Low Carbon Liquid Fuels - A Future Made in Australia Unlocking Australia's low carbon liquid fuel opportunity

Low Carbon Liquid Fuels (LCLFs) are a key tool for the transport sector to adopt zero emissions technologies in a structured and commercially viable transition program by 2050.

LCLFs are attractive to industry, in particular the heavy vehicle road and regional and freight rail sectors, as a "drop in" fuel (i.e. direct replacement for existing fuels) to initially minimise disruption to existing operational practices and established logistics supply chains.

Global forecasts identify the road, rail and the mining sectors (biodiesel and renewable diesel) as the key initial markets for LCLFs, with harder to abate sectors such as Aviation (Sustainable Aviation Fuel - SAF) and Maritime (methanol and green ammonia), where zero emissions technologies are still developing, transitioning to LCLFs later.

LCLFs are an opportunity to provide national economic and energy security and resilience in the transition to zero emissions technologies.

LCLF transition market demand

The current Australian liquid fuel market for the transport sector was 56 billion litres in 2022-2023. Of this, approximately 32 billion litres were diesel fuels, 16 billion litres were petrochemical based fuels, and 7.5 billion litres were aviation fuels[1]. The road transport sector is the largest consumer of energy in the transport sector with over 77% of total energy demand, followed by aviation 11.5%, rail 4.5%, and maritime 4%[2].

The Bureau of Infrastructure and Transport Research Economics (BITRE) "medium growth" scenario forecasts the domestic transport task will increase by 26% over the next decade[3]. This is expected to result in an equivalent increase in fuel consumption resulting in the requirement of an equivalent of over 40 billion litres of diesel fuels by 2050.

There is a strong opportunity and market for LCLFs in the transport sector to form part of a transition strategy to zero emissions by 2050. The use of LCLFs as either a drop in fuel (renewable diesel) or as a blend with existing petrochemical-based fuels (biodiesel) can support industry in achieving staged reductions in their emissions aligned with corporate and national targets. The CEFC[4] notes that to align with global biofuel production requirements, Australia will need to increase its biofuel output by over 40 times current production levels, generating approximately 20 billion litres of biofuel per annum.

The rate of adoption and reliance on LCLFs within the Australian market will be linked to the uptake of zero emissions vehicles, which itself will be influenced by a variety of commercial, supply chain, operational, and technology factors including:

- the capacity of the global OEM sector to provide vehicles into Australia at the appropriate demand levels
- the capacity for industry to fund and secure approvals to upgrade depots to install new recharging/refuelling infrastructure

[1] https://www.bitre.gov.au/publications/2023/australian-infrastructure-and-transport-statistics-yearbook-2023/transport-energy-environment#dl-data

[2] https://www.energy.gov.au/publications/australian-energy-update-2023

[redacted]

[4] https://www.cefc.com.au/media/4f2dctmf/biofuels-and-transport-an-australian-opportunity-november-2019.pdf

- the capacity of the energy grid to meet the energy demand for industry at the appropriate price point
- existing contractual obligations
- existing operational supply chain structures
- retooling and reskilling of the workforce

A low initial uptake of battery electric and hydrogen vehicles could drive higher demand for locally produced and imported LCLFs as an interim step to comply with corporate and national emissions targets.

However, as the road and rail transport sector electrify, the demand for LCLF will decrease. The performance requirements of certain difficult to abate industries, such as aviation (SAF) and maritime, will require continued access to and use of LCLFs as effective zero emissions technology solutions evolve to meet the broader needs of local and global sectors.

LCLF performance considerations

Biodiesel and renewable diesel are two LCLFs that the road and rail sector are interested in as part of the transition process to zero emissions technologies.

Biodiesel is typically produced from oil based renewable feedstocks such as palm oil, sugar cane, corn, algae and waste cooking oils. Pure and high-volume blends of biodiesel have some properties that make it difficult to use as a direct fuel replacement (i.e. "drop in") such as reduced engine performance, increased engine and component wear, shorter shelf life, and its physical properties alter in colder weather. It is much more effective as a blend with petrochemical based diesel fuels (current blends are between 5-20%). Many countries have mandated fuel blending requirements as a transition to emissions reductions within the transport sector[5].

