Build something great™

Boral Timber

Hardwood Residue Bio-Refinery Feasibility Study

2018/ARP013

Technical and Financial Feasibility Report

Public Report

July 2019

FINAL

TABLE OF CONTENTS

This Project received funding from ARENA a part of ARENA's Advancing Renewables Program.

The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

EXECUTIVE SUMMARY

Boral Timber has identified an opportunity to convert its hardwood sawmill residues into a range of renewable energy and industry feedstock products. Boral Timber has undertaken a Feasibility Study into the use of a Mechanical Catalytic Conversion process (MECC) being developed by Global Ecofuels Solutions S.L. (GEFS) based in Spain to convert hardwood sawmill residues into renewable diesel, bitumen and other products. Boral Timber would like to thank ARENA for its support in exploring this innovative approach to renewable energy.

During the study Boral has undertaken a range of activities to test the technical and financial feasible of this potential renewable energy project. Activities undertaken include, pilot plant trials in the GEFS facility in Spain, delivering a preliminary engineering design and costing for the world's first full scale MECC production facility, product attribute testing and potential end use applications, assessing a potential regulatory approvals pathway, completing a business case financial model and commissioning a Proof of Concept LCA report for the MECC process.

Through this program of work Boral Timber has identified that the MECC process is technically able to convert hardwood sawmill residues from Boral's Herons Creek mill into a range of renewable products including; transport grade Renewable Diesel, a renewable bitumen product that is blendable with fossil fuel bitumen for the production of asphalt plus a range of saleable by-products. The Proof of Concept LCA report identifies that the renewable diesel has less than 25% of the carbon intensity of fossil fuel derived diesel. The business case modelling shows that the project is financially viable on an estimated capital spend of $85M.

The next step in the project development is to embark on a detailed engineering design, site selection and regulatory approvals process.

INTRODUCTION

Boral Timber has identified an opportunity to convert its hardwood sawmill residues into a range of renewable energy and industry feedstock products. A successful project will further increase the sustainable nature of Boral's hardwood business and the hardwood industry in general as well as solving an industry problem by value adding its energy dense residues such as woodchip, sawdust and shavings.

Boral Timber has been actively reviewing alternative conversion technologies for over a decade and through this search came across a novel Mechanical Catalytic Conversion process (MECC) being developed by Global Ecofuels Solutions S.L. (GEFS) based in Spain. This technology has the promise of converting biomass into a limited range of renewable products (eg diesel and bitumen) that could replace existing primarily imported fossil fuel equivalent products purchased in high volumes by Boral's broader Australian businesses.

During 2017 Boral Timber demonstrated that the technology worked on its hardwood sawmill residues by undertaking several small scale trials in the pilot plant in Spain. Testing of the initial samples and a review of the preliminary financials indicated merit in pursuing a formal Feasibility Study into this business opportunity.

Boral approached the Australian Renewable Energy Agency (ARENA) to seek support for this study and received approval for a $500k grant to contribute to the $1.2M Feasibility Study. Boral Timber would like to thank ARENA for its support in exploring this innovative approach to renewable energy.

The objectives of the Feasibility Study were to determine the technical and financial feasibility of converting the saw mill residue from Boral's Herons Creek hardwood sawmill via the MECC process into renewable diesel, renewable bitumen and other co-produced renewable products. The Feasibility Study was to undertake the following activities;

Item	**Outcome**
Large scale pilot plant trial	Mass and energy balance
Preliminary engineering design	Capital cost to +/- 20%
Products	Attributes and specifications
Regulatory Framework	Potential pathway/s for regulatory approval
Business case development	Financial model
Review of alternative technologies	Merit Assessment Criteria

This report has been produced as part of the Knowledge Sharing Plan detailed in the ARENA Funding Agreement.

PILOT PLANT TRIAL OBSERVATIONS

Pilot Plant trials were conducted during the period of January to May 2019 at the GEFS facilities in Majorca, Spain.

a) Objectives and Methodology

This Pilot Plant trial campaign was designed to further explore the potential of converting sawmill residue from the Boral Hardwood business into renewable replacements for primarily imported fossil fuel derived products such as transport grade diesel and bitumen. The specific objectives of the trial were, a) generate a steady state mass balance, b) generate a steady state energy balance, and c) test the product quality of the pre and post desulphurised renewable diesel samples.

