EMISSIONS INTENSITY CALCULATIONS FOR THE BIOFUELS MANDATE

Prepared for Ministry of Business, Innovation and Employment

13 June 2022

Hale & Twomey Limited is an energy consultancy specialising in strategic issues affecting the energy sector. With a comprehensive knowledge of local and international energy markets, we provide strategic advice, comprehensive analysis and services across the entire sector.

Hale & Twomey prides itself on being able to analyse and interpret the detail, then translate the implications into strategic directions for our clients. We provide expertise to a broad range of companies and government departments. Hale & Twomey has established a strong reputation in the sector by producing timely, high quality, value-adding work.

Authorship

This document was written by:

Ian Twomey	Phone: +64 4 471 1109, e-mail: ian@haletwomey.co.nz
Shakil Kumar	Phone: +64 4 471 1152, e-mail: shakil@haletwomey.co.nz

Please phone or e-mail for further information.

Disclaimer

Executive Summary

In November 2021, the New Zealand Government agreed to implement a sustainable biofuels obligation from 1 April 2023. The obligation requires obligated parties to reduce the greenhouse gas emissions of the liquid fossil fuels they supply by deploying sustainable biofuels. They must achieve a defined percentage emissions reduction, which will be set by the Government. The Ministry of Business, Innovation & Employment (MBIE) have responsibility for designing the system.

This technical report assesses the planned emission intensity factors that MBIE intend to use in the sustainable biofuels obligation. MBIE is basing the emission intensity factors on those used in the European Union (EU) Renewable Energy Directive II (RED II). This paper assesses two aspects of that application.

1) Assess whether it is reasonable to use the EU RED II lifecycle emission factor for liquid fossil fuels (94 gCO_{2e}/MJ) for New Zealand fossil fuels given any differences in the fuel quality and supply chain.

2) Recalculate the transport emissions component used in biofuel default emissions intensity calculations to reflect New Zealand's location and use that to recommend possible adjustments to the default biofuel emission intensity factors.

The liquid fossil fuel lifecycle emissions include both supply and combustion emissions. We have found that while New Zealand's petrol and diesel combustion emissions vary from those used in the RED II calculation (petrol lower, diesel higher), on average they are similar. We comment that the New Zealand combustion emissions are more in line with the International Panel on Climate Change (IPCC) defaults, it is the EU factors that are unusual.

The supply emissions for New Zealand's fossil fuels are also similar to the EU, despite a very different supply chain. The additional emissions from the shipping leg to import finished product from Asia are largely offset by lower emissions in the rest of the supply chain.

Given these findings, we conclude that the EU RED II lifecycle emissions factor (94 gCO2e/MJ) is valid for application to New Zealand's liquid fossil fuels.

The main change to transport emission calculations for the default biofuel emissions intensity factors, is New Zealand is likely to have more ocean shipping for most biofuels than assumed by the EU. There is some offset in distribution emissions (lower in New Zealand), and for some feedstocks which are imported into the EU there is offset in shipping emissions that it is appropriate to remove. The overall impact is either no change to the default emissions intensity or a reduction of about 3-4% in intensity from the impact of the additional shipping emissions.

There needs to be consideration whether these adjustments are material, given the default emissions factors already assume a lower emissions intensity from the typical, due to modelling a 'high emissions intensity' processing step. The typical intensity factors given in RED II are better than the defaults, reflecting a greater reduction in emissions. This means by using the default factors in the obligation system, biofuel suppliers are encouraged to calculate and submit the biofuel's actual lifecycle emissions in order to claim more emission savings from the biofuel use than if assuming the default. For New Zealand, even if the default emission factors were not adjusted to reflect higher transport emissions on some biofuel routes, we do not consider the incentive to provide actual emissions data will be diminished.

Table of Contents

Glossary

Term	Definition
CH_4	Methane
CO_2	carbon dioxide
DDV	disaggregated default values
e_{ec}	emissions from the extraction or cultivation of raw materials
e_l	annualised emissions from carbon stock changes caused by land-use change
e_p	emissions from processing
e_{td}	emissions from transport and distribution
e_u	emissions from the fuel's combustion
e_{sca}	emissions savings from soil carbon accumulation via improved agricultural management
e_{ccs}	emissions savings from CO2 capture and geological storage
e_{ccr}	emissions savings from CO2 capture and replacement
EU	European Union
GCV	Gross calorific value
gCO_{2e}	Grams of carbon dioxide equivalent (includes emissions of carbon dioxide, methane and nitrous oxide
gCO_{2e}/MJ	Grams of carbon dioxide equivalent per megajoule of energy
GHG	Greenhouse gas
GWP	Global warming potential
HFO	Heavy fuel oil
H&T	Hale & Twomey Limited
HVO	Hydrotreated Vegetable Oil
IPCC	International Panel of Climate Change
JEC WTT	JEC Well-to-Tank emissions reports (JEC is a collaboration among the European Commission's Joint Research Centre, EUCAR (European council for Automotive Research and development) and Concawe (the scientific body of the European Refiners' Association for environment, health and safety in refining and distribution).

