Developing a UK Sustainable Aviation Fuel Industry

Independent Report

1. INTRODUCTION

The Author – Philip New

Philip's experience combines knowledge of the advanced fuels sector and the broader energy system, giving him a cross sector perspective between energy and transport. He works with companies and advisory groups and is on various company boards, including the Board of Norsk Hydro ASA.

He was CEO of the Energy Systems Catapult (2015 – 2022).

Philip also set up and led BP biofuels in 2006 and was CEO of BP Alternative Energy (2013 – 2014).

Purpose and Approach

The government appointed Philip as the independent assessor in October 2022 and author of this report. An independent evaluation was commissioned by the Department for Transport (DfT) to:

- Stress-test the Department's understanding of the barriers to investment in UK sustainable aviation fuels (SAF) – excluding those made from hydrogenated esters and fatty acids (HEFA), and to look at options to address some of those barriers.
- Understand the conditions for a successful and enduring SAF industry in the UK and whether and how the UK could meet those conditions.
- Supplement their evidence base as they develop policy.

The evaluation was designed to be of short duration (around 6 weeks) and based on extensive discussions with a wide range of stakeholders in the matter of the decarbonisation of aviation. No new analysis or modelling was undertaken. Most stakeholder meetings took place in October 2022, with over 60 engagements with independent experts and representatives from organisations including aircraft manufacturers, airlines, aviation fuel suppliers, current SAF producers, SAF project and technology developers, banks, industry representative groups, expert institutions, related government teams and academia.

Emerging conclusions were tested in November with stakeholders and DfT officials, including presentation to the SAF commercialisation subgroup of the Jet Zero Council. Feedback was provided by stakeholders and is reflected in this final report.

Given the relative complexity and novelty of the subject matter and the diversity of perspectives reflecting the breadth of stakeholder participation it was helpful to develop a set of framing observations. This established a common platform from which underlying assumptions could be scrutinised and areas of alignment and disagreement explored, and from which suggestions for interventions could be derived.

The framing section also allows for some consideration of important broader questions which, although at least implicitly resolved in the government's Jet Zero Strategy and not included in the evaluation's brief, merit discussion. They concern the role that SAF should play in the decarbonisation of aviation and the role that the UK could play in a future SAF industry:

- Is producing SAF a rational use of renewable energy resources?
- Will the emergence of alternative aircraft technologies and usage patterns render SAF redundant, risking stranding assets?
- Does the UK need to have a material domestic SAF manufacturing base?
- If so, does government need to continue to intervene to support its development?

The evaluation is therefore presented in two parts – a framing section and, on the basis that SAF is necessary and a UK manufacturing base desirable, a second section that proposes set of possible interventions that would support the creation of a competitive, sustainable and enduring UK SAF industry.

Terminology and Rules of Thumb

There are many different types of SAF, even though they all perform the same function in an aircraft engine, and all have to comply with ASTM (American Society for Testing and Materials) global standards.

As shorthand the evaluation mimics the usage of renewable ground fuels and refers to SAF by generation.

1g SAF is taken as SAF made from HEFA (Hydrogenated Esters and Fatty Acids) – the current commercial scale process for producing SAF.

2g SAF is made from other carbon-containing sustainable feedstocks (whether biogenic or otherwise), so includes the conversion of waste into syngas and thence to fuel via catalysis, the pyrolysis of wastes and other feedstocks, and the conversion of flue gases and waste/residues from biomass feedstocks into ethanol and then to SAF (ethanol made from corn can also make SAF but would not qualify for inclusion under EU and UK rules). These technologies are either ready, but not yet deployed at scale, or are very close to maturity.

3g SAF is taken as "e-fuels" or PtL (Power to Liquids) – fuels made from the catalysis of green hydrogen and CO_2 taken directly from the atmosphere or captured e.g. from an industrial point source (if the fuel is to be carbon-neutral and scalable). Although the process is well understood the first commercial plants are some way off and have a critical dependence (if net zero) on the emergence and deployment of efficient large-scale electrolysis and Direct Air Capture (DAC) capacity.

Cost estimates for 2g and 3g vary significantly, and the economics of initial plants will not reflect long run economics, but at least initially it is highly unlikely that costs for 2g or 3g SAF will be competitive with HEFA.

Carbon intensity reduction of HEFA is normally quoted at 70%, for 2g products 80 – 110% and 3g can be carbon neutral. Contrail and other emissions, including embodied, have not been factored in.

UK/EU acceptable HEFA is made from waste oils and fats – the supply of which is constrained, and competition for which also comes from the production of non-crop-based biodiesel and renewable diesel for road transport. Hence the need to develop SAF with a greater diversity of feedstock types.

The UK mandate requires 10% penetration of SAF by 2030 – roughly 1.2 million tonnes annually, assuming demand recovers to at least pre-pandemic levels. The EU mandate will require 5% SAF by 2030. Neste, Shell and Total all have HEFA plant scheduled to open in NWE soon. Announced 2g projects in the UK have a total capacity of around 500000 tes.

2. KEY CONCLUSIONS

- SAF has a key role to play in aviation decarbonisation for at least the next two (fifteen year) investment cycles.
- The UK has the potential to play a leading role – particularly in the development and deployment of SAF made from carbon-containing waste streams, a technology close to deployment readiness. Alternative power to liquids technologies are less mature and require additional low carbon hydrogen and globally competitive renewable electricity costs.
- The enthusiasm for SAF extends across the stakeholder community to an extent not seen by the author in other aspects of the energy transition. It offers a clear opportunity for leverage that should not be wasted.
- The proposed UK SAF mandate is a very promising market shaping mechanism – creating demand, building distinct "beyond HEFA" markets and potentially sending important price signals.
- The UK is leading the way in creating markets for 2g SAF – much of the potential 2g SAF capacity announced so far globally is UK-based. This leadership could be reinforced through the deployment of the Advanced Fuels Fund.
- Internationally the development of mechanisms to support SAF technology development and production is dynamic. Both the US and EU have announced substantial supply-side subsidies.
- The UK cannot depend on imports of 2g volumes to meet mandate requirement – international focus is on the development of HEFA.
- Consensus is that the mandate needs to be supported by other interventions to attract investment in UK supply, underpinning mandate fulfilment and sustaining an enduring UK industry.
- The need for further intervention is driven by the dependence on debt finance (with a lower risk appetite) and competition driven by the availability of support in other countries and UK sectors.
- Other challenges include stretched UK construction capability.
- Key interventions with the greatest leverage are supporting the UK's nascent advantage in feedstock supply and underpinning revenue confidence.
- There could be a powerful synergy between standards, the mandate and a bilateral public law contract type of mechanism (e.g. akin to the Contracts for Difference (CfD) scheme used in the renewable power sector). There is potential for this to be underwritten by industry, not government.
- Other interventions (e.g. focused guarantees and progressive approach to sustainability metrics) could accelerate key early assets.

With the imaginative application of market shaping levers, the UK's concentration of developers with potential projects, remarkable cross sectoral commitment, legacy strengths in aviation technology and fuels infrastructure and potential strengths in feedstock access and financing could be leveraged to build a SAF industry with only a limited call on public finances. Such an industry would create thousands of green jobs and support fuel supply security.

Key asks from industry:
Pace – the earlier industry has sight of mandate design and intent around other interventions, the better.
Coordination – success requires alignment and coordination across departments – in particular DfT, HM Treasury, the Department for Energy Security and Net Zero, and the Department for Environment, Food and Rural Affairs.
Confidence – how can the UK government demonstrate that it will stay the course?

3. PART ONE: FRAMING

Competitive Context

SAF is almost unique in the renewable ecosystem in that it is exposed to competition across multiple dimensions:

- It is a fungible liquid fuel, easily stored and easily moved. International transport costs – both financial and emission – are low (e.g. indicative costs of $30/te to transport SAF from the US Gulf Coast to NW Europe – which is less than 1% of the product price. The emissions involved for the same journey are around 10kg CO_2eq/te). Therefore, the supply envelope is potentially global. Aviation fuel suppliers and their customers will look internationally for the lowest cost source of regulation compliant SAF, and SAF producers will look internationally for the highest returns for their products.
- Demand is obviously driven by airport throughput but is less fixed than any other energy type except marine fuels, in that aircraft can (in theory) choose to lift fuel at the lowest cost location. Therefore there is potential competition between international airports (although this can be offset by anti-tankering rules). In the long run sustained price differences could drive changes to use patterns and airline route choices, particularly if more cost competitive hubs attract more transit passenger volume.
- 2/3g SAFs are made from feedstocks that have multiple other potential applications. This means that SAF producers will need to compete with other applications (on value add or Marginal Abatement Cost Curve (MACC) advantage) to secure feedstock supply and processing capacity.

The combination of these competitive forces means that a SAF producer will be competing globally with other SAF producers for sales, and locally with other products and processes for feedstocks. Any producer needs to be competitive (at the margin) with other potential geographies and bid for resources against other potential applications in the same geography.

