Advanced Sustainable BIOfuels for Aviation

Deliverable D5.1:

Business Case

Consortium:

Acronym	Legal entity	Role
RE-CORD	CONSORZIO PER LA RICERCA E LA DIMOSTRAZIONE SULLE ENERGIE RINNOVABILI	CO
TRC	TOTAL RAFFINAGE CHIMIE SA	BEN
TRF	TOTAL RAFFINAGE FRANCE	BEN
SKYNRG	SKYENERGY BV	BEN
CENER	FUNDACION CENER-CIEMAT	BEN
ETA	ETA – Energia, Trasporti, Agricoltura Srl	BEN
CCE	CAMELINA COMPANY ESPANA S.L.	BEN
JRC	JOINT RESEARCH CENTRE – EUROPEAN COMMISSION	BEN

CO…Coordinator, BEN…Beneficiary

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Document Type

PRO	Technical/economic progress report (internal work package reports indicating work status)	
DEL	Technical reports identified as deliverables in the Description of Work	**X**
MoM	Minutes of Meeting	
MAN	Procedures and user manuals	
WOR	Working document, issued as preparatory documents to a Technical report	
INF	Information and Notes	

Dissemination Level

PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	
CON	Confidential, only for members of the Consortium	

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1 Abbreviations

ASTM – American Society for Testing and Materials
Bio4A – EC funded project: Advanced Sustainable Biofuels for Aviation[1]
EC – European Commission
EU – European Union
EU28 – Member States of the European Union
GHG – Greenhouse Gas
HBE – 'Hernieuwbare Brandstofeenheid', Renewable Energy Unit
HEFA – Hydro-processed Esters and Fatty Acids
HVO - Hydrogenated Vegetable Oil
IATA - International Air Transport Association
LCA – Life Cycle Assessment
OEM's – Original Equipment Manufacturers
PoS – Proof of Sustainability
RED (II) – Renewable Energy Directive
RSB – Roundtable of Sustainable Biomaterials
SAF – Sustainable Aviation Fuel
t – metric ton, equal to 1,000 kg
    kt – 1,000 t
    Mt – 1,000,000 t
UCO – Used Cooking Oil

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[1] https://www.bio4a.eu/project-2/

2 Summary

The HEFA or HVO technology is one of the few pathways able to produce Sustainable Aviation Fuels. Multiple technology providers have developed their own hydro processing technology, all with their own characteristics. The technology providers can guarantee production yields and operating conditions due to a variety of demonstration and commercial facilities already operational around the world. Although the installed capacity for HVO/HEFA facilities exceeds 5 million tonnes of production per year, only approximately 10,000 tonnes of HEFA-based jet fuel is produced each year.

In this report we seek to find an answer on this discrepancy by assessing the business case of the HEFA jet pathway. We found that the HEFA case is driven by four main elements:

- The cost of feedstock
- The value of policy incentives
- Hydrogen cost
- Capital Expenditure

While the value for policy incentives is the biggest driver of the business case and absolutely vital to make the case work. The feedstock and hydrogen component are probably the key factors in a HEFA facility. This is due to the fact that those also influence the sustainability of the end products. The availability of truly sustainable feedstocks is limited, and the cost of sustainable hydrogen is still significantly higher than its fossil competitor. Additionally, when using a less pure feedstock with a lower price, the necessary processing increases, resulting in higher cost of operation. Each facility will need to secure its feedstock and hydrogen intake to limit its operational, financial and sustainability risks.

The reason for the flourishing renewable diesel markets, and lacking SAF uptake lays with policy and technical circumstances in the facilities. The road transport sector is a mandated market in Europe, while the aviation industry is not. Especially in recent years, now that the blend wall for ethanol and bio-diesel is getting closer under the mandates, the demand for and (incentive) value of renewable diesel is increasing rapidly. Although HEFA-based jet fuel can in some countries[2] already generate the same policy incentives as renewable diesel, this has not shifted production. This is mainly due to the processing conditions for jet fuel being slightly more challenging, impacting the overall yield and operating cost of the refinery. Without dedicated policy for SAF uptake it is therefore unlikely that HEFA facilities will be producing jet fuel on the short to medium term. The proposed 1.2 multiplier for aviation under the RED-II is a first step in this direction and it is therefore vital that the transposition of the directive into national legislation will create a level playing field with renewable diesel. Hopefully this can enable the construction of additional HEFA facilities with a focus on SAF in the future.