LFF	Liquid fossil fuels
LHV	Lower heating value
MBIE	Ministry of Business, Innovation & Employment
MJ/kg	Megajoules per kilogram
MJ/litre	Megajoules per litre
Net CV	Net calorific value (same as lower heating value)
NZ DEF	New Zealand default emission factor
NZ GGI	New Zealand's Greenhouse Gas Inventory
N_2O	Nitrogen oxide
RED II	Renewable Energy Directive II (RED II)

1.0 Introduction

In November 2021, the New Zealand Government agreed to implement a sustainable biofuels obligation from 1 April 2023. The obligation requires obligated parties to reduce the greenhouse gas (GHG) emissions of the fossil fuels they supply by deploying sustainable biofuels. They must achieve a defined percentage emissions reduction, which will be set by the Government. The Ministry of Business, Innovation & Employment (MBIE) have responsibility for designing the system.

Each year a fuel supplier would have to demonstrate that the percentage emissions reduction it achieved, across its fuels, is at least equal to, or higher than, the required percentage. The targets in the Obligation are emissions intensity reduction targets. The emissions intensity reduction target would be calculated by comparing the emissions of its fuels (fossil and biofuels) against the hypothetical emissions had all its fuels been fully fossil origin.

In order to complete this calculation both fossil fuels and the expected biofuels need to have agreed emission intensity factors. These factors will be calculated based on a lifecycle emissions analysis. To avoid the need to develop a complex system from scratch, MBIE is proposing to leverage off the methodology used by the European Union (EU) for its Renewable Energy Directive II (RED II). However certain components, particularly transport may need to be adapted to New Zealand supply.

This paper reviews the application of the RED II to New Zealand for the lifecycle emissions from fossil fuels and biofuels. For fossil fuels the question is whether the average emissions figure used in the RED II is applicable for New Zealand. For the emission intensity of different biofuels, the impact of a variation in transport emissions reflecting New Zealand's location needs to be analysed with adjustments proposed where appropriate.

2.0 Use of energy content

In order to analyse and evaluate energy intensity, the energy content of fossil and biofuels are critical inputs. Energy content (or calorific value) can be measured on a gross or net basis (net is also referred to as the lower heating value - LHV). The gross basis assumes the latent heat of vaporisation of water is recovered whereas net assumes it is not recovered.

For consistency it is important to be aware whether an energy calculation assumes a gross or net energy basis. All the EU calculations are based on the net or lower heating value. This is in line with the International Panel of Climate Change (IPCC) recommendations. However all New Zealand's energy data is on a gross basis so needs to be converted if used to compare with EU data.

The advantage with the biofuels emissions targets is they are on an emissions intensity basis (relative emissions per unit of energy). As long as the calculations have been consistent in the comparison of biofuel and fossil fuel emissions, then the intensity as a percentage won't change between a gross or net basis. However if an EU calculated intensity saving is used to calculate an actual emissions saving in tonnes of carbon dioxide (CO_2), this needs to be done assuming a net energy consumption for consistency with the factor.

This issue is covered in Annex 4 of New Zealand's Greenhouse Gas Inventory (NZ GGI). This Annex notes that:

> *"The convention adopted by New Zealand to covert gross calorific value to net calorific value follows the Organisation for Economic Co-operation and Development and International Energy assumptions:*
>
> *Net calorific value = 0.95 x gross calorific value for coal and liquid fuels"*

We note the data the NZ GGI uses for fossil fuels (Refining NZ fuel property data published by MBIE) calculates both gross and net energy data for NZ fuels. In this case the following net to gross conversions apply:

- Premium and regular petrol: Net CV = 93.4% of GCV
- Diesel: Net CV = 93.8% of GCV
- Jet Fuel: Net CV = 93.6% of GCV

These are more accurate and specific than the overall 95% conversion and similar to international tools for converting gross to net energy for different fuels (e.g. H2 Tools by the Pacific Northwest National Laboratory)[1].

We use these more accurate conversions of gross to net when comparing New Zealand fossil fuel quality data to the EU data used in RED II. In addition, as the EU RED II is going to be the basis of the New Zealand system, we suggest all data for the biofuels obligation system gets expressed on a net energy basis to ensure there is no confusion. This is different than standard practice in New Zealand (e.g. MBIE's Energy Data File).