Renewable diesel is created from biochemical and thermochemical technologies and its chemical properties enable it to perform as a direct substitute for petrochemical based diesel fuels. Renewable diesel can have similar feedstocks to biodiesel however it has a different production process. Renewable diesel can also be produced using the waste products from heavy industrial processes including captured CO_2 emissions that can be reacted with green hydrogen. These CCUS based processes are an evolving technology that have good synergies with Australia's existing industrial sector and emerging renewable energy and hydrogen sectors.

LCLF domestic market production environment

Australia currently produces approximately 11.8 billion litres of liquid fuels per annum which is about 20% of the current domestic demand[6]. The level of domestic production has decreased by approximately 70% in the last decade, resulting in Australia importing over 80% of our overall fuel requirements (45 billion litres). There are currently only two oil refining companies left in Australia, Viva Energy and Ampol which have received government subsidies to support operation until 2030[7]. Currently bioenergy (including biofuels and renewable fuels) make up approximately 1% of the Australian energy market[8], with ethanol being the major product (sugar cane base), biodiesel, and other fuel types.

For LCLFs to be an effective transition fuel in Australia, the different fuels required need to be produced at industrial quantities and integrate efficiently within existing supply chain networks. The pathway to scaling LCLFs to an industrial level requires alignment of demand and supply factors supported by significant capital and development investment including repurposing of existing infrastructure and co-location of industry to garner economic efficiency.

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[5] https://www.sciencedirect.com/science/article/pii/S0301421523004202#bib19

[6] https://www.bitre.gov.au/publications/2023/australian-infrastructure-and-transport-statistics-yearbook-2023/transport-energy-environment#dl-data

[7] https://www.reuters.com/business/energy/australia-prop-up-its-last-two-refineries-with-up-179-bln-2021-05-16/

[8] https://www.agriculture.gov.au/about/news/snapshot-world-biofuels-dec-22

Europe and the US have implemented several programs across the different transport sectors (road, rail, aviation and maritime) that can provide guidance to Australia for industry and government partnerships to establish a commercially viable long term LCLF industry sector[9,10]. As noted above, Australia does have an existing petrochemical production sector with established supply chains and technical knowledge. Utilising this in partnership with other related sectors will facilitate the transition to a commercially viable domestic LCLF production sector.

In preparing a domestic market the Australian Government will need to address the development lifecycle of a LCLF sector that will encompass government and industry partnerships, R&D programs, technology testing, scaling industrial processes, and an established operational environment.

In developing a domestic LCLF market, Australia does have some competitive advantages:

- Stable political and policy environment
- Established mining and oil and gas sectors which provide;
    - Industry knowledge and expertise
    - Existing infrastructure
    - Established supply chains
    - R&D capability
- Have high CO_2 emitting industries that are seeking opportunities to mitigate their emissions and are investing in CCUS technology that can support the development of renewable fuels at a commercial scale (e.g. Lanzatech's bio-engineered CCUS solutions in partnership with Woodside [11,12]).
- A large agricultural sector that can pivot to produce biofuel feedstocks.

Some areas for consideration in the development of an LCLF market are:

- The tyranny of distance – the location and distance between feedstock for LCLFs, the production facilities, and the end user can be quite significant. Established supply chains will need to be remodelled to drive efficiencies and competitiveness of the sector. Capital investment will be required to support the co-location of production facilities with feedstock sources.
- Environmental impacts of intensive and repurposed agriculture to create some types of LCLF feedstocks.
- Concern over food security if repurposing agriculture to create LCLF feedstock.