It would be a mistake to think of SAF only from a single geography, or single product, perspective – whether for supply or demand. Wherever SAF is made, whichever SAF is made, and however demand is established, it must be viewed as an integral and dependent element of complex global supply and demand systems.

Given the challenge of any single producer being both the most competitive supplier and the highest value/most emissions-reduction efficient application of a feedstock, interventions are likely required to arbitrage gaps on both axes.

Pathway Anchors

Different SAF technologies face distinct choices on where best to locate. The consensus (mainly amongst SAF developers) is that the mobility of the feedstock is a key determinant.

Oils, fats, alcohols and agricultural commodities (including wood pellets) are already globally traded, so a producer making SAF from HEFA or bio-derived ethanol is less constrained on location. A bit like oil refining, in principle they could locate close to the supply source or close to the demand centre, with selection driven by a number of specific considerations.

SAF made from Municipal Solid Waste (MSW) and some other waste streams (including flue gases) is anchored locally or regionally to the source of the feedstocks, although in some cases there might be advantage in producing an intermediary product (such as pyrolysis oil) close to feedstock and upgrading to SAF close to market. Capital costs for these pathways vary but typically are relatively high per unit of production. Low cost of capital is an important consideration. In many cases access to cost effective carbon capture capacity and low carbon hydrogen is important.

PtL – access to low-cost renewable electricity (to produce green hydrogen) and CO_2 will be crucial.

All pathways will have learning curve benefits. Most believe that PtL has the greatest potential to scale and reduce cost but is further from realisation at scale.

As a rule of thumb, 1g SAF is very footloose, 2g SAF will be much more rooted to advantaged feedstock sources, supplemented by access to Carbon Capture and Storage (CCS) and hydrogen. 3g SAF has the potential to scale in very low-cost green electron territories.

UK Competitiveness

Stakeholders identified a number of UK competitive advantages:

There is a deep and major market for aviation fuels.

The excellent fuel distribution infrastructure is well suited to handling both domestically produced and imported products. Importantly, it supports potential production at many locations around the UK (e.g. those adjacent to strong feedstock point sources) and also supports potential export volume.

The strength of the commitment to decarbonise across the many participants in the value chain – from producers to suppliers to airlines – is remarkable.

General policy commitment: The Climate Change Act and adoption of carbon budgets is regarded as a clear signal of intent that underpins stakeholder confidence in the UK's commitment. the Jet Zero Strategy – and in particular the announcement of the Advanced Fuels Fund and the outline of the SAF mandate (especially the unique emphasis on creating a dedicated market for 2 and 3g SAF) - is welcomed but stakeholders are anxious for more clarity, soon.

The innovation and engineering legacy across both aerospace and chemicals, with respected innovation infrastructure in aerospace (e.g. ATI).

The UK MSW market is regarded as relatively advantaged – mature enough to have clear pricing benchmarks and with sophisticated value chain actors but still having capacity available for applications beyond EfW. The availability of other feedstock sources (flue gases etc) was also seen as a benefit. Leveraging this capacity to best overall benefit will require coordination across government.

The availability of legacy chemical processing locations with repurposing potential reduces investment need for elements of supporting infrastructure and improves capital efficiency. These sites are typically located in parts of the UK that have experienced significant de-industrialisation and economic decline – e.g. Tyne/Tees/Humber, Stanlow and South Wales – but are also adjacent to hydrogen and CCS hubs.

The existing refining base provides good co-processing capability – that is, the ability to utilise existing refining processes and upgrade SAF intermediary products to market-ready fuels efficiently and reliably.

The UK's potential for regional leadership in CCS was widely noted – as was the ambition to develop green hydrogen. SAF production is potentially very synergistic with these emerging technologies, both economically and geographically. Coordination across energy vectors would be beneficial.

Green finance capacity is a relative strength.

Sustainability standards – seen as world-leading.

Brexit: the potential to set UK-specific arrangements was noted.

UK Challenges

EPC capability/capacity was widely regarded as being stretched – and likely to remain so given the anticipated pipeline of infrastructure and energy projects.

Dependence on debt finance. A typical SAF project carries a capital cost ticket of between £500m and £1 billion. This is too big for venture capital and, as the initial projects will all be first of a kind, too risky for most private equity and fund investors. There are some potential strategic equity funded projects, but most announced projects are planned to be delivered through special purpose project vehicles with debt finance playing a prominent role. Debt finance will look for significant safeguards if funding is to be offered at reasonable cost of capital.

UK green finance capacity and capability is strong, but well bid and conditioned by exposure to risk mechanisms in adjacent sectors in the green transition. The development of renewable electricity generation has been underwritten by a CfD mechanism (now from the Department for Energy Security and Net Zero), very successfully. CfDs are being developed for low carbon hydrogen and CCS investments while energy infrastructure and new nuclear generation will be treated as part of the regulated asset base – with regulated returns. This opens a degree of cross sectoral competition between respective risk mitigation mechanisms – currently transport fuel mechanisms compare very poorly with current and proposed renewable electricity, energy infrastructure, CCS and hydrogen risk socialisation mechanisms.

Electricity prices are comparatively high. Like most countries, the marginal price of UK electricity is set by the gas price. The US benefits from lower gas prices (the US is long gas, and there is an export bottleneck that keeps US prices down while increasing international prices) and the EU has applied caps to gas prices that have the effect of reducing wholesale electricity prices for all users. Offtakers are treated more equitably in the UK than in many countries (so the difference in price charged to households and large industrial users is smaller). The UK grid is efficient and highly connected, so "islanded" areas with localised price advantages (as in N Norway) do not feature. Marginal connection cost is not socialised – so connecting to the grid can be expensive. UK renewables are relatively expensive compared with leading hydro/solar resource holders and while absolute costs should continue to decline the relative cost gap is unlikely to reduce materially.

Limited public investment capacity – the contrast with the public finance capacity in the US in particular is stark.

CCS/green hydrogen capacity short – this creates a dependency with significant uncertainty around the timing and terms of access by SAF producers to these emerging technologies.

Sustainability standards. These are high – but can reduce the range of potential feedstocks and constrain supply. This increases the importance of government and industry implementing a coordinated approach to feedstocks to ensure that sustainable feedstocks are utilised to best effect.

Brexit. Investors seek to maximise optionality – of both feedstock source and market access. Investors will want to be able to bring feedstocks into the country if they need to, and to be able to sell their product internationally – so any UK plant will need to meet EU standards. Supply chain and labour access issues are also exacerbated.

International Comparison

The United States of America

Low feedstock barriers – palm oil is the only prohibited biomass feedstock. Significant extra HEFA capacity is being developed (W Coast), potentially utilising additional feedstocks (e.g. cover crops and marginal crops) to offset lipid supply constraints. As demand for ethanol in cars declines with the growth in battery vehicles the prospect of corn ethanol capacity switching to AtJ becomes stronger.

Lower electricity costs (trapped gas) – this may diminish as LNG debottlenecks, but large offtakers will still receive lower prices.

Incentives are provided from a range of different government sources (tax authorities, individual states and federal agencies) these multi-agency incentives are therefore "stackable" and in part based on carbon intensity. There is no SAF mandate, but very generous supply side support.

The incentives and protections available under the inflation reduction act are already pulling higher risk technology projects to the US.

Build costs are often cited as lower in the US than Europe.

Legacy technology strengths – a consequence of NREL and other programmes, and lessons learned from earlier VC backed projects.

The prospect of significant volumes becoming available arises – particularly using feedstocks that would not qualify for UK use. Absent mandates in Europe it should be expected that airlines with transatlantic routes would rely on US supply to meet voluntary lower carbon fuel targets. There is a risk that supply side incentives support development of 2g volumes that could undercut UK supply, in part depending on the UK response with countervailing duty.

The European Union

Northwest Europe is on a rough par with the UK – less MSW capacity.

Technology leadership ambition (e.g. Germany has announced a commitment to invest €1.5bn in building two PtL demonstration assets).

Hydrogen ambition is strong, with very aggressive goals and generous support.

The mandate targets are volume based, the buy-out price is variable and uncapped. Jet kerosene for internal flights will be taxed, there is no explicit revenue guarantee mechanism announced yet. Anti-tankering regulations have been outlined. Sustainability standards are roughly aligned with the UK. The EU will enable possible subsidies utilising ETS revenues. There is a sub target for PtL (but not for other non-HEFA SAF), but worth noting that PtL is also likely to be encouraged as a ground fuel (and is already being supported for marine).

A few individual countries have already implemented mandates. There has been a strong reaction to the US Inflation Reduction Act announcement, starting with the proposed EU Net Zero Industry Act, and some evidence that the EU are taking a stronger line on the imposition of countervailing tariffs on subsidised US imports. The implications of the emerging Carbon Border Adjustment Mechanism (CBAM) regulations needs to be assessed.