3.0 Determining the emissions intensity of liquid fossil fuels in New Zealand

The first requirement is to establish whether the fossil fuels lifecycle emissions value assumed in RED II is applicable for New Zealand quality liquid fossil fuels (LFF). This needs to be calculated for the two grades of petrol (regular and premium) and diesel. Although each fuel has a slightly different lifecycle emission factor, RED II assumes a single lifecycle emissions for all LFF of 94 gCO_2/MJ. This is done to avoid emissions savings being claimed from changing the fossil fuel mix. MBIE is also proposing to use a single lifecycle emissions factor for the biofuel obligation scheme.

In order to compare New Zealand quality fuel, we need to understand the basis of the RED II assumptions. The basis of the total emissions for fossil fuels used by the EU of 94 gCO_2/MJ is in the Definition of input data[2] paper.

[1] https://h2tools.org/hyarc/calculator-tools/lower-and-higher-heating-values-fuels#:~:text=The%20lower%20heating%20value%20(also,the%20reaction%20products%20is%20not

[2] JRC Science for Policy Report, *Definition on input data to assess GHG default emissions from biofuels in EU legislation*, Version 1c – July 2017 (pg. 6)

Table 1: EU lifecycle emission factors for diesel, gasoline and HFO

Table 1 Emissions associated to the production, supply and combustion of diesel, gasoline and heavy fuel oil

$gCO_{2\,eq}$/MJ final fuel	DIESEL	GASOLINE	HFO
Supply emissions	21.9	19.9	13.6
Combustion emissions	73.2	73.4	80.6
Total emissions	**95.1**	**93.3**	**94.2**

Sources

1 Directive (EU) 2015/652.

2 ICCT, 2014.

3 JEC-WTTv4a, 2014.

We understand there may have been changes in the data prior to finalising the RED II, as some of these reports referred to (such as the JEC-WTT reports) are being regularly updated. Also, if the factors calculated above were weighted based on the typical EU consumption of fossil fuels, the factor should have been 95 gCO_2/MJ[3]. It is important to understand this and note there has been a degree of rounding to finalise on a single factor.

The LFF lifecycle emissions are made up of both consumption and supply factors and we compare each separately with New Zealand data.

3.1 Combustion emissions

For the comparison of combustion emissions, we compare the energy content of the fuels, which for the EU RED II are provided in Annex III. The New Zealand data used in this comparison is the last five years data (2017-2021) published in MBIE's Energy Data. The New Zealand data has been fairly consistent over a long period of time.

Table 2: Comparison of energy content (net basis)

		EU RED II	NZ Energy Data	EU RED II	NZ Energy Data
		MJ/litre	MJ/litre	MJ/kg	MJ/kg
Petrol	Total (weighted)	32	32.8	43	43.9
	Regular		32.8		43.9
	Premium		32.9		43.8
Diesel		36	36.1	43	43.0

There is some difference in petrol energy content although the alignment is very close for diesel. The figure of 43 MJ/kg for EU petrol is quite low as the IPCC 2006 defaults give a figure of 44.3 MJ/kg[4], which is higher again than the New Zealand value. There is much better alignment on diesel where the IPCC default is also 43.0 MJ/kg.

Although there is some variation in the energy content, the key issue is how this converts into combustion emissions. We note that the combustion emissions are on a CO_2 equivalent basis

[3] Based on BP World Energy Data for 2019 for petrol, diesel and fuel oil consumption in the European Union the average would be 94.7 gCO_2/MJ .

[4] 2006 IPCC Greenhouse Gas emissions calculation guidelines Table 1.2

(CO_{2e}) which means they also include methane (CH_4) and nitrogen oxide (N_2O) emissions released during combustion and the associated Global Warming Potentials (GWP) multipliers of those gases. The IPCC recommended GWP multipliers have changed since the RED II release although generally the increase in the CH_4 multiplier is offset by a reduction in the N_2O multiplier. There is no clarity on the basis of the EU LFF combustion emission factors shown in Table 1 and it is unusual to have a higher combustion emissions factor for petrol than diesel.

To obtain a clear comparison, the table below shows the CO_{2e} factor for the EU compared against IPCC defaults (excluding CH_4 and N_2O) and New Zealand factors calculated in a couple of different ways.

Table 3: Comparison of combustion emissions factors[5]

g $CO_{2\text{-}e}$/MJ	EU	NZ DEF	NZ Last 6 years	IPCC 2006 default*
Petrol	73.4	71.3	72.3	69.3
Diesel	73.2	75.5	75.1	74.1

* IPCC 2006 default excludes impact of CH4 and N2O which adds around 1g CO2-e/MJ to each factor

There is variation between the New Zealand data and the EU data, with New Zealand's combustion emissions being lower on petrol and higher on diesel. However, New Zealand's factors are far more in line with IPCC defaults for the fuel type, so it is actually the European figures that are unusual. While different on an individual fuel basis, when averaged as a fuel pool based on New Zealand's consumption of each fuel, the singe factors for fossil fuel combustion are similar which avoids concerns over single fuel differences.