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[2] Like The Netherlands

3 Introduction

This report describes the business case for a commercial HEFA facility producing SAF. There are multiple commercial HEFA facilities already build in Europe, and multiple others are in development or under construction. However, very few are producing Sustainable Aviation Fuels on a continuous basis, although most of them have the option to produce SAF from a technical point of view. Clearly, the current market dynamics favour the production of renewable diesel which is produced in millions of tons vs SAF which has an annual global production capacity of 10 k tons. The goal of this report is to look at the financial business case and the main hurdles & constraints of this pathway. The results provide insights in the main drivers of the business case, which will in the following deliverable, *5.2 Market Dynamics* as well as *5.3 waste feedstock market analysis,* be in more detail assessed. All three deliverables will lead to recommendations for policy in deliverable 3.3.

3.1 Introduction to the business case

Although six distinct pathways are certified as a standard under ASTM D7566, and consequently could be used within commercial aviation, most flights on SAF have been powered by fuels produced through the HEFA technology. This pathway converts oils and fats to hydrocarbons in the jet and diesel range. Most of these refineries produce renewable diesel on a continuous basis, and only sometimes SAF is produced on a batch basis. The only HEFA facility in the world, continuously producing SAF is World Energy (formerly known as AltAir Fuels) in Los Angeles.

The ultimate goal of the Bio4A project is to produce an approximate 5,000 t of SAF from Total's La Mede facility. While testing the production, the second goal is to make SAF a more continuous output product of this refinery and future additional refineries. Therefore we seek to understand the financial dynamics behind the HEFA pathway. In the following we will detail out the results of the techno-economic assessment. This is followed by the assessment of the main hurdles and constraints for scaling the HEFA technology in Europe, including a high-level SWOT analysis. This report is finalized by a first outlook on the market dynamics which will be in more detail assessed in deliverables 5.2, 5.3 and 5.4.

4 The Business case – Techno-Economic Assessment

In this chapter the financial feasibility is assessed by using a Techno-Economic model. A tailor-made valuation model was created using Excel, the model can be provided upon request. The model assesses the viability of a HEFA based SAF production facility as described in more detail below. The main outputs of the model are the minimum fuel selling price (MFSP) as well as various indicators of the financial viability of the investment (internal rate of return, net present value, etc). To visualize how the different cost components contribute to the MFSP a cost build-up waterfall graph is generated. In addition, a sensitivity analysis was carried out to determine the impact of the main business case drivers on the financial viability

We will present the results and data here publicly, as this deliverable is stripped from any confidential input. The business case is based on a set of assumptions, which will be discussed in more detail in the next section.

4.1 Assumptions

To assess the economic viability of a HEFA-based SAF production facility we choose to follow the below high-level scenario regarding the three most important elements of the facility (location, scale and feedstock). The consequence of this scenario is shown in the detailed assumptions discussed in the next section.

4.1.1 Scenario

Location

The plant is fictionally located in the European Union close to a port and well connected to a nearby airport. This allows for efficient logistics of both the feedstock material as well as final products. This matches with the currently existing and planned HEFA facilities, which are all located next to a port area and often well connected to nearby airports. To quantify the effect of the European RED-policy we assume the situation in The Netherlands. In the Netherlands the aviation industry can currently opt-in in the RED system, as explained in the market dynamics report (D5.2). Although it is still unclear how the RED-II transposition will translate in clear incentives, this is currently the best location for SAF supply in Europe.