A series of pilot plant trials were conducted from January to May 2019. The pilot plant trial campaign consisted of eight x single day trials targeting up to 1,000kg of biomass processed per trial. The expected time for each trial given the start up and shutdown requirements of the plant was 12 hours of elapsed time. Longer trials were not considered as it was impractical to run the pilot plant on a continuous 24 hour basis due to skills availability, space and material handling constraints.

The trial successfully converted biomass in the form of pelletised blackbutt sawmill residues supplied from the Herons Creek sawmill. The raw biomass was converted to pellets at a third party processor in Australia to enable effective shipping and customs importation of the biomass to Spain. Carrier Oil, pH Adjuster and the catalyst were all sourced from the regular supplier used by GEFS.

b) Trial Results - Mass Balance

The following table summarises the mass balance results from the pilot plant trial campaign.

Quantities Measured	v. biomass Consumed
Input	
Biomass (@10% mc)	100%
Carrier Oil	20 - 25%
Lime	1 - 3%
MECC Catalyst	1 - 3%
TOTAL	**125 - 135%**
Output	
Renewable Diesel Raw	30 - 35%
Bituminous Product	35 - 45%
Reaction Water	30 - 35%
Pyrolysis Oil	5 - 10%
Off Gases	5 - 10%
Biomass Water	~10%
TOTAL	**125 - 135%**

NB. The volume of Off Gases could not be accurately measured and the numbers above represent the calculated balancing number.

c) Trial Results - Mass Balance

An energy balance was calculated during the preliminary trials conducted in January 2019. The results were of limited use for the following reasons: a) the pilot plant was not constructed with industry benchmark heat recovery systems, b) the reactor turbine in the pilot plant is driven by a diesel engine rather than an electric motor, c) the pilot plant's mixing system uses a thermally inefficient heating system to remove the humidity water from the biomass. Further development of the Energy Balance will be calculated during the final engineering design should the project proceed beyond this stage of Feasibility.

d) Renewable Diesel - Laboratory Testing Results

Samples of the pre and post desulphurised renewable diesel were tested at the NATA accredited Laboratory based at the CALTEX Refinery at Lytton (Brisbane) during July 2019. Boral wishes to acknowledge the support of Caltex in conducting these tests for The Project.

Pre Desulphurised Renewable Diesel
Pre desulphurised renewable diesel is an interim product and does not have an Australian Quality Standard. This testing was conducted to understand the properties of this liquid (especially sulphur content), and to ascertain the extent of post treatment that would be required to meet the Automotive Diesel Fuel quality standards.

Refer to Appendix 1 for a copy of the test report.

The tests showed that the raw renewable diesel contained 1,938ppm of sulphur, well within an acceptable range for an input into a desulphurisation process.

Post Desulphurised Renewable Diesel
A smaller quantity of the raw renewable diesel was processed through a proprietary desulphurisation pilot plant operated by Sodium Express S.L. (SODEX) in May - June 2019.

Refer to Appendix 2 for a copy of the test results.

The tests showed that the desulphurised renewable diesel complied with the DRAFT Fuel Quality Standard (Automotive Diesel) Determination 2019 was released by the Federal Minister for the Environment and would comply with the definition of Renewable Diesel apart from known limitations of the trial including the absence of standard industry additives the unavailability of a fractionation process.

In conclusion the testing conducted indicates that the diesel produced from the MECC process, with the appropriate post treatment, would conform to the DRAFT Quality Standards (Automotive Diesel) Determination October 2019 and comply with the definition of Renewable Diesel.

PROJECT DELIVERABLES

The following sections describes in more detail the deliverables of this Feasibility Study.

a) Merit Assessment Criteria

The development of a set of Merit Assessment Criteria is unique for each potential renewable energy proposal. The following Merit Assessment Criteria were specifically developed for assessing different technologies for converting hardwood sawmill residues into renewable energy and other products within a Boral context. As such this set of criteria should only be used as a guide for other potential biomass conversion opportunities.

A. Products

Boral is a consumer of fossil fuel derived energy and industrial feedstocks and is continually investigating and pursuing ways to reduce its carbon footprint. Boral was seeking a technology that would produce a range of renewable products that could directly substitute fossil fuel derived products used internally by Boral (e.g. transport diesel fuel, bitumen) without the need for significant further processing. This led to the following Merit Assessment Criteria;

Produce "Ready to Use" renewable products that are in demand within Boral's Australian operations

B. Value Creation

Hardwood sawmill residues are currently consumed in low energy applications such as thermally inefficient fuel for co-fired boilers, landscaping and other agricultural uses. Boral was seeking a business opportunity that would more highly value the embodied energy contained within its residues. This led to the following Merit Assessment Criteria;