LCLF production incentives

At a global level, LCLF markets are being developed in partnership between government and industry supported by a blend of policy and production incentives to facilitate industry investment at the appropriate scale. The supports are required across all aspects of the development pathway to encourage investment and create a sustainable sector. To achieve the required production scale for an LCLF sector in Australia, and as noted in the consultation paper, the Government has several levers available to facilitate investment:

- Supply side:
    - Production stage incentives / tax credits for LCLF production and feedstock generation
    - Project finance to facilitate scaling to industrial capacity
    - Grant schemes to support R&D and testing phase
- Demand signals:
    - Establishing Low Carbon Fuel Standards and Regulations that are aligned with global policy
    - Tiered blending and volume mandates

[9] https://www.fuelseurope.eu/renewable-and-low-carbon-fuels-value-chain-industrial-alliance
[10] https://www.lcfcoalition.com/join-today
[11] https://lanzatech.com/lanzatech-and-woodside-energy-announce-strategic-collaboration/
[12] https://www.woodside.com/what-we-do/new-energy/lower-carbon-services

- Tiered carbon intensity standards

International LCLF competition

With significant global interest in the establishment of LCLFs to support the transition to zero emissions by 2050, Australia faces international competition in the development of a domestic LCLF sector. Competition may be in the form of direct LCLF imports into the Australian market or export competition of LCLFs into global markets. Potential competition will come from industry in countries which have similar high emitting industry sectors, extensive petrochemical industries, established biofuel sectors, intensive agricultural capability, low labour cost inputs, and extensive government subsidy programs. Significant LCLF producers (biofuels) currently include the US, Brazil and Indonesia.

The OECD estimates approximately $820 billion ($US) was spent annually in agricultural subsidies in the period 2019-21[13] (for the 54 participating nations of the report). The World Bank Group estimates that agricultural subsidies during this period generated an estimated $1.1 to $1.5 trillion ($US) in equivalent CO_2 emissions per annum[14]. The report also acknowledges that governments need to consider the broader environmental impacts associated with biofuels including land degradation, water quality, pesticides, and air pollution.

Options to support an Australian domestic low carbon liquid fuel production

The EU recognises that to achieve decarbonisation targets for LCLFs the production capacity of the sector will need to scale to meet forecast industry demand. Investments will not only need to consider the LCLF production technologies, but also the production of feedstocks and energy generation. This latter requirement is estimated to be 4-6x the cost of the production of LCLFs [15].

The transport industry, and specifically the sectors within, will need to assess whether biofuel or renewable fuel will be the most effective transition fuel for their operations. Considerations include supply chain reliability and energy security (i.e. continued access to fuel type for forecast transition period), vehicle operational performance (engine performance and maintenance), fuel costs, capital costs to transition to zero emissions technologies and impacts on existing commercial arrangements.

Understanding the profile for the transition in demand for LCLFs across the road transport, aviation and maritime sectors as zero emissions technologies evolve will inform industry and government on short to long term investment and planning options in the production of LCLFs. European forecasts view demand for LCLFs to initially be the domain of the road sector, slowly transitioning to maritime and aviation over the next decade.

Figure 1 forecasts the changes in demand for LCLFs in Europe between the road, aviation and maritime sectors, in response to the tiered mandates for aviation and maritime fuels[16]. Government policies and pricing signals will influence the uptake of LCLFs. For example, the recently adopted ReFuelEU Aviation initiative in Europe, which includes blending mandates for sustainable fuels in aviation. Such mandates will reach 6% by 2030 and gradually increase to 70% by 2050, with a significant share allocated to e-fuels (35% in 2050)[17].

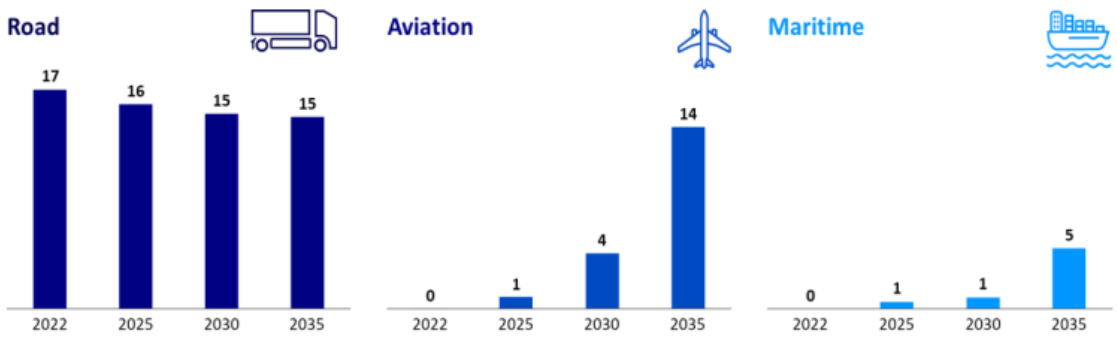
[13] https://www.oecd.org/agriculture/topics/agricultural-policy-monitoring-and-evaluation/government-support-to-agriculture-is-increasing.htm