Scale

A scale of 500,000 metric tonnes feedstock input is chosen. This is an approximate average between the three main European HEFA facilities, which have shown interest and/or focus on the production of SAF:

- SkyNRG's DSL-01	150,000 t
- Total's La Mede refinery	600,000 t
- Neste's Rotterdam refinery	1,000,000 t

Feedstock input

The feedstock used in a HEFA facility is one of the key drivers for the sustainability performance of the plant, see deliverable 5.2. However, the feedstock is also key in the financial performance of the plant. Waste based feedstocks, like Used Cooking Oil, are preferentially treated under the RED-II legislation. This causes these feedstocks to yield higher value end-products. However, as a consequence of the increasing mandates and therefore demand for these feedstocks, the feedstock will be a more expensive input to the plant. In this analysis we use waste-based feedstocks as an input because of the increased sustainability performance and will assess the sensitivity of this input.

4.1.2 Assumptions

For most assumptions, general industry values are taken. Wherever this was not possible, average numbers are used for industrial sites in Europe.

Facility assumptions

For the facility we took the following general parameters. It´s good to note that the business case starts at year 3, where year 1 and 2 are allocated to the facilities´ construction activities. Year 3 starts with a 45% operation and from Year 4 the facility is expected to operate on its maximum capacity, this is set on 91.5% to cover for maintenance. 91.5% comes down to 8,015 hours of operation.

Table 1. Facility assumptions

Parameter	Value	Note
Total years business case	25 years	Starting Y3
CAPEX investment timing	2 years	Y1: 50%, Y2: 50%
Ramp-up of operation	Y1-2: 0%, Y3: 45%, Y4: 91.5%	
Uptime	91.5%	

Financial assumptions

The following financial parameters have been used.

Table 2. Financial parameters

Parameter	Value	Note
Depreciation period	10 Y – Straight line	Industry
Debt:Equity ratio	70:30	Industry rate
Interest rate	5%	Market value
Discount rate	5%	Industry value
Corporate Tax	20.5%	Based on The Netherlands

Capital Expenditure

The CAPEX investment is scaled based on the two known HEFA plants discussed in the introduction, Total's La Mede facility is excluded from the CAPEX estimate, as this is a brownfield revamp of an existing facility instead of a greenfield facility. The below values are scaled to our 500,000 mt refinery with a 0.6 scaling factor using the following formula[3].

$$CAPEX\ of\ Bio4A\ facility = CAPEX\ of\ facility\ X * \left(\frac{Scale\ of\ Bio4A\ facility}{Scale\ of\ facility\ X}\right)^{0.6}$$

SkyNRG's DSL-01	150,000 t	250,000,000 EUR[4]
Neste's Rotterdam refinery	1,000,000 t	670,000,000 EUR[5]

This leads to an average rounded CAPEX for the Bio4A assumed facility of **480,000,000 EUR**.

Utility assumptions

The process utility parameters are taken from literature. Although directionally correct, the accuracy of these values is limited, as the actual values are confidential to each technology provider. Each technology provider has a slightly different approach to the HEFA technology and the workings of its system, in reality the intake of utilities and operating conditions might differ.

The most important utility is the hydrogen intake, this has a significant impact on the CO_2 emission reduction potential of the fuel. The conventional technology, Steam Methane Reforming, produces hydrogen from natural gas whereas electrolysis offers a more sustainable alternative when using renewable electricity and water. The hydrogen intake will also influence the cost of the final product as one of the key input factors. In this case we use a theoretical

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[3] Ereev, S. Y., & Patel, M. K. (2012). Standardized cost estimation for new technology (SCENT)-methodology and tool. Journal of Business Chemistry, 31-48.

[4] https://skynrg.com/press-releases/klm-skynrg-and-shv-energy-announce-project-first-european-plant-for-sustainable-aviation-fuel/

[5] https://www.neste.com/neste-oil-celebrates-grand-opening-europes-largest-renewable-diesel-refinery-rotterdam

approach (derived from the chemical equation) to determine the hydrogen intake. We're assuming the use of used cooking oil which is based on rapeseed oil as a feedstock. We assume a standard rapeseed oil consisting of a triglyceride with three C18 molecules and six double bonds. To fully deoxygenate and saturate a tonne of this oil we need the equivalent of 0.0414 t H_2.[6]

Table 3. Utility inputs

Parameter	Value	Note
Hydrogen	0.045 t H2 / t feedstock	Theoretical value to saturate rapeseed, X Dupan et al 2007
Electricity	0.970 MWh / t feedstock	SA De Jong, Green Horizons
Water	384 M^3 / t feedstock	SA De Jong, Green Horizons
Natural gas	5.25 GJ / t feedstock	SA De Jong, Green Horizons

