and public transport



### Domestic Aviation targets

20% fossil free domestic aviation by 2030

50% fossil free domestic aviation by 2035

Net zero domestic aviation by 2045

### International Aviation targets

20% fossil free international aviation by 2035

50% fossil free international aviation by 2045

Net zero international aviation by 2050





## RELEVANT RESOURCES

Aerospace Technology Institute [FlyZero Reports](#) – present a route for a new generation of zero-carbon emission aircraft, airlines, airports and infrastructure.

Hydrogen in Aviation - [Launching Hydrogen Powered Aviation Report](#)

[Launching Green Hydrogen Powered Aviation in Aotearoa New Zealand](#)

[ARUP & MBIE: Pilot Hydrogen Hubs for Trialling Advanced Aviation in New Zealand](#)

[AZEA Vision: Flying on electricity and hydrogen in Europe](#)

[Simplifying Hydrogen Aviation Powerlist 2023](#)

[IATA Net Zero Roadmaps](#), in particular the aircraft technology and the energy and new fuels infrastructure roadmaps. Liquid hydrogen is clearly recognised as a key future fuel for aviation. The other three roadmaps - operations, finance, and policy - are also useful.

[A Framework for an Australian Clean Transport Strategy](#) sets out a clear framework and policy recommendations for different tiers of government for all transport modes.