The default emissions factors are currently being reviewed due to New Zealand's move to 100% import supply in 2022. Typically, imported fuel is less dense than fuel which was produced at the Marsden Point refinery, which may lead to slightly lower emissions per energy unit. As well as the fuel quality update, the new default emission factors will use the most recent updates to the IPCC recommendations for calculating emissions (e.g. latest GWP) along with CH_4 and N_2O factors calculated for New Zealand's fleet using more detailed tier 2/3[6] methodology rather than defaults.

Recommendations from this work are yet to be published and will need to go through an approval process. However, on an indicative basis it is likely the petrol and diesel emissions factors will both drop a little from the NZ DEF figure shown above, which would likely reduce the overall calculated lifecycle emission factor calculated in Table 6.

3.2 Supply emissions

This section reviews the supply emissions used for fossil fuels in the RED II to assess the applicability to the New Zealand supply chain. Unfortunately, there is no easily accessible breakdown of the RED II fossil fuels supply emissions. The referenced reports (sources shown in Table 1 above) show a detailed breakdown but give a different total emissions value. The most recently published Well to Tank report (V5) (the V4 report is noted as a reference document), was published in 2020 and states that they use the same base information as the EU RED II. This V5

[5] NZ DEF is New Zealand's current default emission factors used in the emissions trading scheme.

[6] Tier 2 and 3 are more accurate calculation methodologies used where more detail is known about how the fuel is combusted (e.g. details on the vehicle fleet and kilometres travelled) so that a more detailed calculation can be done than only using the amount of fuel consumed (which is Tier 1 methodology).

Report gives a result closer to the RED II data than the V4 report, but still lower. The difference is shown below.

For fossil fuels, Table 4 shows that the JEC WTT v5 component breakdowns are in total lower than the figures used in RED II (Table 1), although the gap between gasoline and diesel is similar which implies they use the same refining emissions factor. It may have been that the EU assumed a higher crude oil supply component as other factors appear consistent through the material.

Table 4: Breakdown of supply emission components[7]

Table 5a. JEC and Sphera GHG emissions in g CO_2 equivalent (CO_{2eq}) per MJ of fuel delivered, at tank, for fuels produced in Europe.

gCO_{2eq}/MJ fuel	Gasoline		Diesel	
	JEC WTT v5	Sphera GaBi 2020	JEC WTT v5	Sphera GaBi 2020
Crude oil supply	10.6	6.4	10.8	6.5
Another feedstock supply	-	1	-	0.4
Refinery	5.5	9.6	7.2	3.4
Conditioning and distribution	1	0.6	0.9	0.6
TOTAL	**17**	**17.6**	**18.9**	**10.9**

Note 1. The GHG emissions are expressed in g CO_2 equivalent (CO_{2eq}) per MJ of fuel delivered, at tank. The table refers to IPCC characterisation factors, taken from the 4th Assessment Report (AR4), 2007 in order to be in line with the methodology used in the JEC WtW studies.
Note 2. These datasets do not consider any bio-components blended to the finished refined product (That means, the data refer to 100% fossil fuels).

We assume it is the crude factor that is higher in the EU RED II in order to make a comparison to the Zealand supply chain. This allows us to review the individual factors and how they might vary given New Zealand's supply chain (now based on 100% imported finished product).

Crude exploration and production: New Zealand's factor should be the same as the EU, as the calculation uses Middle East supply as the marginal supply. Middle East supply is also valid for Asian refineries that supply New Zealand.

Crude Transport: The crude supply route from the Middle East (marginal supplier) to Asia is between half or a quarter shorter than Europe (Europe's very large crude cargoes go around the Cape of Good Hope). This would mean a small saving for NZ supply (0.35-0.50 gCO_2/MJ).

Refining: New Zealand is now largely supplied from large sophisticated Asian refineries capable of manufacturing our product specification (Singapore and South Korea primarily). These are some of the largest, most efficient global refineries so should, on average, be more efficient than the European average. This could result in lower refining emissions for NZ supply. We assume a 10% refinery efficiency saving in our build up.

Ocean Transport of finished product: The EU supply calculations assume refining in Europe so there is no ocean transport for finished fuels as there is for New Zealand. Using the EU data for product tanker efficiency this would be an additional 1.9 gCO_2/MJ for imported fuels, based on a Singapore-NZ voyage (South Korea will be only slightly more). We have cross checked this with our shipping model and it looks like a reasonable level of consumption for a return voyage – if anything slightly high given the improvement in ship efficiency in recent years.

[7] JEC Well-to-Tank Report v5, 2020, page 23.