Facility yield factors

Similar as the utilities, the yield factors of a HEFA facility depend to a large extend on what technology is being used. The actual conversion rates of the various technologies are not in the public domain and therefore we use values from literature. What is important to note is that some technologies operate in a setting where both diesel and jet fuel can be generated, while others work in an either the one or the other setting. When maximizing for the jet fuel output it is to be noted that the production of lighter fractions also increases, resulting in a lower 'middle distillate' output than in a situation where diesel output is optimized. In the results section the sensitivity of these yields is discussed in more detail.

Table 4. Yield inputs

Parameter	Value	Note
Jet fuel yield	49%	Pearlson 2013
Diesel yield	23%	Pearlson 2013
Naphtha yield	7%	Pearlson 2013
LPG yield	10%	Pearlson 2013
Total yield	89.9%	Pearlson 2013

Revenue assumptions

The revenue can be categorized within three components.

1. The fossil revenue from the Jet fuel, Diesel, Naphtha and LPG products. These are publicly available indexed prices, when available in Europe.

2. The value of the incentives generated by the sustainable fuels under the Renewable Energy Directive. Every member state in the EU has its own system to increase its share of sustainable fuels in the fuel mix (please refer to deliverables 5.2 and 3.3 for more details regarding the RED implementation). For this TEA, we assume the case of The Netherlands, which already has a so-called aviation opt-in. The mandated volumes are managed through 'Renewable Fuel Units' (HBE's). These units are currently worth approximately 10 EUR/HBE. However, this value has turned out to be very volatile and as it is very unclear how this value will develop over the next years, we take an average value for the past five years, which is 7 EUR/HBE. A HBE is received for every GJ of renewable energy put in the system. For SAF this means 44 GJ, is 308 EUR per tonne of fuel. As we assume to use a waste-based feedstock and will go to the aviation market, the fuel is eligible for double counting and a 1.2 multiplier. Making the current policy incentive worth 739 EUR per tonne. This value is however the value generated when the fuel is put on the market (fuelling an aircraft, fuel sold at a fuelling station next to the highway, etc.). It is not likely that the facility can generate this entire value, therefore we

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[6] X Dupain et al. 2007

assume a 75% sales rate of this value, see Table 5 for the final HBE values attributed to the facility.

3. The final component on the revenue side is the voluntary premium an airline is willing to pay for the fuel. This is estimated to be 0 in the base case, this value is used to solve the business case. The additional premium will be set on such a level that a NPV of 0 or higher can be achieved, if necessary. This shows the needed value per t of jet fuel to make a financeable business case.

Table 5. Revenue assumptions

Parameter	Value	Note
Fossil prices		
Jet fuel	570 EUR/t	IATA Fuel price monitor, Europe average 2019
Diesel	570 EUR/t	Indexmundi; average 2019
Naphtha	510 EUR/t	Relative to jet and diesel price
LPG	510 EUR/t	Relative to jet and diesel price
Policy		
HBE Value	7 EUR/HBE (GJ)	Average 2015 – 2019 value
Jet / Diesel	44/44 HBE/t	RED II
Naphtha / LPG	45/46 HBE/t	RED II
Aviation multiplier	1.2	RED II
Double Counting	Yes, 2	RED II, Waste feedstock
Sales percentage HBE's	100%	
HBE Value jet	554 EUR/t	
HBE Value diesel	462 EUR/t	
HBE Value Naphtha	472 EUR/t	
HBE Value LPG	483 EUR/t	

Costs assumptions

The cost of the various inputs are shown in Table 6. Most important factors will be the feedstock price and hydrogen price, both will be assessed on sensitivity. The feedstock price is based on the average price of UCO in Europe in 2019 (Greenea, 2019). For the hydrogen price we assess two scenarios, one fossil based H_2 production, where the SMR technology is used and the other based on renewable electricity where electrolysis is used.