As with the US, the scale of the EU market as a whole is significantly greater than the UK – although in both there are state or nation specific policies alongside federal policies.

Other countries

Potential PTL production hubs: geographies with very low cost solar, islanded grids, port access, acceptable political risk (e.g. Norway / Iberia/ North Africa / Gulf / Chile…) could develop as global cost leaders in 3g SAF production over time.

Although approaches differ, the pace of development of support mechanisms in both the US and the EU has accelerated. The risk is that the UK – arguably a leader in the development of SAF until very recently – will be overtaken and capital attracted to other geographies.

Alternative Technologies

To SAF or not to SAF?

The challenge is whether SAF development and deployment in the UK should be actively pursued at all. There are two issues – whether SAF is an efficient use of renewable resources, and whether jet turbines will be replaced by hydrogen or electric power units (whether direct combustion, fuel cell or battery electric) in aircraft at a pace and scale that so undermines demand that SAF assets are stranded and investment uneconomic.

While economic value add will be (inter alia) a consequence of market arrangements it is probable that converting almost any given feedstock to SAF will not be the most techno-economically efficient way of utilising that feedstock in service of meeting system-wide emissions reduction goals (the same applies to ground fuels). Consequently, in many conventional whole system energy model pathways the development of 2 and 3g SAF emerges as a relatively high-cost component in the decarbonisation toolbox, and one that is therefore deployed later in any net zero techno-economic timeline or roadmap (although it should be recognised that many models are weak in their handling of biogenic waste streams).

There are three practical problems with this approach, given that aviation is the fastest growing source of emissions. The first is that the optics of choosing to not deploy SAF – and instead rely on the eventual emergence of different technologies (see below) – are challenging. The second is that sector enthusiasm for the transition to lower carbon fuels is widespread – evidenced by the voluntary positions adopted by airlines both individually and collectively. Such a high degree of alignment behind the case for change is unusual across multiple other industries. It would be a missed opportunity were this enthusiasm not to be harnessed. The third is that some of the resources that SAF could use have an alternative application that is incremental to and (if unabated) higher carbon than other technologies (for example waste incineration to generate electricity) but have scarcity value as feedstocks in hard to decarbonise sectors. So we should not be surprised that, despite the techno-economics, governments are not letting the great be the enemy of the good and have decided to support the development and deployment of SAF to help tackle aviation emissions now.

Hydrogen and battery

The consensus is that they will feature, but there is a wide error bar (15 – 20 years) between techno-optimists and sceptics. The pace and materiality of them are dependent on technology, infrastructure and travel patterns. The more bullish assessments are that long range wide body hydrogen aircraft are possible by 2060, with short range single aisle aircraft appearing in the mid-2030s. However, as with the transition from petrol and diesel to battery electric cars, inertia in fleet replacement, changes to usage patterns and – critically – infrastructure need to be considered. The key question is the amount of jet fuel that will be needed and when. For volumes of jet fuel to materially decline due to substitution requires not only the availability of new aircraft, but the replacement of existing fleets and the deployment of hydrogen refuelling capacity at airports globally. There are many chicken-and-egg dependencies involved. It is unsurprising that major manufacturers are not aligned and that airlines are sceptical.

The pragmatic issue is whether there will be sufficient substitution of SAF over the next 20-30 years to undermine the climate case for SAF and pose a threat to the investment economics of new SAF capacity. Based on current feedback there is a very low probability of demand reducing through energy substitution in the investment life of SAF projects coming online over at least the next 10-15 years, assuming that asset investment life is typically 15-20 years. There is further mitigation in that in many cases 2g SAF plants have the potential to re-orient their processes to make renewable products other than SAF. There is 2.41Mtes estimated savings[1] with SAF relative to the "do nothing" case from aviation if the UK does not adopt SAF.

Any transition will take long enough to still require (and reward) the development of global SAF capability.

Proposed Market Arrangements.

Today the market for SAF is – with few exceptions – voluntary and based on the leadership shown by some airlines in committing to their own voluntary emissions reduction targets. In many cases airline customers – whether corporate or individual – are offered the choice to top up the price of tickets to support the use of SAF (just as they are sometimes able to opt into a carbon offset scheme). Voluntary commitments are laudable but given that SAF costs significantly more than standard jet kerosene, absent other incentives the market will not grow (in 2021 the combined commitments amounted to around 0.04% of global jet fuel demand). Current market arrangements are ad hoc, often bilateral, and few if any insights can be taken that provide confidence to potential investors around future market dynamics, price setting mechanisms etc.

Different countries are taking different approaches to the development of markets and supply – in the US the emphasis is on building a supply base, providing a mix of incentives (typically grants and tax subsidies). In Europe and the UK the emphasis is on demand creation - the key mechanism is a mandate with buy out price – obliging the obligated party (in the UK the suppliers of aviation fuel to airlines) to achieve minimum inclusion targets (in Europe volumetric, in the UK based on carbon intensity reduction) or pay a buy-out price to avoid the obligation. The proposed UK mandate has some further important characteristics – notably a relatively high sustainability threshold on qualifying feedstocks and the imposition of a cap on the proportion of HEFA SAF in the mandate.

This holds the prospect of the US becoming the lowest cost source of SAF (largely because of SAF production subsidies, lower energy costs, and lower sustainability thresholds). EU/UK sustainability standards would prevent much potential US SAF from qualifying for use (e.g. HEFA from oil crops or alcohol to jet made from corn ethanol) and a critical question is the extent to which subsidised SAF would be allowed tariff-free access to trans-Atlantic markets (the UK TRA has recently determined that US HVO should be permitted without a countervailing duty being levied).

Although critical details are yet to be announced (including the carbon intensity goal, the buy-out price, the positioning of the HEFA cap and the point at which certificates will be generated), the overall SAF target has been set at 10% of the UK jet fuel market by 2030 – so potentially around 1.2 Mtes. Some of this – up to the cap limit - will be met by HEFA. The balance will have to be met using 2g or 3g SAF. In effect, the HEFA cap creates a separate market for non HEFA SAF.

HEFA is available today, new capacity is coming on stream and most observers believe that the global HEFA market will be balanced or even long over the next decade or so. UK obligated parties will seek the best value qualifying volumes of HEFA – the likelihood is that as mandates shape demand and HEFA supplies increase a normal market will develop with HEFA SAF clearing at the marginal cost of supply.

Supply of 2g/3g SAF volumes suitable to fulfil the UK mandate above the HEFA cap will be tentative at first – and come onstream in the latter 20s at best. There are several feedstock and technology combinations, and a broad range of production costs are claimed.

[1] Jet Zero Strategy https://www.gov.uk/government/publications/jet-zero-strategy-delivering-net-zero-aviation-by-2050

A two-tier market will emerge, with the HEFA volumes needed to meet the demand cap under the mandate pricing at global clearing levels (adjusted for freight and sustainability compliance) and 2g volumes selling into a separate market – where there will be a defined demand (the difference between the overall mandate and the HEFA cap) and in effect a ceiling price (the buy-out price).

This mandate mechanism holds the prospect of a clear price signal being created (depending on how the demand target is established and the buy-out price set). In theory, were the demand to be set to ensure the market is tight (so at a level where the marginal litre of fuel would need to be bought out – but with sufficient supply to enable substantive mandate compliance) and the buy-out price set at a level that would provide an investible return to the investor in marginal capacity, the market would clear at or around the buy-out price, with adjustment of the HEFA cap potentially providing an agile mechanism to respond to changes in supply, preserving price confidence (on the basis that it could be simpler to tweak the HEFA cap than to change the overall mandate level).

Such dynamic management of the market is important because in the unlikely event that the market is oversupplied, it would clear at the marginal cost of production, leaving investors with significant uncertainty over price in a very immature market. If significantly short, fuel suppliers would resort to paying the buy-out price, leaving airline passengers with a higher fuel bill but without the carbon saving benefits.

The onus is on maintaining the sweet spot in setting both targets and buy out price for the mandate to work, but managed well, the mandate would establish firm demand and send a strong price signal to investors while capping the cost to consumers. Clearly, the earlier the design of the mandate can be confirmed the better, in service of providing potential investors, suppliers and offtakers the time to develop their plans and build confidence around mandate compliance.

Build or Buy?