Increase the value of Hardwood Sawmill residues

C. Scalability

The hardwood forest estate is geographically dispersed and does not have the concentration of volume of other biomass sources (eg softwood, sugar cane, etc.). Boral recognises that there are several established technologies in biomass conversion that operate on a larger scale but may not be suitable for smaller scale biomass volumes. This led to the following Merit Assessment Criteria;

The technology is viable and scalable to economically available levels of biomass feedstock available within Boral's hardwood timber business

D. Financial Return

Boral was seeking a technology that not only would improve the economic value of its residues but would also generate a viable financial return in its own right. This led to the following Merit Assessment Criteria;

The Project is commercially viable using industry benchmark returns.

E. Rural Industry

Boral operates its hardwood timber mills in rural and regional areas and recognises that transporting biomass long distances reduces the economics of any biomass conversion process. Therefore Boral was seeking a fit for purpose technology that would be suitable to operate in rural areas. This would entail considerations such as availability of suitably zoned land, local planning outcomes, technical skill base, transport and other infrastructure. This led to the following Merit Assessment Criteria;

The process technology is supportable within rural communities

F. Socially Responsible

Boral was seeking a technology that is consistent with its core values including Occupational Health and Safety outcomes, environmental responsibility, a move to a lower carbon footprint, and building sustainable industries. This led to the following Merit Assessment Criteria;

The technology is consistent with Boral's values and social responsibility to operate

G. Technology Maturity

Boral was seeking to develop a business opportunity that can convert its existing volume of hardwood sawmill residues in the short to medium term. This led to the final Merit Assessment Criteria;

The Technology Readiness Level (TRL) of the process would see a commercially viable plant within the next 3 to 5 years

The Merit Assessment Criteria was designed to provide a qualitative comparative tool for assessing different technologies across a range of financial and non-financial parameters. Table 1 below provides an example of how a technology (in this case the MECC process) was assessed against the Merit Assessment Criteria.

Table 1 - Assessment of MECC against Merit Assessment Criteria

Criteria	**Outcome of Feasibility Study**	**Suitability Rating**
Products	MECC produces renewable diesel and bitumen products that are directly or partially substitutable for their fossil fuel equivalent products	High
Value Creation	Intrinsic lift of sawmill residues	High
Scalability	MECC can operate effectively at 50,000 tpa of biomass	High
Financial Return	Delivers a viable financial return in this application	High
Rural Industry	Similar scale chemical processing plants operate in the nearby Newcastle / Hunter Valley region	High
Socially Responsible	This enhances Boral's sustainability and carbon footprint credentials and would be built to high safety and environmental standards	High
Technology Maturity	The technology has been assessed at Commercial Readiness Level (CRL) 3 at the conclusion of this study and would be suitable for construction and commissioning within 3 to 5 years	High

Suitability Rating Legend: Low Medium High

b) Engineering Design and Construction Plan

The Feasibility Study undertook to prepare a preliminary design and construction plan for the first full scale facility of a MECC plant worldwide. The project team determined that the most economic model was to develop a two site solution for this project. Site 1 is designed as a solid materials handling site including the installation of a pellet plant to grind, dry and compress the biomass into the most cost efficient transportable format. Site 2 is designed for liquids processing and would include pellet receiving, MECC plant, desulphurisation plant plus storage and dispatch operations. The final location of each site will be determined at a later stage in the project development.

A separate Construction Plan would be developed for each site with a number of individually awarded contracts. Contracts would be awarded based on a comprehensive tender process including items such as acceptance criteria, payment schedules, liquidated damages, etc.