Table 6. Cost assumptions

Parameter	Value	Note
Feedstock price	700 EUR/t	UCO price 2019, Greenea
Hydrogen price	2500 - 5000 EUR/t	Irena, 2018; current SMR and electrolysis price[7]
Electricity price	40 EUR/MWh	EU Industry value
Natural gas price	10.4 EUR/GJ	EU Industry value
Water price	0.04 EUR/M^3	EU Industry value
Labour	2,750,000 EUR/Y	Based on 5 shifts 6 operators per shift 1 supervisor per shift 5 additional technical specialists

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[7] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Sep/IRENA_Hydrogen_from_renewable_power_2018.pdf

Land rent	375,000 EUR/Y	7500 m^2 , 50 EUR/m^2
Maintenance	2% of CAPEX	Industry estimate
Insurance	0.5% of CAPEX	Industry estimate
Overhead (ICT, Consumables, HSSE, etc)	1,000,000 EUR/Y	Industry estimate

5 Results

The results are initially presented following the base case values, as discussed above. This is followed by a discussion around the sensitivities of certain values and on different scenario's such as a growing incentive value. To present the results we will use the following three metrics.

> *NPV*
>
> The net present value (NPV) is used as an indicator of the economic viability of the six different pathways. The NPV method is a valuation tool that calculates how much value a project adds with regards to the investment made in the project. To get the NPV, the future cash flows of the project's lifetime are discounted for the devaluation of money over time. The sum of these discounted cashflows (including the investment in year 0), results in the NPV.
>
> *Minimal Fuel Selling Price*
>
> The contribution of each cost element (e.g. feedstock, utilities, CAPEX, etc.) is summed towards a total minimal fuel selling price (MFSP) of the jet fuel product. The results are presented in a waterfall graph to show the relative contribution of each element. Each cost component is summed and averaged over the lifetime of the plant and calculated per metric tonne (t) of jet fuel. This also means that the income of other products (diesel, naphtha, LPG) is presented as negative cost in the waterfall. In case of a situation in which the NPV is negative, we use the 'voluntary premium on the jet fuel' and adjust it to such a value to create a NPV to be 0.
>
> *10-year business case*
>
> This overview will show the main revenue and costs components of the process. This will also give an indication of the profitability of the process. It is important to note that this business case overview is generated with an NPV of 0.

5.1 Base case

The results from the base case are shown in below Table 7. As can be seen the NPV of the investment turns out to be negative in the current situation, this is also shown by the other values IRR and payback periods. The Minimum Fuel Selling Price of 1497 EUR/t still leaves a premium of 927 EUR/t. Although the HBE value can cover a large part of the premium (554 EUR/t), this is not enough to create a positive cash flow situation.

Table 7. Results of base case

Parameter	Value	Note
NPV	(999,000,000)	EUR
IRR	Negative	
Payback period	Negative	
Equity payback period	Negative	
MFSP allocated to jet	1,496	EUR/t

Figure 1 shows the cost build-up towards the Minimal Fuel Selling Price (MFSP) of SAF. It is important to note that this graph shows the cost for each component allocated to the produced SAF. This can be easily shown by the feedstock cost, for each tonne of feedstock 0,49 t of SAF is produced, this results in the double price for feedstock 1417 EUR/t in the cost build-up. With this method we can deduct the value of the co-products (diesel, naphtha, LPG) from the cost build-up. Eventually resulting in a MFSP of 1496 EUR/t. The value for HBE's for jet fuel can cover part of these costs 554 EUR/t. The remainder is covered partly by the fossil price value, leaving a price gap of approximately 400 EUR/t to be covered by a voluntary premium.