The UK faces a choice. While the likelihood is that the HEFA volumes needed to comply with the mandate will be available, either imported or manufactured in the UK using imported feedstock (e.g. the co-processing currently practiced at the Phillips 66 refinery), the UK is unique in establishing a stand-alone market for 2g SAF. International production of 2g SAF is very uncertain and the UK's ability to bid away any such volume from other markets is unclear. The question is whether the mandate – which establishes demand and could provide a degree of pricing confidence – will suffice to both attract imports and deliver in conjunction with already announced initiatives such as the Advanced Fuels Fund (AFF), UK investment in capacity to provide the volumes that would be needed to meet its policy commitments and decarbonisation targets. If the mandate is not seen as a sufficient instrument to support the development of UK capacity we will, absent any additional intervention, be reliant on imports of 2g SAF. If the imports are not there we will need to accept:

- **widespread buy outs of obligations, and/or**
- **rowing back from our current emissions targets, and/or**
- **dilution of our sustainability standards.**

As things stand, dependence on capacity building in other countries (over which we have no influence) and from which product would need to be bid by the UK offering the highest price presents significant risk.

Further Intervention?

Building enough capacity to underpin UK mandate targets will require several projects to be successful. Most of the envisaged SAF projects will be built using special purpose vehicles – blending debt finance with equity. So is the mandate both necessary and sufficient to build a market and underpin domestic supply? The clear feedback is that it isn't. This is supported by the evidence:

- The mandate cannot be selective as to the geographic source of the product – it has to apply to any product that meets the technical and sustainability criteria, regardless of country of origin.
- As with other aspects of the green transition, the technologies and related value chains are immature, the market is unformed, and dependence on access to adjacent emerging technologies (green hydrogen/CCS) is high. The AFF should mitigate some of these risks, but debt finance in particular will look for more security.
- The availability of stronger revenue risk mitigators in other emerging UK energy transition technologies disadvantages SAF.

If the UK is to enable a domestic supply base to develop, further intervention is necessary.

Such intervention, if done promptly, has further supporting benefits – it positions the UK as the committed leader in the deployment of next generation SAF technologies, opening potential inward investment opportunities and export potential for UK technology, know-how and products. It provides a landing pad for the most promising outcomes of the AFF, leverages the commitment to transition that is strongly held across the sector and offers synergy and local growth benefits alongside the development of green hydrogen and CCS.

Postponing intervention until the picture is clearer is a possible choice – but against the off-chance that a surplus of 2G product emerges in other countries sometime in the next 5 years the UK risks needing a much more radical – and most likely costly – intervention later if policy and decarbonisation targets are to be met. Absent access to physical supply, market experience will still be weak and supply challenges even more pressing. Sectoral alignment will need to be rebuilt and enthusiasm rekindled in the hope that developers and investors haven't either given up completely or moved elsewhere and that any momentum built through the deployment of AFF support has not been wasted.

The conclusion is that if the UK is to have any confidence that its aviation decarbonisation goals will be met – at least in the next ten years – then the development of a domestic supply base for 2g SAF is desirable and that, if this is to happen, further intervention beyond the steps outlined in the Jet Zero Strategy will be required, ideally in place in time for FID stage gates in the 2025/26 window.

Framing: Concluding Observations

The stakeholder discussions have confirmed that if decarbonising aviation is seen as a policy priority SAF has an important role to play. Airlines and other governments are clearly of this view and the likelihood of liquid fuel substitution coming early enough to either constrain SAF investment returns or reduce the need for carbon mitigation in the medium term is seen as small.

The production and consumption of SAF must be seen in a global market context. The UK has several competitive strengths, but also some important gaps. The clearest potential role for the UK will likely be in the development of a 2g SAF sector, utilising the availability of feedstocks and proximity to markets.

The proposed SAF mandate will establish demand – importantly, it creates a two tier SAF market with HEFA and 2g product both featuring, but in distinct categories. This creates a distinct market for 2g volumes. The UK should not depend on this being met by imports.

The proposed SAF mandate could provide a strong incentive to attract 2g technology and investment to the UK but this is not seen as sufficient to unlock material investment – by dint of the dependence on debt finance and market and technology immaturity.

In the following part two of this evaluation, options for intervention will be reviewed and assessed.

4. PART TWO: INTERVENTIONS

Introduction

The first part of the evaluation concluded that the development of a UK-based SAF manufacturing industry is a requirement if medium term UK policy goals are to be met with confidence.

The introduction of a SAF mandate from 2025 requiring at least 10% (c1.2 million tonnes) of aviation fuel to be made from sustainable sources from 2030 (including a proportion *not* made from 1g HEFA) means that the key driver is securing the supply of 2g SAF. This would also have the benefit of positioning the UK at the forefront of the deployment of one of the most promising technology pathways to SAF (and a platform technology for other applications). Developing a manufacturing base aligns well with the stimulus provided by the Advanced Fuel Fund, offers synergies and support to other key strands of the UK decarbonisation strategy (particularly CCS and green hydrogen), provides new life to abandoned chemical industry assets and with it contributes to levelling up. It should not lead to higher consumer costs – the market will select from the best value providers regardless of origin – and holds the prospect, through the expansion of supply options for compliant feedstocks, of accelerating progress down the cost curve and increasing diversity of supply choices.

The other key conclusion was that further intervention is required if this industry is to be bought to life in the UK. The UK has some competitive strengths on which to build and is arguably a world leader in developing the opportunity for sustainable and 2g SAF, thanks to the potential of the proposed mandate design to create a separate market for 2g product with clear qualification criteria. It is imperative that the government press forward with concluding the details of the SAF mandate if current industry and investor uncertainty is to be addressed, but this will not be sufficient (even with the addition of the AFF) to build confidence that investment into a UK 2g SAF industry will follow at the pace and scale policy commitments require. This is because the development of a material SAF sector will depend on accessing debt finance – with a relatively low risk appetite especially given the emerging technologies and untested markets – which has exposure to significant revenue (and other risk) mitigants in adjacent green shift sectors (e.g. in the CfD scheme for renewable electricity and under development for low carbon hydrogen and CCS). In addition, the generosity of proposed subsidy mechanisms in other countries – particularly the cumulative effect of the Inflation Reduction Act alongside other stackable policy incentives including the renewable fuel standard in the US and the recent spate of announcements of targeted support to SAF and adjacent technologies as part of RePower EU - risks drawing capital and research away from the UK.

Approach

In assessing the potential interventions some informal criteria were applied to each possible idea:

1. Does it address the key barriers to investment mentioned most frequently in stakeholder conversations?
2. Does it support the goals and timings laid out in the Jet Zero Strategy (JZS) and support an economically sustainable and scalable industry?
3. Does it distort the market or have broader potential system-distorting consequences?
4. Does it build on existing policy and regulatory positions?
5. Does it require a material call on public funds (as the EU and US responses do)?
6. Is it practical and deliverable?

These criteria have informed some framing principles around a potential intervention strategy: Fundamentally **the creation of a SAF investment supportive market environment, avoiding subsidy, ensuring risk falls where it is best managed, and utilising and adapting market arrangements to best**

effect to minimise cost to both the general taxpayer and the airline industry. The evaluation does not propose the application of enduring supply-side subsidies (as proposed in US and EU) beyond the support provided through the AFF.

The key barrier most frequently cited was revenue confidence. This is a fundamental condition precedent for debt finance investment in particular. A second issue that is important and potentially tractable is feedstock.

Although developers express confidence in sourcing feedstock for their initial projects, for the industry to scale and be sustainable it must be rooted in a secure, bankable, feedstock environment. With feedstock supply confidence the prospect of scale up and continuous improvement is much stronger. Without it, any UK industry risks being confined to a small number of relatively inefficient plants. Subsidising technology or construction risk (beyond the initial support to technology development under the AFF) holds the risk of distorting outcomes and disadvantaging those technology developers and project managers who have built capability and have confidence in their approach. These risks are, in broad terms, best seen as equity risk (technology) or debt and equity risk (construction). These considerations form the fundamental framework for proposed interventions: building a supportive environment by focusing on revenue and feedstock confidence, with technology and construction risk owned by industry and investors. Possible options for focused, limited duration interventions are also considered.

Pace is important – to meet JZS targets, secure investment against international competition, secure the volumes to meet policy targets and leverage AFF achievements. This means that any programme needs to be straightforward enough to be implemented rapidly but also justifies some specific shorter-term interventions to remove or mitigate potential blockers to early investment and accelerate learning, supply chain development and market maturity.

Building an enduring investment-supportive environment.

As noted above, the two critical enablers to encourage investment in the deployment of 2g SAF in the UK are at either end of the value chain. Upstream, the development of a deep, bankable feedstock pool and downstream, supporting confidence in the revenues that can be captured by effectively implemented projects.

Interventions in these areas are a pre-requisite if a successful UK SAF manufacturing sector is to develop.