[14] https://openknowledge.worldbank.org/server/api/core/bitstreams/61d04aca-1b95-4c06-8199-3c4a423cb7fe/content

[15]https://www.eib.org/attachments/lucalli/20240101_financing_sustainable_liquid_fuel_projects_in_europe_en.pdf

[16]https://www.eib.org/attachments/lucalli/20240101_financing_sustainable_liquid_fuel_projects_in_europe_en.pdf

[17] https://www.consilium.europa.eu/en/infographics/fit-for-55-refueleu-and-fueleu/



Note: Aviation includes EU-27 international and domestic air traffic; maritime includes EU international and domestic shipping, covering all reported monitoring, reporting and verifying (MRV) emission and fuel data, for example 100% of emissions and fuels on voyages between EU ports, 100% at-berth and 100% of voyages between an EU port and one outside the European Union ("Full MRV Scope").

Source: Calculation by Roland Berger; assumption from public sources such as the European Commission, Concawe, Transport & Environment, SkyNRG, IEA and IRENA.

Figure 1: EU LCLF Demand Forecasts By Transport Sector Through to 2035 (MTOE)

As demand from the road and rail transport industry for LCLFs declines as zero emissions technologies become more established and operational supply chains adjust, LCLFs are a potential low cost and economic solution for stationary peaking power usage. Electricity costs increase as self-sufficiency ratio increases. Low capex, high opex solutions like bio-diesel engines are perfect for extreme peaking applications – a much more efficient solution than batteries, which are suited for higher utilisation and load following applications.

In addition to the requirements to establish the appropriate supply and demand incentives for the LCLF sector in Australia, the local manufacturing sector will need to be appropriately resourced, tooled, and have access to an appropriately trained and skilled workforce. Understanding the local and global manufacturing and supporting supply chains required to establish and operate an LCLF sector will identify the key local manufacturing and industry sectors that can be further developed or transitioned to achieve a competitive industry. Appropriate government sector development policy and incentives, including workforce development strategies, skills and training, and regional development (as many production facilities will be regionally based) will be required to align local manufacturing with the timing of broader industry growth.

Differences in sector development funding requirements

Investment in the LCLF development and production pathway will be influenced by the existing capability and capacity of participants. Large established organisations in the oil, gas and energy sectors are capable of financing large sustainable liquid fuel projects whereas independent project developers (and technology providers) are significantly smaller, with less access to capital and require external support to deliver to industrial scale. Decision makers in Australia should consider these variations in funding requirements, when structuring incentive mechanisms for supporting the development of the LCLF sector. Moving from demonstration projects to industrial scale production is a capital intensive requirement with the majority of projects proposed in Europe having a project value in excess of greater than $800 million ($US)[18].

Further research and investigation

To inform the government's decision making and to provide more robust information for industry and investors in the development of a domestic LCLF sector, further research, technical

[18]https://www.eib.org/attachments/lucalli/20240101_financing_sustainable_liquid_fuel_projects_in_europe_en.pdf

investigations, and sector planning should be progressed based on Australian industry and environmental factors:

- Map LCLF industry sectors (feedstock, production, logistics) domestically and globally through to 2050. Identify the capability, capacity and timing requirements of the domestic sector to scale up to meet local production estimates.
- Map fuel and energy demand and forecast temporal transitional requirements across transport sectors.
- Map current and future domestic and international feedstock sources, growth opportunities and emission contributions required to meet industrial scaling and fuel security requirements.
- Establish development targets and timelines for the LCLF industry to align with domestic and global demand forecasts to facilitate local industry competitiveness.
- Map the manufacturing requirements to support the development of the LCLF sector, identifying existing local manufacturing capabilities and supply chains.
- Map the workforce capability, training and reskilling requirements to match workforce development with sector growth.
- Review existing subsidy programs for the petroleum and energy sectors so as to identify how these can be repurposed to facilitate an emerging domestic LCLF sector.