Local Distribution: For Europe this includes transport of product by pipeline, barge and truck to fuel terminals and then transport from fuel terminals to retail site and emissions associated with those sites. Total emissions are only about 1 gCO_2/MJ which based on the biofuels data (which state they use the fossil fuel data for these factors) are about 2/3 primarily distribution and 1/3 for the retail site. For New Zealand, as ships go straight to distribution terminals (only a small amount of internal pipeline distribution), this figure mainly covers only distribution to retail sites and emissions related to these sites. This is likely to be around half the EU figure.

Table 5: NZ supply emissions comparison with EU fossil fuel supply route

Component	NZ supply change	Approximate impact
Crude exploration of production	No change	Nil
Crude transport	Shorter	-(0.4-0.5) gCO_2/MJ
Refining	Likely more efficient	-(0.5-0.7)[8] gCO_2/MJ
Ocean Transport	Additional component	+1.9 gCO_2/MJ
Local Transport	Reduced in NZ due to direct import shipping to most terminals	-0.5 gCO_2/MJ
Net Change		+0.2-0.4 gCO_2/MJ

Overall, there would only be a very small increment in New Zealand's fossil fuel supply chain emissions compared to the EU despite its differences. Given the rounding in calculating the average emission factor, it is not material although we use it when recalculating the average below.

3.3 Summary

Following the above analysis, we calculate an average fossil fuel lifecycle emissions factor for New Zealand fossil fuels. The average is based on New Zealand 2019 consumption split[9]. An additional 0.3 gCO_{2e}/MJ has been added to the supply emissions.

Table 6: New Zealand fossil fuel average emissions

Emission calculation	Petrol	Diesel	weighted average
Combustion	71.3	75.5	
Supply	20.2	22.2	
Total	91.5	97.7	95.1

The average gives a figure around 95 gCO_{2e}/MJ, which appears to be higher than the EU RED II figure although we note using the same methodology the EU figure would have been 94.7 gCO_{2e}/MJ, very close to the New Zealand calculation. Although not yet confirmed, the expected

[8] Assumes a 10% improvement

[9] 2019 is used to avoid what should be temporary COVID impacts on the consumption balance.

update to New Zealand's default emission factors[10] would reduce New Zealand's average LFF lifecycle emissions to a little below the EU's figure at around 94.5 gCO_{2e}/MJ.

The EU emissions table (Table 1) also included a factor for heavy fuel oil although its inclusion would have had little impact on the average as its use is very low compared to diesel and petrol. Heavy fuel oil is even a smaller proportion of the New Zealand fuel pool, particularly following the change to lower sulphur fuel oil and the refinery closure (this has led to many vessels shifting to using diesel for fuel rather than fuel oil). Therefore a fuel oil factor would have no impact on the average life cycle emissions for the New Zealand fuel pool.

Given the overall similarity in the pool average lifecycle emissions, despite the differences in assumptions around individual fuel emissions and supply chains, the analysis demonstrates it is reasonable for New Zealand to follow the EU approach for the assumption on LFF lifecycle emissions.

We recommend that New Zealand also uses a figure of 94 gCO_{2e}/MJ for LFF lifecycle emissions to compare with biofuel lifecycle emissions as any minor differences are not material over the whole fossil fuel pool.

4.0 Determining the emissions intensity value for biofuels transport

4.1 Calculation methodology

MBIE has proposed that the disaggregated default values (DDV) expressed in the European Union Renewable Energy Directive II (RED II) are used to enable the obligation to become operational from 1 April 2023, with the exception of emissions from transport and distribution (e_{td}).

It is expected that the majority of biofuels used to meet the obligation in the initial years will be imported. These biofuels are likely to come from existing biorefineries, where the production methods and the associated emissions factors are understood and contained within the RED II methodology.

DDVs for transport and distribution however may need to be updated to reflect New Zealand's location, and therefore the likely emissions resulting from a fuel's transport to New Zealand and distribution within our borders. This report considers and recalculates those transport and distribution emissions, particularly those for the finished biofuel.

The RED II methodology for calculating lifecycle emissions is shown below[11].

The lifecycle GHG emissions from the production and use of biofuels shall be calculated as the sum of the disaggregated emissions of each component of the supply chain, including feedstock production.

This can be represented by the equation:

---

[10] This update take account of 100% fossil fuel import supply and changes to the IPCC methodology for greenhouse gas emissions.