Feedstocks (and other inputs)

Current high-level recommendations are:

1) Expand the allowable feedstock pool as far as possible within energy act constraints – for example ensuring that the decision in principle to include recycled carbon feedstocks (RCFs) is implemented as soon as possible. Note – this is a question of balance. Expand the net too widely and there is a risk of unintended consequences in adjacent sectors (e.g. renewable diesel) and less sustainable subsidised imports from other geographies may undermine any UK investment case.
2) Anything that can be done to build confidence in MSW feedstock supply is welcomed. This extends beyond the DfT's remit and involves multiple government departments – and so requires cross-government coordination and cooperation.
    a. The development of a clear view on how best to use the UK's waste resources should be encouraged. There is a strong argument that the exploitation of waste and other biogenic feedstocks should be prioritised to address the challenges of the hardest to abate sectors rather than be burnt to generate incremental relatively

high carbon electricity. Any review should address the question of the role of Energy from Waste in a future net zero grid, particularly when CCS capacity is not close to EfW assets.

   b. To support the development of less mature technologies in hard to abate sectors consideration should be given to exempting the use of waste feedstocks in fuel applications from inclusion in the ETS.
   c. Any competition for subsidy offered to EfW for CCS adoption should also be open on fair and equitable terms to waste to fuel producers, and access to any subsidised CCS capacity should be offered to local assets that would also see benefit.
   d. The needs of the SAF sector should be explicitly addressed in the forthcoming government biomass strategy.
   e. Explore options to review the classification of the use of waste feedstock to prioritise use in the most difficult to decarbonise sectors.

3) A bankable project needs a bankable feedstock supply contract. Today this can be problematic – tier 1 MSW feedstock suppliers might be unwilling to contract feedstocks to a SAF project (given overall uncertainty) and instead commit supplies to alternative projects, restricting future availabilities for SAF. DfT should explore developing MSW feedstock offtake guarantee mechanisms with tier 1 feedstock suppliers for early projects, where DfT underwrites the contract if the SAF project does not initially meet planned throughputs and keeps the supplier financially "whole" against the cost of securing alternative offtakes.
4) The high cost of electricity in the UK, and the high costs associated with securing new grid connections, was mentioned by several projects. An interesting precedent was recently established in EV charging infrastructure, where Ofgem has proposed modifying the conditions under which certain grid improvement costs are socialised, rather than treated as a cost to be borne exclusively by the marginal offtaker. This might be of benefit to SAF investments and should be explored further.

Conclusion

Feedstock availability and access is a potential major UK competitive advantage. It is a critical success factor for any UK SAF manufacturing sector. For it to be realised these ideas need to be developed and actioned, the enquiry extended to test other possible interventions, and a cross-department implementation plan established.

Revenue Confidence

This was the issue raised most frequently and with most emphasis by most stakeholders.

As previously discussed, the mandate should send a strong price signal if the 2 and 3g SAF market is short. The mandate provides certainty about the share of the UK jet fuel market to be taken by SAF and breaks this down into sub-markets for HEFA and 2-3g SAF. The expectation is that jet fuel purchased by airlines in aggregate will be an amalgam of at least three different products in three separate submarkets each with independent prices, the price per litre being the sum of the different prices pro-rated to mandated volumes (so in 2030 say 90% fossil jet kerosene, 5% HEFA, and 5% 2g SAF with potentially 3g (PtL) as a fourth product).

The scope of this evaluation excludes HEFA SAF for consideration of further interventions and the working assumption is that HEFA SAF (and fossil jet kerosene) will in all circumstances clear at the international market price.

Despite the potential for clear price signals, and even assuming that the details of the mandate are clarified quickly, and related uncertainties resolved, investors are looking for more certainty on 2 and 3g SAF pricing – particularly mitigating downside risks most likely occurring if the market is long, or regulation and market rules are changed.

The challenge is to develop a mechanism that gives sufficient revenue confidence for a project to be bankable and for it to be deployed quickly enough to support the projects that will reach FID in the next two-three years. Potential interventions are targeted at non HEFA (2g) SAF only.

Given the extreme unlikelihood of contractually committed long term fixed price commercial offtakes between suppliers and producers (given the uncertainties of market and project), two broad themes emerged:

- Extend the mandate mechanism to provide a price floor (for non HEFA SAF) as well as a price cap.
- Implement a price stability mechanism, utilising a bilateral Private Law Contract (akin to a CfD) for UK non HEFA SAF production.

Work needs to be done on both – neither are straightforward fixes. Common questions are price discovery – both of strike price and reference price – and who pays. At this stage the greatest challenge seems to lie with the price floor option, but some promising potential design choices are emerging around price stability mechanisms (akin to a CfD type mechanism) – that should be developed further.

The Floor Price Mechanism

The attraction of the price floor concept is that it could be seen as an extension of an already proposed mechanism (the SAF mandate). For the price floor to work the government would need to underwrite producers whenever market prices go below a given floor. How this would be managed is unclear. The obligated parties under the proposed mandate are (as is the case with ground fuels) the fuel suppliers, not the producers. The suppliers could source the volumes they need internationally and will pay market prices for them. If a blanket UK market floor price were imposed this could result, simply in the supplier holding the added margin – they will still pay the international market price for the product even if they sell it in the UK at the floor level. Given the need to ensure that the benefit sits with the (UK) producer, how this might be done using certificates in a way that benefits the UK producer and supports investment is the challenge, especially given the likelihood of imported products and legal constraints on the use of the mandate to favour UK producers. The alternative – a simple set of bi-lateral revenue certainty agreements between the government (or other counterpart) and UK producers – loses the benefit of being an extension of the mandate mechanism and has further complexities. A floor price mechanism, unlike the low carbon electricity CfD, is also a one-way bet – not dissimilar to Renewable Obligation Certificates. The guarantor would pay when the price fell below the floor, has no countervailing upside exposure when prices are high. Whatever the solution, the price discovery challenge remains.

The Private Law Contract Mechanism

Given the centrality and intensity of debate surrounding approach in stakeholder discussions this section is more extensive.

<u>Background</u>

Price stability through the low carbon electricity CfD scheme has been deployed to great effect in the UK, increasing investor confidence and helping to bring costs down for renewable electricity projects (such as the offshore wind sector). Other CfD business models are being designed for use in the low carbon hydrogen and CCS sectors. Stakeholders like them as they guarantee a price (the strike price), they are a bi-lateral private law contract (between the project company and the counterparty) and investors are familiar with them. Under a CfD, the project offers to build a certain amount of capacity and receives support if the reference price, typically the market price for the product, is lower than the contracted strike price, but the producer must pay the difference if the market price rises above their agreed strike price. Because the producer will normally be selling the physical product at the market price (which they could of course choose to hedge or term up as an independent commercial choice) the strike price operates only as an insurance mechanism. Whatever the market does, the producer is guaranteed the strike price (no more, no less) that is underwritten by the counterparty, but the strike price itself is not the price the physical product will fetch in the market. Establishing the strike price, and agreeing an appropriate market price marker, are obviously critical steps. In the case of offshore wind the electricity wholesale market price is familiar and readily accessible and strike prices have been set through allocation rounds ('auctions'). Typically the cost of underwriting the arrangement is socialised across the end users of the product – so payments to renewable electricity projects are levied on electricity suppliers via the Supplier Obligation, and suppliers pass on the costs to their consumers – although today, thanks to the increase in gas and consequently electricity prices, strike prices are lower than the wholesale market price for electricity and renewable energy projects are returning money to the CfD scheme. It is worth noting that entering into CfDs, like power purchase agreements and other offtake contracts, are voluntary. They will not necessarily be the universal or exclusive arrangement in a future market. Companies can choose the extent to which they balance CfD and merchant volumes in their production portfolio.

Implementation

The Low Carbon Contracts Company (LCCC), an arms-length government company set up to operate the original CfD scheme, has significant experience and expertise in developing and operating these mechanisms, but even so implementation is not instantaneous. The creation of a new government-driven price stability mechanism requires primary legislation – estimates range from 2 to 4 years for this to be achieved. The novelty and complexity of the proposed mechanism also drives delivery timelines. Current estimates range from 3 to 5 years from initiation of the design process of the policy mechanism to construction starting on a new SAF project, so between 2026 and 2028. The narrower the requirements of a proposed SAF mechanism and the more it has in common with existing instances of CfD design, the quicker it will be to design and deliver. The question is whether a fit for purpose mechanism can be conceived that can collapse these planning timelines further.