To deliver on the above, and to ensure an integrated approach between government, industry, and academia it is recommended to utilise the industry growth centre and CRC network to establish:

- Industry alliances within LCLF sectors to leverage skills, knowledge and demand (i.e. Aviation, Maritime, Road Transport, Rail).
- Research and development programs in partnership between industry, academia and government.

[redacted] Responses to specific consultation questions

What do you think is the highest priority form of support?

To support the establishment of a domestic LCLF sector that can produce fuels to meet industry needs at the appropriate scale, a mix of capital, production, and demand incentives will be necessary supported by a strong policy and regulatory environment to provide clear direction and targets. This will enable existing industry to expand to the necessary scale and encourage new industry and technologies to be developed to aid the transition towards zero by 2050.

As the sector transitions across 2030, 2040 and 2050 milestones, the extent of the identified supports should be reviewed in consideration of sector needs (i.e. aviation), technology evolution, international supply chains, and costs at the time.

Figure 2 provides an overview of the challenges identified by European industry, grouped in three key segments, in transitioning to LCLFs at an industrial scale across all key transport sectors[19].

[19]https://www.eib.org/attachments/lucalli/20240101_financing_sustainable_liquid_fuel_projects_in_europe_en.pdf

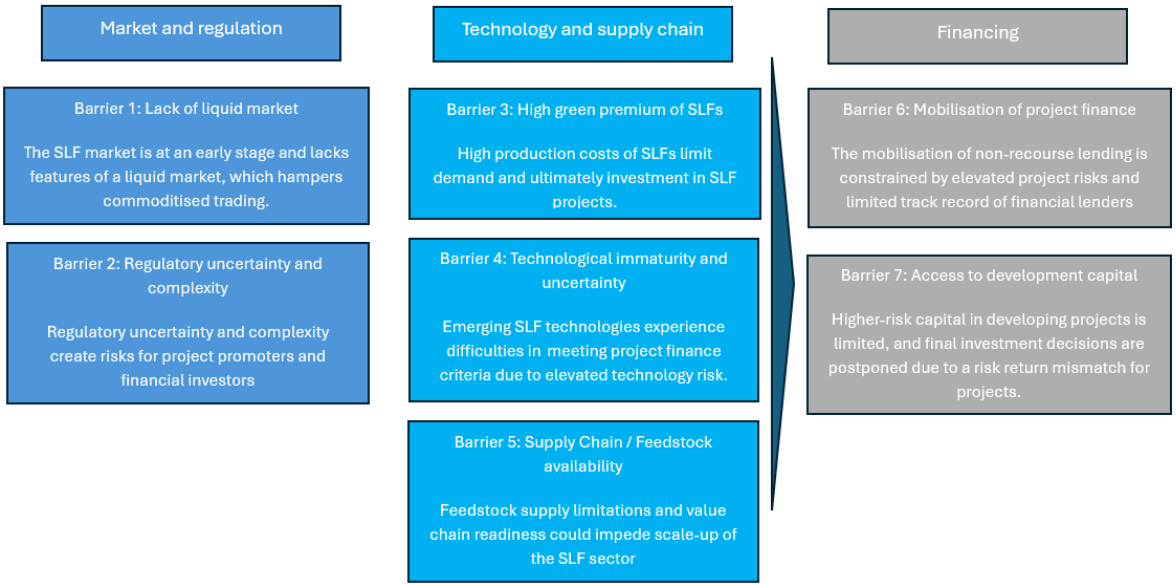


Figure 2: Perceived Market Challenges in the EU

LCLFs are an emerging market in terms of technology, capacity, operations, financing, and competition that require regulatory certainty to encourage industry sustained investment. The evolution of the market will be dynamic and that government and industry will need to evolve with the market and not be afraid to fail in some circumstances.