[11] Renewable Energy Directive (2018/2001) Annex V, Section C

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr}$$

Where:

E *= total emissions from the use of fuel expressed in terms of grams of CO2 equivalent per MJ of fuel (gCO2e/MJ).*

- $\boldsymbol{e_{ec}}$ *= emissions from the extraction or cultivation of raw materials*
- $\boldsymbol{e_l}$ *= annualised emissions from carbon stock changes caused by land-use change.*
- $\boldsymbol{e_p}$ *= emissions from processing*
- $\boldsymbol{e_{td}}$ *= emissions from transport and distribution*
- $\boldsymbol{e_u}$ *= emissions from the fuel's combustion*
- $\boldsymbol{e_{sca}}$ *= emissions savings from soil carbon accumulation via improved agricultural management*
- $\boldsymbol{e_{ccs}}$ *= emissions savings from* CO_2 *capture and geological storage*
- $\boldsymbol{e_{ccr}}$ *= emissions savings from* CO_2 *capture and replacement*

Each $\boldsymbol{e_{xy}}$ *value for each biofuel type, such as ethanol produced from sugarbeet, will need to be determined to understand the emissions intensity impact of all biofuels used to meet the sustainable biofuels obligation.*

RED II calculates both typical and default values for each biofuel supply chain expressing that as a greenhouse gas emissions saving. The saving is calculated on a per unit of energy basis as follows:

(a) greenhouse gas emissions savings from biofuels:

$$SAVING = (E_{F(t)} - E_B)/E_{F(t)},$$

where

E_B	=	total emissions from the biofuel; and
$E_{F(t)}$	=	total emissions from the fossil fuel comparator for transport

Fuel suppliers are able to calculate the actual emissions of their biofuel supply or use the default saving. The default saving factors are lower (more conservative) than the typical, which represent the average of the pathways of biofuels used in the EU. In fact the same emission factors are used for all supply chain components except processing (e_p), where a more conservative (higher) emissions level is assumed in the default calculation. For biodiesel this is about 5 gCO_{2e}/MJ higher (about 10% higher in total). The ethanol pathways vary between typical and default more by feedstock type and processing route with the default often 110-125% higher than the typical factor (+4-14 gCO_2/MJ).

We understand the more conversative approach in establishing the default factor is to ensure biofuels will, whatever processing route, provide at least this saving. It also encourages suppliers to provide actual emissions for their particular supply chain so they can get credit for a higher emissions saving than the default.

4.2 Biofuel transport emissions

The transport and distribution component (e_{td}) being reviewing as part of this work includes all transport emissions except initial collection of the feedstock. That means it covers transport of partially processed material (e.g. semi refined oils), transport of finished product to port (if needed), international shipping, internal country shipping, pipeline, rail and truck transport (either of finished or partially processed product), finished product from terminal to retail site and retail site emissions. For these last two factors, the same emissions (on an energy basis) is used for biofuels as is used for LFF.

It is mainly the transport of the finished material (ocean transport of finished product) that is expected to vary for the New Zealand supply chain, and in some cases EU defaults already include some allowance for those pathways where feedstock is shipped to the EU.

Table 7 shows the transport emission for all the main biofuels along with the percentage they are of the total default emissions. We also show the transport and emissions of the final biofuel as that better represents the portion that might be impacted by this analysis. It is slightly different for biodiesel as the final transport emissions represent transport emissions within the EU, and there are some non-EU emissions (e.g. transport of semi-processed oils) that are relevant to analyse when comparing with New Zealand's supply chain.

Table 7: Transport emissions for biofuel defaults

Biofuel	Transport emissions (e_{td})	Final Transport emissions[12]	E_{td} as percent of total (default)
Sugar beet ethanol (STET1b)	2.3	1.6	6%
Corn ethanol (CET1)	2.2	1.6	4%
Other cereals excluding corn ethanol (CEET 1)	2.2	1.6	4%
Sugar cane ethanol (SCET)	9.7	6.0	34%
Rapeseed biodiesel	1.8	1.3	4%
Sunflower biodiesel	2.1	1.3	5%
Soybean biodiesel	8.9	1.3	19%
Palm oil biodiesel (methane captured)	6.9	1.3	13%
Waste cooking oil biodiesel	1.9	1.3	13%
Animal fats from rendering biodiesel	1.7	1.3	8%

[12] Final transport emissions are the portion of the transport emissions relating to transport of the finished biofuel (for ethanol pathways) and for those incurred within the EU for biodiesel/HVO pathways (expected to be similar to transport of the finished biodiesel.

Biofuel	Transport emissions (e_{td})	Final Transport emissions[12]	E_{td} as percent of total (default)
Hydrotreated vegetable oil from rapeseed	1.7	1.2	3%
Hydrotreated vegetable oil from sunflower	2.0	1.2	5%
Hydrotreated vegetable oil from soybean	9.2	1.2	20%
Hydrotreated vegetable oil from palm oil (methane collected)	7.0	1.2	15%
Hydrotreated vegetable oil from waste cooking oil	1.7	1.2	11%
Hydrotreated vegetable oil from animal fats from rendering	1.5	1.2	7%

In most cases the transport component is a relatively small part of the overall emissions, with the ones that are higher reflecting a source of biofuel or raw material from outside the EU (i.e. with an ocean transport component).