Synergies between a Price Stability Private Law Contract and the proposed SAF Mandate

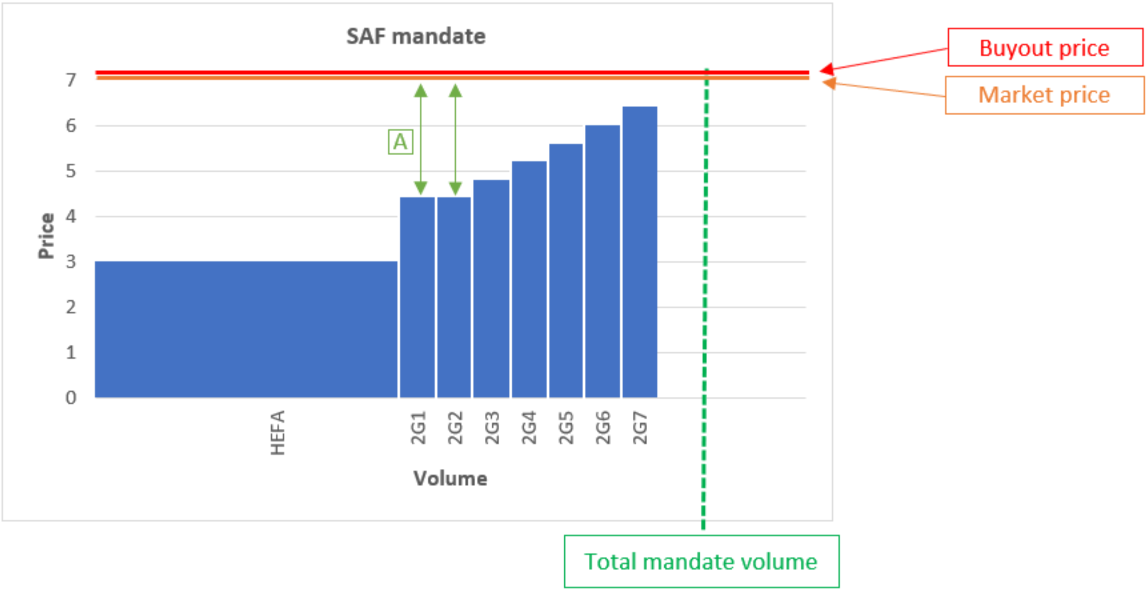
The great advantage that SAF has compared with the development of CfDs in other low carbon sectors comes from the mandate (from 2025) and existing product standards. This reduces the burden to be carried by a price stability mechanism significantly – the mandate establishes demand and will play a major role in setting market price. International ASTM (American Society for Testing and Materials) standards define the performance qualities of the end product and the mandate, the energy act and other legislation has defined the feedstocks and processing routes that will be allowed. A SAF price stability (revenue certainty) mechanism, when taken in conjunction with existing mechanisms, exists for a clear primary purpose – to provide certainty on the price per litre a producer can realise. A price stability mechanism could, in effect, be an insurance policy against the risk of material negative changes to producer prices for 2g SAF, whether because the market for 2g SAF becomes oversupplied or a change in government policy and regulation. *A price stability mechanism will not set the market price for 2g SAF. That will be set through physical supply and demand – with demand being set by the mandate. The aviation sector will likely be purchasing 2g SAF at this price whether a price stability mechanism for SAF exists or not.*

SAF Mandate and Price Stability Mechanism Illustration.

The following price curve charts illustrate (at a very abstracted level) how the two mechanisms could work in parallel. The data series 2Gn represents individual 2g SAF projects, showing plant capacity (x axis) and fully built-up economic cost sufficient to yield an investment return (y axis). Prices, costs and volumes are entirely hypothetical. For representational purposes the HEFA cap is assumed to be set at 50% of the total mandate volume.

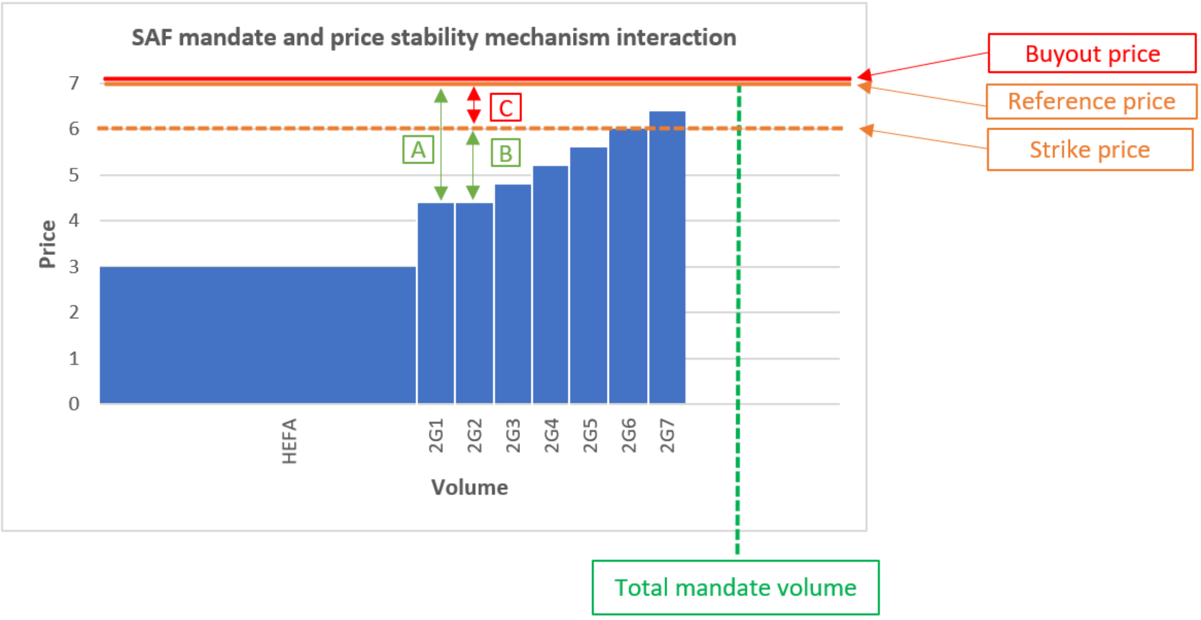
In the first example no price stability mechanism is assumed and a short market (so total 2g SAF supply not reaching mandate volumes) is shown. It is assumed that the buy-out price is set at a level that supports investment in new 2g capacity (if not, the mandate will not be met). In a short market fuel suppliers will have to pay the buyout price at the margin if they are to comply with the mandate. In such a market it is reasonable to assume that the market/reference price for physical product will be close to the buy-out price. Margins will be a function of cost and buy out price. In this case the most efficient producer of 2g SAF will make a margin (A) above their fully remunerated production costs.

Figure.1



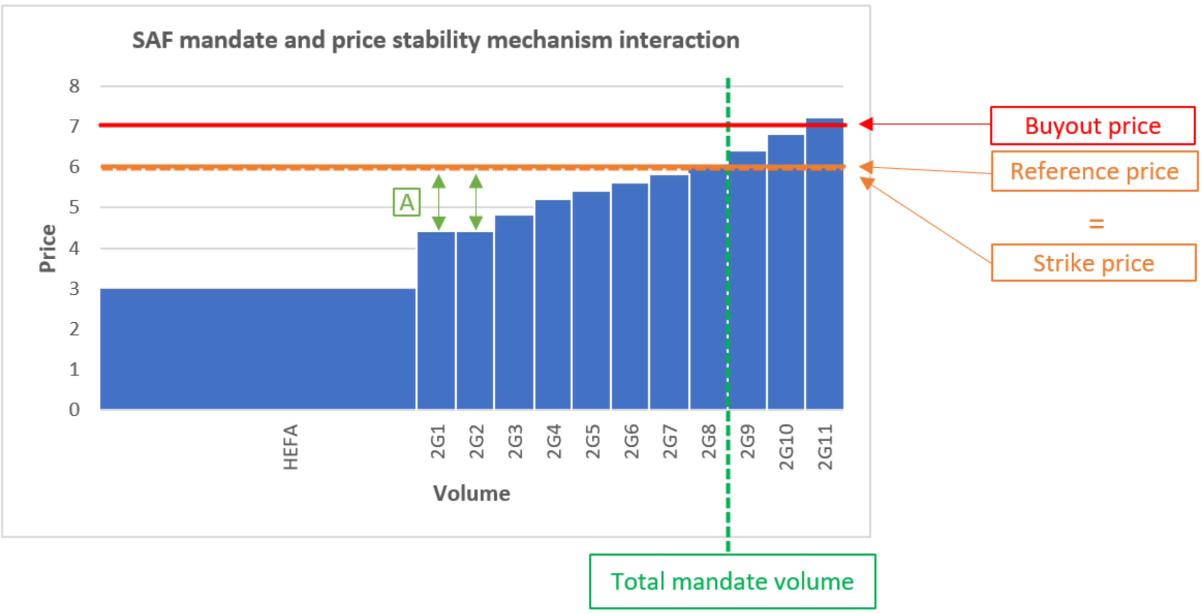
In the second example, the same conditions are assumed to apply, but a price stability mechanism has been introduced. Much depends on the relationship between a potential strike price and market price for SAF. If it is accepted that in a short market for 2g SAF the 2g market will likely settle at or near the mandate buy out price, then the question is where a strike price might be set. A strike price higher than the buy-out price (if the buyout price remunerates marginal capacity) would not make economic sense (as it would be subsidising uneconomic capacity). The buy-out price in effect caps a strike price. In this example it is assumed that, after a competitive process, the strike price has been established at a level lower than the SAF market/reference price. Product will be sold at the market/reference price, so any project that has participated in the price stability mechanism will receive the SAF market price for their product but will then return the difference (C) between the strike price and the market/reference price to the scheme administrator when the reference price is above the strike price (as has happened recently with offshore wind in the low carbon electricity CfD scheme, when the wholesale market price of electricity rose above strike prices).