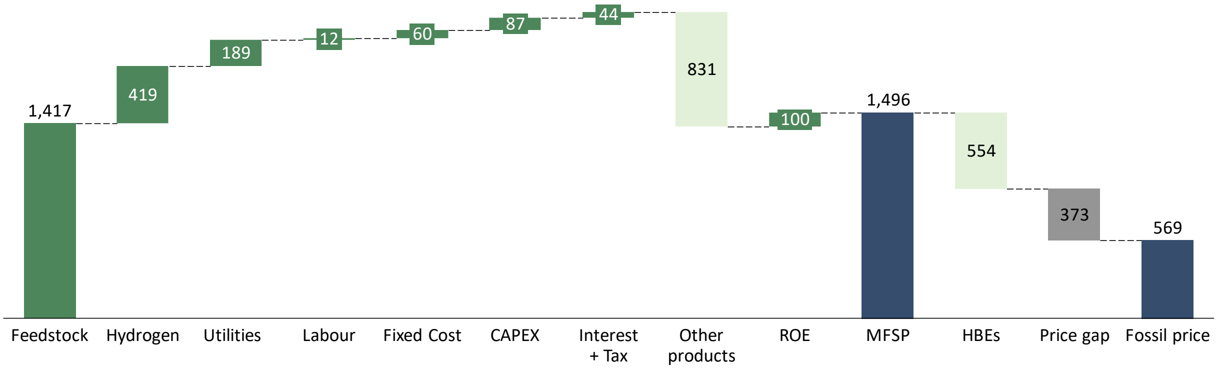

Figure 1. Cost build-up of MFSP

When solving for the NPV to become 0, we will insert a voluntary value for the jet fuel. As a positive NPV also increases the interest and tax value, the voluntary value is higher than the price gap shown in Figure 1. The total voluntary premium to solve the case is 408 EUR/t. The results in Appendix A show the detailed business case for an operational period of 10 years. This shows the positive EBITDA and net income values. Table 8, shows the financial parameters for this case. It is to be noted that although the NPV is 0, this is still not a case that looks attractive to financiers.

Table 8. Financial results for an NPV of 0

Parameter	Value	Note
NPV	0	EUR
IRR	1.48%	
Payback period	13.77	Years
Equity payback period	10.16	Years
MFSP allocated to jet	1,532	EUR/t

5.2 Sensitivities

Although the base case gives an initial understanding of the economic viability of a HEFA facility the more interesting information lays with the sensitivity of the various assumption on the NPV and MFSP. In Figure 2 and Figure 3 the sensitivities are shown for respectively the feedstock price, hydrogen price, CAPEX and HBE value. These sensitivities are shown on two parameters, first the NPV and second the Minimal Fuel Selling Price (MFSP).

HBE Value

When looking at the NPV and MFSP sensitivity, we note the heavy reliance on a solid policy value. This value is currently the most important business case influence. If this value returns to its 2017 value of 3 €/HBE the case looks completely different and there would be a negative NPV of a billion. On the other hand, if the HBE price would stabilize on the very high price it currently has (12 €/HBE), the case looks very positive. A similar effect can be observed if the fossil value suddenly increases, while the feedstock price remains constant or when airlines are willing to pay a premium for the jet fuel product.

Feedstock

As noted before the feedstock price is very volatile and of major importance for the viability of the business case. In this case, we show the effect of the feedstock price increasing from 700 to 900 EUR/t and decreasing to 500 EUR/t. The absolute influence of this factor is slightly less than the HBE, but still very significant and especially for the MFSP the most crucial factor. In reality, the value for policy and cost of feedstock are connected. In case of a market mechanism, like the HBE, the value for policy would increase with an increasing feedstock price to compensate for the increased production costs. It is therefore unlikely that both the price of HBE's decrease with an increasing (waste-) feedstock price.

Hydrogen price

The biggest contributor to the utility costs is the hydrogen price. Therefore, switching from either a fossil Steam Methane Reforming hydrogen source to a renewable electrolysis-based hydrogen source can have a significant impact on the financial viability of the project. For policy makers it is therefore important to create guidelines in which not only the feedstock source, or a threshold CO_2 saving value, is important but stimulate additional CO_2 reduction, possible through the use of sustainable utilities, as well. The cost of hydrogen is also impacted by the feedstock intake of the facility. In case a less pure, cheaper feedstock is used this can be beneficial for the feedstock price and availability, however due to the larger amount of impurities, more hydrogen and severe operating conditions are needed to process the feedstock into the right quality end product.

CAPEX

The capex value, although important, has in the case of a HEFA facility limited impact on the economic viability. The case is mostly driven by OPEX in the form of Feedstock and Hydrogen and revenue from policy and fossil value. The CAPEX is secondary to the viability of the case.