How would you design production incentives to make production competitive in Australia?

Production incentives should be developed to support the initial development and subsequent scaling of the market to facilitate the establishment of effective competition to maintain a competitive price point for LCLFs. For markets such as SAF, alignment with European and US policy and regulation will be critical in terms of the evolution of this market (in terms of scale and timing) and the appropriate incentives to industry to balance against technology availability and maintain operational performance, safety and capability requirements.

In Europe, various LCLF production pathways covering the three different modes of transport (road, maritime and aviation) are being developed across the transition period to 2050. Although some pathways are commercially more advanced than others (namely in the land transport task), the related technological landscape is evolving with uncertainty on production pathways, fuel types and offtake segments, requiring an incentive program that adapts and responds to these market adjustments.[20]. Accordingly, incentives need to be targeted to the industry sector and its development pathway, applying a dynamic lens to facilitate technological and industry evolution over time.

How could the introduction of a production incentive scheme affect competition in fuel production and supply markets, and also amongst fuel users?

A production incentive scheme could boost competition in both fuel production and supply by lowering barriers to entry and encouraging innovation and industry investment.

The US Inflation Reduction Act, introduced in 2022, offers infrastructure tax credit incentives of up to 30% and energy production tax credits linked to regional, employment creation, and technology solutions which has resulted in more than $115 billion ($US) invested by industry[21].

Increased competition will benefit users through a more efficient price and improved product offerings matched to market demand. The availability of a consistent and appropriately priced LCLF

[20] https://alternative-fuels-observatory.ec.europa.eu/policymakers-and-public-authorities/european-policies-and-legislation
[21] https://home.treasury.gov/news/press-releases/jy1830

market (domestic production and imports) may encourage a more rapid take up of LCLFs. Conversely, a poor domestic LCLF market, where competition for global supplies impacts on price and product availability, may result in delays in industry transitioning to zero emissions technologies, or pursuing the adoption of alternative technological solutions.

Production incentive schemes will need to consider the domestic demand profile (and timing) and the capability of the supply market, domestically and globally, to align with this.

Would production support need to offer a different rate of incentive for SAF and renewable diesel?

The aviation sector is evolving its zero emission technology substitutions options, with SAF production generally having higher costs (to renewable diesel) due to a tougher regulatory environment and technological challenges. The greater demand (ratio 4:1) and lower production costs for renewable diesel for other transport functions (road, rail and potentially maritime) supported by readily developable technology and production supply chains, will attract initial industry investment into that area of the LCLF production sector.

As noted in the following section, European and US Governments have developed SAF specific programs to support the development of SAF separate to other LCLFs (but in consideration of the broader decarbonisation strategy).

To inform the structure of an industry incentive scheme for SAF, a better understanding of the research, capital and operational investments required to develop domestic LCLF sectors (including SAF) to achieve appropriate commercial scale (through development, testing, scaling and production) is needed, aligned with the industry sector transition pathways to 2050.

Would a potential production support program need to prescribe certain proportions of production volumes towards SAF or renewable diesel?

Yes, with supports tiered to reflect the transition to 2050 and cognisant of R&D requirements, technology evolution and industry production capability.

The EU "Fit for 55" policy identifies the need for the pursuit and investment in a wide spectrum of different production pathways to create a sustainable and cost-effective SAF sector[22]. To facilitate the production of SAF, the EU has adopted minimum blending requirements, 2% by 2025, 6% by 2030, 20% by 2035 and 70% by 2050. Within this, the EU requires synthetic, or e-fuels, to comprise up to 35% of blends by 2050.

The US (Sustainable Skies Act) has applied a production tax credit to encourage the production of SAF with $1.50 ($US) per gallon at 50% GHG lifecycle savings, increasing to up to $2.00 ($US) per gallon for greater than 50% GHG lifecycle savings. The US will also provide $1 billion ($US) in grant funding to support the development of new production facilities[23].

Would production support need to provide different levels of support for emerging and established production pathways?