Figure.2



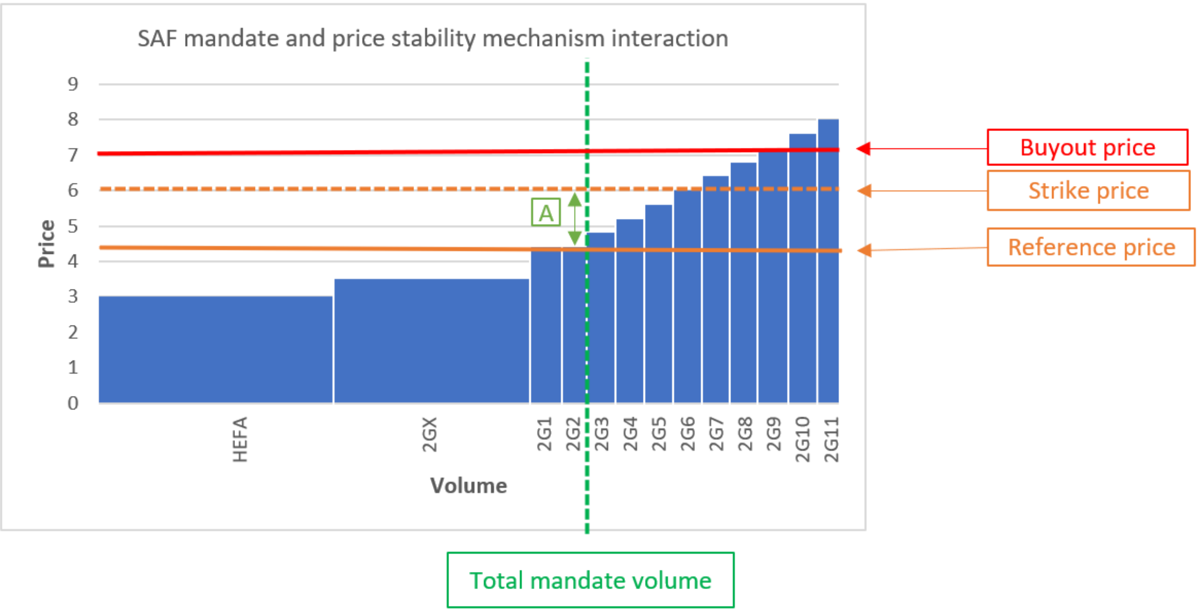
In the third example below, we retain the same buy out price and strike price but assume that more capacity has entered the UK market – more than enough to meet the mandate requirements. In this case the market/reference price detaches from the buy-out price – the marginal supplier is 2Gx and the market price is assumed to settle at the fully built-up cost of supply for that project – in this instance at about the same level as the strike price. In the instance where the reference price is the same as the strike price no money is being transferred between the participating projects and the price stability scheme administrator/contract management company.

Figure.3



In the final example below, the buy out price and strike price is unchanged, but a significant quantity of low-cost additional volume is assumed to have entered the market. This has the effect of significantly reducing the market/reference price – the marginal supplier is now 2G2. Those projects that participated in the stability mechanism will get the market/reference price for the product they supply and will also receive a top up payment (A) from the stability scheme that brings their revenues up to the strike price level. This applies no matter how low the market/reference price falls, so all participating projects (as long as they are economic at the strike price) will be able to maintain operations – they will always be able to offer a price that keeps them in business.

Figure.4



Price Discovery

A key dependency will be the emergence of a market-accepted price quote for 2g SAF. Without it, there won't be a market reference price and a price stability mechanism will rely on potentially unrelated proxy price quotes (Jet kerosene and HEFA/HVO), making the mechanism more complex and potentially less efficient. That said, should a fungible market form there is a high likelihood of a price quote following.

Two mechanisms for establishing the strike price have been raised:

- Bi lateral negotiation
- Allocation rounds / auctions

Neither is a straightforward choice. Most project developers preferred the bi lateral negotiation approach – at least in the earliest years of the market. It carries less risk than competing in an auction, may offer more capacity to reflect technology uncertainty and perhaps better reflects the differences between technologies at the early stages. The key drawbacks are the time it will take to complete such negotiations and the potential for asymmetric outcomes. Selection of viable projects to participate in the negotiation, and eligibility criteria for agreeing a contract will retain elements of the competitive and comparative nature of reverse auctions anyway.

Reverse auctions – effectively nominating a volume (perhaps linked to mandate targets) and offering contracts at the marginal strike price offered by different projects – will place a major burden on project developers having confidence in their cost and volume projections, but they hold the prospect of being faster to implement. Competitive auctions, importantly, inject a clear incentive for optimisation and continuous improvement to drive down costs in the SAF sector – as has been seen in offshore wind to great effect.

Who Underwrites?

It is far from certain that a well-designed price stability mechanism alongside the proposed SAF mandate will require material injections of funding – indeed, it might be that projects with a support from a price stability mechanism have a strike price lower than market price, in which case they would be paying the scheme counterparty/contract management company.

That said, establishing how a possible price stability mechanism would be funded is critical. It obviously represents a potential liability for the counterparty, were 2g SAF prices to fall significantly. Three options have been debated:

- Underwritten from general taxation.
- Underwritten from the hypothecation of ETS receipts levied on the aviation sector.
- Underwritten by an industry levy similar to the existing price stability mechanisms in the renewables sector.

Most stakeholders accept that winning agreement for funding from general taxation will be challenging – particularly given the broader challenges faced by public finances now. The aviation sector argues strongly that ETS revenues (from reducing free allocation for the aviation industry) will create a new revenue stream that should be used to underwrite a price stability mechanism – the EU has signalled a willingness to utilise aviation ETS revenues to support SAF. Their view is that the UK airline industry is already comparatively highly taxed. The biggest practical challenge is that this would be viewed as equivalent to a further call on general taxation – UK ETS revenues today are not hypothecated but included in the general income pool.

The case for industry (whether fuel suppliers or airlines) underwriting the scheme rests on pragmatism – it takes the issue of a potential liability on the public purse off the table and would help to accelerate development in progressing the design of such a scheme for SAF. It holds the potential of industry having greater influence on how the scheme operates, including how any costs and benefits are syndicated. It will be consistent with other sectors that have a similarly clear end-user market (such as electricity – but not yet formed for hydrogen and CCS where end users are not clear and markets unformed). If the imperative is to support the development of SAF manufacturing at some pace, which is a goal that all stakeholders have advocated, this is the approach most likely to yield results quickly. It therefore carries a degree of enlightened self-interest – as mentioned earlier, the earlier a supply base can be built, the more likely learning curve savings will bring fuel prices down.

If this were to be agreed in principle it has the added benefit of potentially opening a broader discussion on ways in which an industry-led, government supported approach could accelerate further the development of the sector.

Conclusion

The industry ask for a CfD type private law contract mechanism delivered quickly enough to enable projects to get into construction mid-decade has been consistent. That the proposed SAF mandate and standards do much of the heavy lifting (e.g. around closing the cost gap between SAF and kerosene), otherwise carried by CfDs in other sectors, means that the scope of a SAF price stability mechanism can be restricted to providing a price guarantee/insurance policy, giving hope that a relatively simple and narrowly defined mechanism could be designed around tried and tested approaches, reducing delivery time. Agreeing a method for setting the strike price and establishing appropriate settlement mechanisms are among the major tasks associated with this approach. If designed in a way as outlined above, in tandem with the SAF mandate, it is as or more likely that a private law contract arrangement akin to a CfD would be receiving payments as paying out, and if it could be established that Industry – directly or indirectly – underwrites the mechanism the probability of earlier implementation increases. Early and fast-paced consultation on this approach is a high priority recommendation from this evaluation.

Additional possible interventions.

A number of other ideas that would be supportive of the development of a UK manufacturing base emerged during the evaluation. A subset of the most promising is presented below. They are predominantly geared towards kick-starting UK production, with one important exception – which emerges as a consequence of supply-side policies proposed in EU and US.

a) Enabling Condition: Qualifying product.

The UK does not allow stacking of subsidy or support in principle. It is important that this applies to imported products that have already qualified for subsidy in the country of manufacture if UK producers are to avoid the risk of being undercut by imports. Failure to do this strengthens the case for a price stability mechanism even more.

b) Production Kick-Starters:

1) Icebreaker

Opportunity: Getting assets on the ground quickly has many benefits:

- It builds finance, EPC and market familiarity.
- It encourages supply chains to form.
- It strengthens access to feedstocks and co-dependent technologies (low carbon hydrogen and CCS).
- It establishes UK as an international leader.
- It builds on AFF

Method:

Select a limited number of the most promising projects that could be moved to construction quickly and "fast track" their construction by agreeing a set of guarantees against key variables. The government (or a potential industry fund) would not be providing a blanket investment guarantee, but instead make good any shortfall against critical project KPIs (typically build cost, schedule and operational performance related) that would be agreed between the project and government.