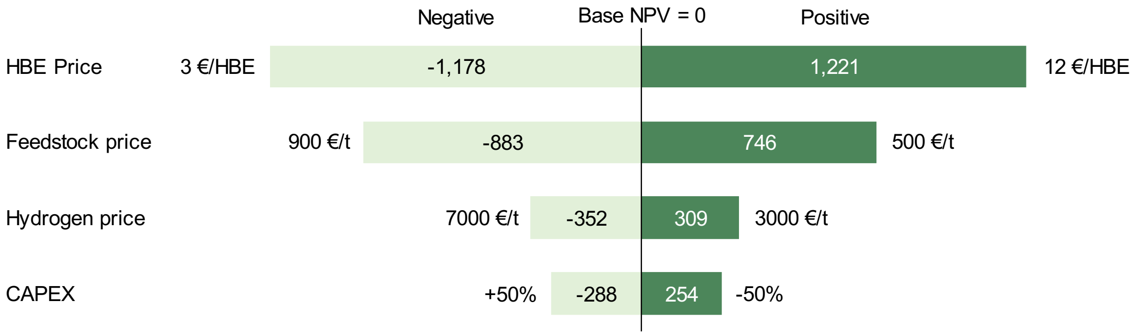

Figure 2. Sensitivities on NPV value

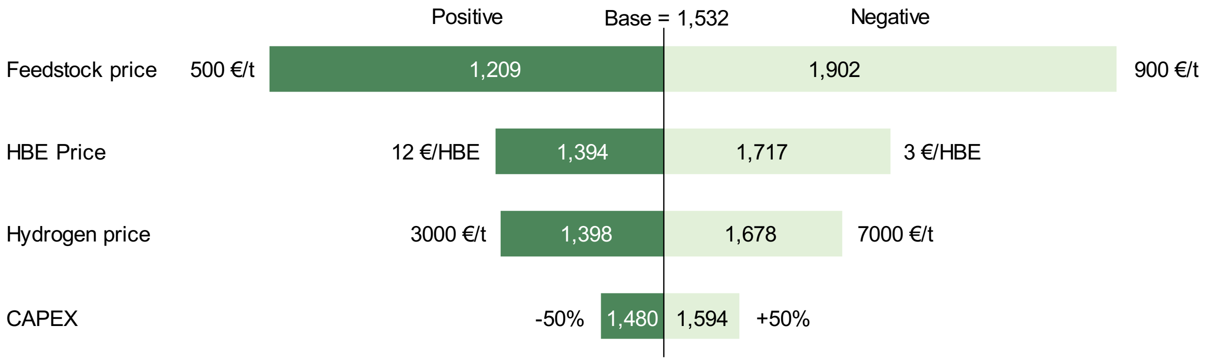

Figure 3. Sensitivities on MFSP

5.3 Reflection on business case

The results have shown that the business case of a HEFA facility producing jet fuel is challenging under the volatile market circumstances. At the same time, the current situation (mid 2019) shows a very high value for policy, which makes the case viable under current circumstances. However, this is still too uncertain and volatile for a stable return and investors are therefore hesitant to invest in new HEFA capacity. It is for that reason that most of the HEFA/HVO facilities so far have been build and invested in by players already active in the oil market, they see the risks but more importantly the long-term strategic value.

A second point of reflection lies with the internal competition for diesel and jet fuel production in a HVO facility. It is naturally easier to produce diesel as the diesel carbon chain length matches the feedstock carbon chain length. This results in operating conditions in which less hydrogen is needed, and less iso-cracking takes place. By operating less severe conditions, there will be less lighter fractions, increasing the yield of higher value middle distillates. This results in the fact that from a production point of view the HVO diesel case is always better than the HEFA jet case. It is therefore vital that specific policy is developed to stimulate the construction of additional HEFA jet focused facilities. It is to be seen whether the 1.2 multiplier for aviation under the RED-II is enough to enable new facilities.