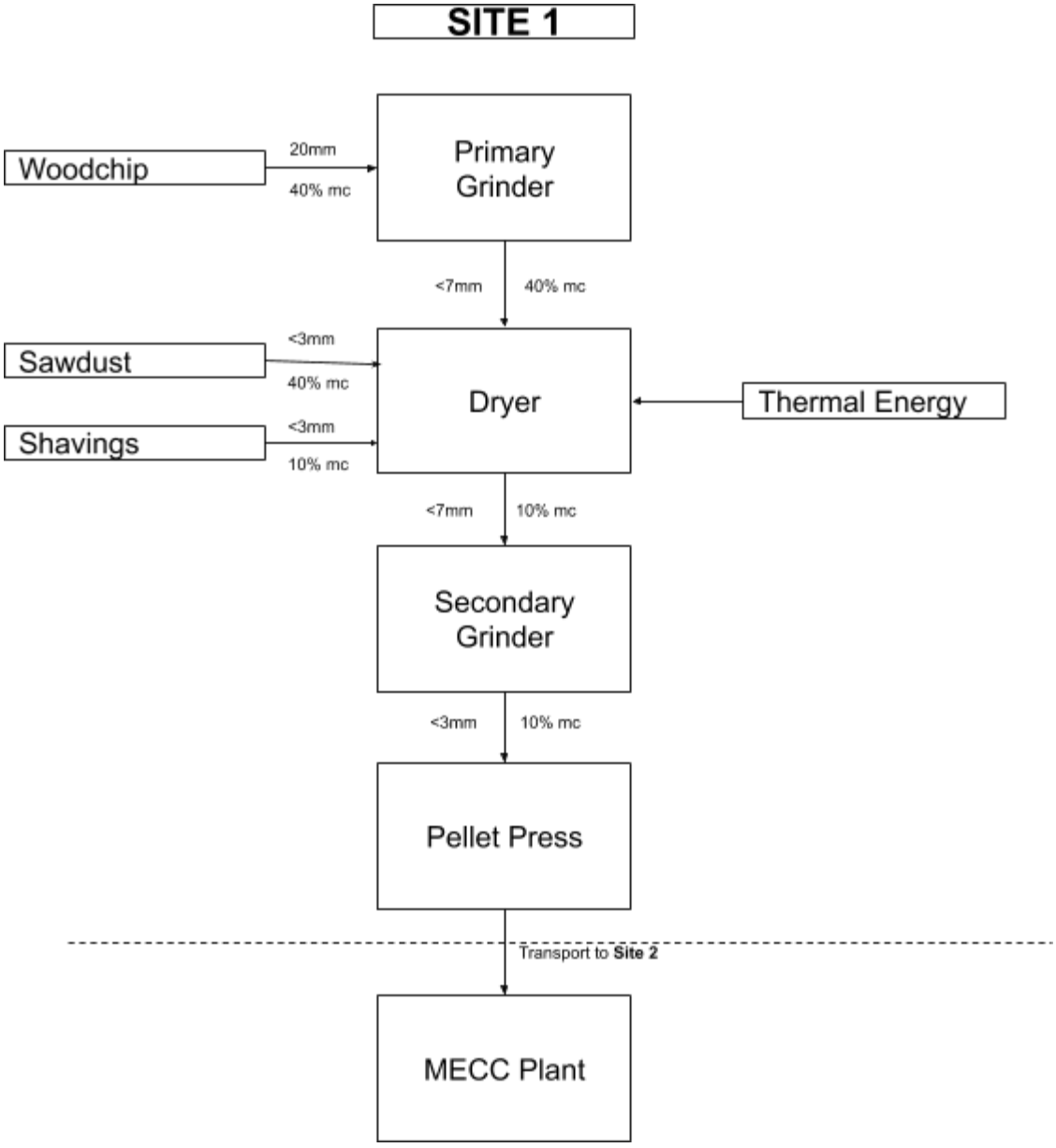
The design philosophy adopted for costing the largest contract, the MECC plant, is to build the plant in transportable modular units that can be built, assembled and tested in the engineering workshop. Once acceptance testing is complete the plant would be disassembled to its modules, transported and reassembled on site, thereby significantly reducing the on-site installation and commissioning time.

c) Feedstock Preparation

The feedstock specification for the MECC plant requires biomass to be pre-processed to bone dry (0%) moisture content and particle size <3mm. The Herons Creek sawmill produces three separate sawmill residue feedstocks with different sizes and moisture contents.

Feedstock	Moisture Content	Particle size
Woodchip	~35-40%	~20mm
Sawdust	~35-40%	<4mm
Shavings	10-12%	<4mm

It is intended that the biomass will be converted to pellets as the most cost effective way to store and transport biomass to the MECC site. Pellet plants are a mature technology and are relatively common throughout the forest products industry worldwide although few plants have been explicitly built for eucalyptus biomass. The manufacturing process is outlined in the chart below;



Thermal energy:- Depending on final site location and the availability of natural gas, either natural gas or LPG would be selected as the thermal energy source due to its high burning efficiency, low cost and limited capital investment required. Some pellet plants use biomass as thermal fuel however whilst biomass is a cheaper source of thermal fuel it is less thermally efficient and highly capital intensive.

d) Residue Disposal Method

Site 1 - There is minimal particulate residues generated in a pellet plant with all fines diverted back into the production process. The water / steam from the biomass drying process has few impurities and can be vented to atmosphere as steam, condensed and disposed in trade waste with minimal post processing, or used as industrial water on site, for example dust suppression and wash down.