Risks:

- Demands bi-lateral negotiation to establish criteria and agree risk allocation.
- Doesn't guarantee scale up – not a substitute for the interventions in building a more investment-friendly environment.
- Potential government balance sheet liability

Mitigations:

- Only covers the "make good" costs, so exposure should be limited
- The government can influence some of the key success variables
- Potential to leverage UK Infrastructure Bank as a keystone investor

2) Runway:

Opportunity:

The core technologies for 2g Sustainable Aviation Fuel (SAF) – feedstock processing, conversion and upgrading - need to be integrated and implemented at scale. Get this right and technology and construction risk will reduce, skills build and supply chains form. Achieving outstanding emissions reduction outcomes for 2g SAF can create dependencies on the availability of adjacent technologies, such as low carbon hydrogen and CCS. If access to these technologies becomes a precondition for qualification, we risk the industry developing at the pace of the slowest component, and possibly not developing at all.

Method:

- Agree a ratchet on mandate emissions criteria over time, such that early build assets can sell production ahead of integrating with dependent emissions reduction technologies, so mobilising early investment.
- Co-processing, utilising existing refinery capacity, should be explored as a way of reducing capex and modularising expansion. This mechanism may support the broader adoption of co-processing pathways.

Risks:

- Asset stranding – early movers never access the dependent technologies or fail to integrate effectively.
- SAF production assets become so expensive that they are unfinanceable.

Mitigations:

- Robust plans and milestones and off-ramps for non-compliance need to be established at the outset.

5. CONCLUSIONS AND RECOMMENDATIONS

Headline Conclusions

With imaginative application of market shaping levers, UK can leverage the concentration of developers and cross sectoral commitment to build a SAF industry with limited call on public finances.

- SAF has a key role to play in aviation decarbonisation for at least the next two investment cycles.
- UK has the potential to play a leading role – particularly in the development and deployment of 2g SAF.
- The proposed UK SAF mandate is a very promising market shaping mechanism – creating demand, building distinct "beyond HEFA" 2g markets and potentially sending important price signals.
- UK cannot depend on imports of 2g volumes to meet mandate requirements.
- Consensus is that mandate needs to be supported by other interventions to encourage investment in UK supply.
- Key leverage points are supporting nascent advantage in feedstock supply and underpinning revenue confidence.
- There could be a powerful synergy between standards, mandate and a Private Law Contract arrangement akin to a CfD. There is potential for this to be underwritten by industry, not the government.
- Other interventions (e.g. focused guarantees and progressive approach to sustainability metrics) could accelerate key early assets.

Key asks from industry:

Pace – the earlier industry has sight of mandate design and intent around other interventions, the better.

Coordination – success requires alignment and coordination across departments – in particular DfT, HM Treasury, the Department for Energy Security and Net Zero, and the Department for Environment, Food and Rural Affairs.

Confidence – how can the UK government demonstrate that it will stay the course?

Headline Recommendation

Create a SAF investment supportive environment in the UK by:

- leveraging the potential of the SAF mandate
- developing private law contract revenue confidence mechanisms
- securing scalable and bankable feedstock supply
- ensuring a level playing field for UK producers
- implementing specific short-term interventions to de risk early projects.

Specific Recommendations

Leverage the SAF mandate.

Expedite the conclusion and publication of the design of the proposed mandate mechanism, and in doing:

- Ensure that the mechanism sets a clear ambition for 2g SAF volumes.
- Ensure the mandate mechanism sets a buyout price that remunerates investment in marginal 2g SAF capacity.
- Ensure that the mandate eligibility conditions align with feedstock access requirements.
- Test how the HEFA cap could be a mechanism to support investment as well as sustainability and feedstock allocation objectives.

Develop a Private Law Contract Revenue Confidence Mechanism

Fast-track the design with the goal of having a mechanism in place to enable project construction to start in fiscal 2025/26.

To support rapid deployment:

- Start consultation as early as possible.
- Develop a Private Law Contract as a mechanism to work in association with the mandate.
- Keep the design intent as simple and narrow as possible (e.g. price insurance)
- Avoid duplication and re-invention: Look to re-use as many components of existing CfD mechanisms as possible.
- Invite industry to play a leading role in the design and development of such a mechanism, acting as underwriters, developing and deploying a levy-funded pot and potentially establishing a counterparty/scheme operator function.
- Explore auction mechanisms to facilitate a level playing field and enable price discovery.

Securing a scalable and bankable feedstock supply

1) Expand the allowable feedstock pool as far as possible within energy act constraints, including ensuring that the decision in principle to include Recycled Carbon Fuels (RCFs) is implemented as soon as possible.

2) Build confidence in MSW feedstock supply:
   - Develop a clear cross-government view on how best to use the UKs waste resources, underpinned by a cross-departmental action plan.
   - Waste and other biogenic feedstocks should be prioritised to address the challenges of the hardest to abate sectors.
   - Address the question of the role of Energy from Waste in a future net zero grid, particularly when CCS capacity is not close to EfW assets.
   - The use of waste streams as a SAF feedstock should be exempted from inclusion in the ETS.
   - Any competition for subsidy offered to EfW for CCS adoption should also be open on fair and equitable terms to waste to fuel producers, and access to any subsidised CCS capacity should be offered to local assets that would also see benefit.
   - The needs of the SAF sector should be explicitly addressed in the forthcoming government biomass strategy.
   - Explore options to review the classification of the use of waste feedstock to prioritise use in the most difficult to decarbonise sectors.
   - Develop feedstock offtake guarantee mechanisms with tier 1 feedstock suppliers for early projects.

3) Explore extension of socialisation of grid reinforcement costs proposed for EV charging infrastructure to other decarbonisation initiatives.

Ensuring a level playing field for UK producers

Ensure countervailing tariffs, or similar mechanisms, prevent subsidised imported product from enjoying a double incentive benefit.

Short term interventions

Select a limited number of the most promising projects that could be moved to construction quickly and "fast track" their construction by agreeing a set of guarantees against key variables.

Agree a ratchet on mandate emissions criteria over time, such that early build assets can sell production ahead of integrating with dependent emissions reduction technologies, so mobilising early investment.

Co-processing, utilising existing refinery capacity, should be explored as a way of reducing capex and modularising expansion.

Endnote:

Many individuals and organisations were extraordinarily generous with their time and expertise. I am very grateful to everyone who has participated in this evaluation. The views held within it are my own response to the evidence and perspectives so helpfully offered.

6. ANNEX – SCOPE OF THE INDEPENDENT EVALUATION

In the limited time available, (approximately 6 weeks) the evaluation had to focus on key areas and questions in the context of a UK SAF market, identified to be most important to the UK. The key questions that the Department for Transport looked for the evaluation to answer are:

- What are the key conditions for a successful and long-term SAF industry?
- What measures have other countries put in place; have these been effective, and why?
- Can UK industry continue to compete in the long term without government support?
- Can the UK industry meet these conditions with government support? If so, how?
- How does this differ between SAF production technologies?
- What additional measures and tools are available to government and to industry to address these market barriers?

This scope includes:

- An assessment of how competitive the UK supply/value chains are when compared to key international competitors.
- A comparison with different renewable energy and transport sectors to understand what has worked for those sectors, including a consideration of the similarities/differences with SAF. An example list of sectors, not exhaustive, is wind, carbon capture and storage, hydrogen production and use, and electrification.
- Is the UK able to overcome geographic and other barriers including material (e.g. steel and concrete), electricity and labour costs, so that UK SAF production can compete in the long term without government support?
- What competitive advantages does the UK have? Considerations could include links to existing policies or investment in this and other renewable technologies, or links to wider UK strengths, for example, research and innovation.

This scope does not include deployment of the mature HEFA technology. DfT are not seeking new evidence or views on incentive mechanisms for this pathway, which is already commercially developed.

DfT are also seeking parallel advice on the following. We expect work done in relation to these questions to be undertaken in collaboration and partnership with work on the questions above:

- How do financial investors view the competitiveness of UK SAF production?
- What do banks see as the key opportunities for investment in SAF? What would drive investment; where is that investment taking place?
- What are the key barriers to investing in SAF production? How do these compare between countries including the UK?
- What are investors' expectations as to how the global and UK SAF markets will develop; which barriers could be overcome and how?
- What types of measures might need to be in place to stimulate significant investment in the UK, including industry, investment community and government led measures?
- What would provide sufficient support to de-risk SAF investment so that it is more attractive for a wider group of investors?
- What types of investors are interested in SAF investment? Which investors will play which role at different stages? Who might play a key initial role and how do we bring them on board?