6 SWOT, Dynamics and Concluding remarks

The results of the business case show the challenges and opportunities for a HEFA facility in Europe. The economics look negative under the base case assumptions and there is a challenge on sourcing enough sustainable waste feedstocks. This will be discussed in more detail in other reports of the Bio4A project. Nevertheless, there is still room for new investments in this sector when looking at the business case and the limited amount of options to decarbonize aviation. Furthermore, the same time the business case is very sensitive to changes in specific parameters, the price for feedstock, the dependency on hydrogen and the value of incentive structures can shift the case quickly from positive to negative and the other way around. The conclusions of the HEFA business case are shown in Figure 4, in the form of a SWOT assessment.

Strengths

- Robust, investable and well known technology
- Various technology providers available, facility developers can choose the optimal technology
- OPEX driven pathway, with the right contracts the business case can be enabled

Weaknesses

- Limited technical scaling improvements still possible
- Relatively expensive technology when small scale is used, while feedstock challenges make a smaller scale plant more attractive

Opportunities

- There is a growing market, more and more push from (European) governments and consumers to stimulate the uptake of SAF, leading to increased incentive value
- Very limited alternative SAF production technologies are commercia; HEFA currently the only real option

Threats

- Limited truly sustainable and affordable feedstock available
- Future technologies might overtake HEFA in the future
- Sustainable hydrogen still expensive, threat to business case

Figure 4. SWOT analysis of HEFA business case

Appendix A – 10 year business case – solving the NPV for 0

Bio4A - 10 year operational business case

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Financial results													**X 1000 EUR**
Operation	0%	0%	45%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Revenues													
Revenue from fossil products	-	-	112,975	229,715	229,715	229,715	229,715	229,715	229,715	229,715	229,715	229,715	229,715
Revenue from HBE	-	-	104,369	212,216	212,216	212,216	212,216	212,216	212,216	212,216	212,216	212,216	212,216
Revenue from remaining premium	-	-	49,011	99,657	99,657	99,657	99,657	99,657	99,657	99,657	99,657	99,657	99,657
Revenue	**-**	**-**	**266,355**	**541,588**	**541,588**	**541,588**	**541,588**	**541,588**	**541,588**	**541,588**	**541,588**	**541,588**	**541,588**
Cost													
Feedstock cost	-	-	(157,500)	(320,250)	(320,250)	(320,250)	(320,250)	(320,250)	(320,250)	(320,250)	(320,250)	(320,250)	(320,250)
Utility cost	-	-	(67,548)	(137,347)	(137,347)	(137,347)	(137,347)	(137,347)	(137,347)	(137,347)	(137,347)	(137,347)	(137,347)
Labour cost	-	-	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)	(2,750)
Total fixed cost	-	-	(13,375)	(13,375)	(13,375)	(13,375)	(13,375)	(13,375)	(13,375)	(13,375)	(13,375)	(13,375)	(13,375)
Total cost	**-**	**-**	**(241,173)**	**(473,722)**	**(473,722)**	**(473,722)**	**(473,722)**	**(473,722)**	**(473,722)**	**(473,722)**	**(473,722)**	**(473,722)**	**(473,722)**
EBITDA	**-**	**-**	**25,182**	**67,866**	**67,866**	**67,866**	**67,866**	**67,866**	**67,866**	**67,866**	**67,866**	**67,866**	**67,866**
Depreciation	-	-	(48,000)	(48,000)	(48,000)	(48,000)	(48,000)	(48,000)	(48,000)	(48,000)	(48,000)	(48,000)	(48,000)
EBIT	**-**	**-**	**(22,818)**	**19,866**	**19,866**	**19,866**	**19,866**	**19,866**	**19,866**	**19,866**	**19,866**	**19,866**	**19,866**
Interest	(8,400)	(17,220)	(17,358)	(16,635)	(15,911)	(15,188)	(14,465)	(13,742)	(13,018)	(12,295)	(11,572)	(10,849)	(10,125)
Taxes	-	-	-	(662)	(811)	(959)	(1,107)	(1,255)	(1,404)	(1,552)	(1,700)	(1,848)	(1,997)
Net income	**(8,400)**	**(17,220)**	**(40,176)**	**2,569**	**3,144**	**3,719**	**4,294**	**4,869**	**5,444**	**6,019**	**6,594**	**7,168**	**7,743**