In order to assess whether New Zealand's expected biofuel supply chain has a material impact on the default emissions intensity, we initially assess how New Zealand's supply chain will vary from the EU and how that would impact the transport component. To do that a breakdown of the components of the EU transport factors is needed as only some of the transport components would change[13].

As an example of the transport components, for sugar cane ethanol from Brazil (also a reasonable default basis for supply to New Zealand), the components covering road transport within Brazil (sugar cane from mill to ethanol plant and ethanol transport to port) and some of the road transport within the EU and at the refuelling station will all be the same for New Zealand. It will only be the ocean transport and less internal EU distribution that will be different.

The details of the basis of the transport emissions calculations were included in the paper "Definition of input data to assess GHG default emissions from biofuels in EU legislation."[14] In order to calculate the difference in emissions, H&T has recalculated the key ocean transport emissions so it can apply the same methodology to the New Zealand supply route. The complete calculations are never shown so it is necessary to duplicate calculations to ensure the methodology is understood.

Most of the EU biofuels emission factors assume the feedstock is grown, processed and distributed in the EU (all those with a transport emissions of less than 2.5 gCO_2/MJ). This is unlikely, at least initially, for New Zealand where Asia is more likely to be the source. In these cases, an additional

[13] A partial breakdown is available from EU Joint Research Centre (https://publications.jrc.ec.europa.eu/repository/) although to get the detail you need to link to hidden sheets.

[14] JEC Science for Policy Report, Version 1C – July 2017

freight step from Singapore to New Zealand may be appropriate. The biofuels in the EU system that include international shipping include:

- Sugar cane ethanol (from Brazil)
- Soybean biodiesel/HVO (from Argentina, Brazil and the US)
- Palm oil biodiesel/HVO (from Asia)

For these biofuels, the New Zealand transport leg will not be additional but will vary from the EU default.

4.3 New Zealand transport emissions biofuels calculation

At least in the initial years of the biofuel obligations, it is likely that, at the margin, New Zealand's biofuels will largely be sourced from Asia. Any domestic production should have much reduced emissions against the default, so suppliers would expect to use actual emissions for the intensity factor. Due to likely limited domestic production against the biofuel requirement, we do not consider local production is appropriate for calculating default emission intensity factors at this stage.

Biofuel may come from Australia (fuel ethanol and/or biodiesel) but again the supplier would be encouraged to use actual emissions as the emissions saving should be significantly better than the default which assumes Asia (certainly in terms of shipping emissions).

There are a number of different shipping options for biofuels in the RED II calculations. The most appropriate for the transport of biofuels to New Zealand is the chemical tanker (assuming 15,000 tonne cargo) emissions which is calculated on largely being an empty return leg (appropriate for New Zealand). Hydrotreated fuels (jet fuel and diesel) may be able to be transported together with petroleum fuels on larger tankers which would be an emission saving per unit of fuel, but that is not assumed to be the default route.

H&T has calculated the emissions per unit of energy for key voyages to New Zealand, with a Singapore - Wellington voyage used as the default from Asia. The emissions are higher on those fuels with lower energy content (e.g. ethanol) than those with a higher energy content (e.g. HVO). To provide an indication of how the emissions can change depending on the length of the voyage, size of the ship and the product carried we calculate the emissions for a few key voyages below.

Diesel – Medium range tanker (40KT) – Sing-NZ	1.9 gCO_2/MJ
FAME – Chemical tanker (15KT) – Sing – NZ	3.7 gCO_2/MJ
Ethanol – Chemical tanker (15KT) – Sing – NZ	5.1 gCO_2/MJ
Ethanol – Chemical tanker (15KT) – Australia – NZ	1.4 gCO_2/MJ

We have made the following assumptions for the adjustment of EU default transport emissions to reflect the likely New Zealand supply chain.

- For all default emissions calculations for biofuels grown, processed and distributed in the EU, we have added the applicable emissions associated with an Asia to New Zealand shipping leg and removed those internal EU distribution emissions not applicable to New Zealand. This increases transport emissions by 3-4.5 gCO_2/MJ depending on the energy content of the biofuel.
- For sugar cane ethanol we have substituted the shipping leg from Brazil to the EU with a ship from Brazil to New Zealand and changed the tanker type assumption to reflect that a return

cargo is unlikely (this is the case with the EU). Some not applicable EU internal distribution emissions are also removed. This is an increase of around 2 gCO_2/MJ for the transport emissions.

- For soybean biodiesel, the EU assumes a mix of domestic (10%) and imported soybean from Argentina, Brazil and the United States. We think it is far more likely that New Zealand would directly import soy based biodiesel from a country that grows and manufactures it. Therefore we have removed the international shipping (and a small amount of internal distribution) from the EU figure and added a United States (West Coast)[15] to New Zealand shipping leg. This results in a small reduction in calculated transport emissions.
- For palm oil biodiesel, we have removed the Asia-EU shipping leg for processed oil (and a small amount of internal distribution) from the EU figure and added an Asia -NZ leg for finished biodiesel. This change is relatively neutral.