Yes, as noted previously, a mix of support will be required to enable the testing, development and scaling of appropriate technologies and fuels. These support mechanisms will need to consider the differing development pathways of different fuels, the alignment with industry transition plans, and global policies and programs already in place to facilitate an efficient and competitive sector.

The supports, as noted in the consultation paper, would be a mix of different programs tailored to the development pathways (including feedstocks) along the transition journey, including:

- Blending targets
- Production tax credits

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[22] https://www.easa.europa.eu/en/domains/environment/sustainable-aviation-fuels-saf#:~:text=EU%20ETS%20provides%20an%20incentive,allowances%20they%20need%20to%20purchase.

[23] https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/fact-sheet---us-and-eu-saf-policies.pdf

- R&D support
- Capital investment constructing new production facilities

What are some of the design considerations Government should consider?

The Government should consider the interrelationships of the domestic and global LCLF markets, the alignment of different industry sectors to transition and adopt LCLF, the availability of feedstocks for biodiesel and renewable fuels, and the global investment strategies of governments and industry in the LCLF sector.

Specifically, the Government should consider: growth of LCLF markets (domestic and global), the operation of a steady state market, the production supply chain reliability (i.e. feedstocks and other inputs), transition in LCLF demand from one industry sector to another (i.e. road and rail market to aviation and maritime), market decline as zero emissions technologies in harder to abate areas are developed and adopted by industry, and sustaining bespoke markets such as aviation.

The Government is seeking your views on the following considerations regarding emissions and sustainability criteria:

Do you support an emissions reduction threshold being included as part of eligibility criteria for fuels to receive support under a production incentive program?

Yes

What threshold would you seek be included in eligibility criteria (for example 50 per cent emissions reduction relative to conventional fuels, or another emissions reduction ratio)?

50% as an initial threshold as discussed in the consultation paper and aligned with international practices where possible.

Do you think any threshold should increase over time?

Yes, the threshold should be tiered to reflect the evolution of different sectors, and as discussed in the consultation paper, applied and aligned with other countries programs to limit potential adverse outcomes, i.e. dumping of LCLFs into the Australian market.

What are the community benefits associated with LCLF production in Australia?

Short to medium term community benefits – through to 2050 – from an effective and competitive LCLF sector are:

- new employment opportunities,
- reduced health impacts from particulates emissions,
- reduction of GHGs.

As noted by the CEFC[24], the transition to a net zero carbon economy will create new employment opportunities across manufacturing, construction, R&D, operation, agriculture, and supply chains. The CEFC estimate, based on global figures, that a target of 20 billion litres (50% of the forecast diesel demand in Australia by 2050) of domestically produced LCLFs could generate up to 250,000 direct and indirect jobs in Australia. As discussed in the section *"LCLF domestic market production environment"*, Australia currently produces approximately 11.8 billion litres of fuel domestically. A decade previously, Australia produced approximately 40 billion litres of fuel domestically. With appropriate investment in production facilities aligned to LCLF, Australia has the demonstrated capacity to be able to effectively produce high volume fuels to support the overall transport task.

Should design of a mandate, low carbon fuel standard, target or other demand option create requirements for a certain proportion of fuel use be drawn from Australian produced LCLF?

A low carbon fuel standard and other supporting demand side mechanisms should focus on supporting the competitive aspects of Australian industry and domestic LCLF supply requirements.

[24] https://www.cefc.com.au/media/4f2dctmf/biofuels-and-transport-an-australian-opportunity-november-2019.pdf

Demand side mechanisms should be cognisant of the availability of local feedstocks and the capability and capacity of the local market to appropriately scale up for the period of the use of LCLFs (acknowledging that LCLFs will be a transition fuel for the majority of the transport sector to a zero emissions environment) and consider the potential impacts of LCLFs on other sectors such as agriculture.

International LCLFs and feedstocks (should these be imported to support a domestic production market) should also be rigorously assessed against the low carbon fuel standard to ensure compliance. Standards should also consider domestic and international blended feedstocks. The Guarantee of Origin Scheme is essential to track and verify emissions of LCLF.