Table 8 summarises the change in supply route assumptions for the main biofuels, how that impacts the transport emissions and the default emissions intensity. For most biofuels this reduces the intensity saving from the biofuel by 3-5%, although for some there in no change.

Similar calculations are done for hydrotreated vegetable oils (HVO) in Table 9. As the feedstock assumptions are the same as for biodiesel the adjustments for each biofuel are similar to those covered in Table 8.

Table 8: First generation biofuels adjusted default emissions factors

Biofuel	Change in supply routes	EU transport emissions	Adjusted transport emissions	EU RED II default emissions intensity	Adjusted default emissions intensity
Sugar beet ethanol (STET1b)	Assume additional Asia-NZ leg with less internal distribution	2.3	6.9	73%	68%
Corn ethanol (CET1)	Assume additional Asia-NZ leg with less internal distribution	2.2	6.8	40%	35%
Other cereals excluding corn ethanol (CEET 1)	Assume additional Asia-NZ leg with less internal distribution	2.2	6.8	38%	33%
Sugar cane ethanol (SCET)	Stay with Brazil but change shipping to reflect NZ destination and less internal distribution	9.7	11.6	70%	68%
Rapeseed biodiesel	Assume additional Asia-NZ leg with less internal distribution	1.8	5.2	47%	43%
Sunflower	Assume additional Asia-NZ	2.1	5.5	52%	49%

[15] This is chosen as there are West Coast Biorefineries

Biofuel	Change in supply routes	EU transport emissions	Adjusted transport emissions	EU RED II default emissions intensity	Adjusted default emissions intensity
biodiesel	leg with less internal distribution				
Soybean biodiesel	Change shipping route to reflect import of finished biodiesel from source to NZ	8.9	8.5	50%	50%
Palm oil biodiesel (methane captured)	Remove Asia-EU shipping and add Asia – NZ leg and less internal distribution	6.9	7.0	45%	45%
Waste cooking oil biodiesel	Assume additional Asia-NZ leg with less internal distribution	1.9	5.3	84%	81%
Animal fats from rendering biodiesel	Assume additional Asia-NZ leg with less internal distribution[16]	1.7	5.1	78%	74%

Table 9: Hydrotreated vegetable oils adjusted default emissions factors

Biofuel	Change in supply routes	EU RED II transport emissions	Adjusted transport emissions	EU RED II default emissions intensity	Adjusted default emissions intensity
Hydrotreated vegetable oil from rapeseed	Assume additional Asia-NZ leg with less internal distribution	1.7	4.6	47%	44%
Hydrotreated vegetable oil from sunflower	Assume additional Asia-NZ leg with less internal distribution	2.0	4.9	54%	51%
Hydrotreated vegetable oil from soybean	Change shipping route to reflect import of finished biodiesel from source to NZ	9.2	8.2	51%	52%
Hydrotreated vegetable oil from palm oil (methane collected)	Remove Asia-EU shipping and add Asia – NZ leg and less internal distribution	7.0	5.9	49%	50%

[16] In theory the Asian processor could have transported the animal fats from New Zealand among other countries. This recalculation does not look at transport emissions upstream of the processing so we have not included emissions from that leg in the default.

Biofuel	Change in supply routes	EU RED II transport emissions	Adjusted transport emissions	EU RED II default emissions intensity	Adjusted default emissions intensity
Hydrotreated vegetable oil from waste cooking oil	Assume additional Asia-NZ leg with less internal distribution	1.7	4.6	83%	80%
Hydrotreated vegetable oil from animal fats from rendering	Assume additional Asia-NZ leg with less internal distribution	1.5	4.4	77%	74%

4.4 Summary of calculations

The adjustments to the biofuel default emissions intensity factors proposed primarily reflect an expectation that New Zealand will initially use imported biofuels so there will be more ocean freight than assumed in the EU defaults. However, the adjustment is still relatively small compared to the EU typical emission intensity variation from the default factors.

Should New Zealand decide to require a minimum saving in emissions for a biofuel to be allowed to be used in the obligation scheme (e.g. a 50% emissions savings minimum) then any changes to defaults below this level will have no material impact.

It can be questions whether the transport emission adjustments are material, and if it may be more straightforward to use the EU RED II defaults without adjustment. That will be a decision for MBIE.

It is clear, whatever decision is made, that suppliers will be incentivised to provide actual emissions associated with their biofuel lifecycle supply as these should have a better emissions intensity than the defaults which are designed to cover a 'high emissions' route. This will be particularly true for New Zealand where significant gains (better emissions intensity factors) could be achieved by using biofuels from either a domestic or Australian source.