Site 2 - The MECC process is highly efficient in converting raw materials into saleable products. The main sources of residue requiring a disposal plan are;

- Water / steam from the biomass drying - as per Site 1 above
- MECC Reaction gases - to be oxidised in a gas burner to provide process heating for the MECC mixing circuit.

e) Technical Risk Analysis

The Feasibility Study has determined that the core technology behind the MECC process is robustly designed. The remaining unit operations, with the exception of a small scale desulphurisation process, are relatively mature technologies, including pellet plants, fractional distillation, site infrastructure and services.

The remaining technical risk factors to be considered for a full scale facility are outlined below;

Hardwood species:- All trial work has so far been conducted on Blackbutt (*Eucalyptus pilularis*). The performance of other species in terms of yield and capacity is yet to be determined however similar results are expected due to the close genetic make-up of other east coast hardwood species.

Desulphurisation:- The MECC process delivers a raw renewable diesel product where the sulphur content exceeds the standard for transport grade diesel and needs to be desulphurised before use. Hydrofinishing desulphurisation is a mature technology in the petrochemical industry but is high capacity and capital intensive. For the Feasibility Study a small sample of the raw renewable diesel was processed through an experimental desulphurisation process developed by Sodium Express S.L. Should a suitable small scale desulphurisation process not be commercially available at the time of constructing the MECC plant the pre-desulphurised renewable diesel could be sold as an interim product to existing petrochemical companies and transported to their existing desulphurisation plants for processing into a Renewable Diesel.

Renewable Bituminous Product (RBP)
The laboratory scale testing completed during the Feasibility Study indicated that the RBP is likely to be suitable for the production of asphalt when blended with fossil fuel derived bitumen. A full scale product development plan including; plant trials, road trials, stability

trials and technical specification development will be required to ascertain the final utilisation of this material in the Asphalt industry.

f) Financial Viability

The Feasibility Study concluded that the MECC process applied in this application would be financially viable based on a preliminary capital estimate of ~$85M.

The applicability of the MECC process to other Hardwood sites would need to be determined on a case by case basis. In particular, issues such as the quantity of residues and the availability of suitably zoned landed within the biomass catchment would need to be considered.

g) Timeline to Commercialisation

The remaining stages that need to be undertaken to progress this business opportunity are:

Site Selection, Final Design and Regulatory Approvals
These processes will likely take 18 to 24 months to complete.

Engineering Procurement and Construction
These activities will commence after all regulatory approvals have been achieved for the project and would expect to take 18 months to complete.

Commissioning and Ramp-up
Given this is a new technology it can be expected that commissioning and ramp up may take 6 months to achieve design operational specifications for the plant.

h) Offtake Agreements

Renewable Diesel
Laboratory testing showed that the renewable diesel product from the MECC plant, once post treated including desulphurisation, meets the DRAFT Australian Fuel Quality Standard (Automotive Diesel) determination October 2019. There is a current market for existing alternative diesel products (eg biodiesel) in Australia. Given the relatively small volume of diesel produced at this plant (<0.1% of the Australian diesel market) it is expected that sales of this renewable diesel will be made via these existing market mechanisms.

Renewable Bituminous Product
The product offtake strategy for RBP needs to be confirmed once the full product development plan has been completed - see section e) above. Assuming the laboratory results are replicated, the volume of RBP produced could be consumed within the east coast asphalt industry.

i) Regulatory Pathways

A review of the planning pathway options based on a two site option that splits the project into two components was undertaken by an internal planning specialist within the Boral Australia Group. This review identified the matters set out below.

There are five broad areas that need to be considered when determining what potential planning pathway would be applicable for the development of a full scale MECC facility. In this instance the MECC facility includes two distinct components:

1. A pellet plant; and
2. A biorefinery

As the preferred approach will split these components over two distinct sites, each component must be considered individually as each will require a separate planning approval (and environmental protection licence). The five areas considered for each include a) characterisation of the project component, b) permissibility based on zoning rules and characterisation, c) the scale of the project component, d) the proximity of the site to sensitive receivers (i.e. residential land/dwellings) and e) the capital investment value of the project component.

Based on the current level of project development, the internal advice we have received so far indicates the following:

Characterisation - There is potential for both components of the Project to be defined as a "Resource Recovery Facility (RRF)" as the process involves the refining of a waste product into a reclaimed resource (i.e. sawmill residue and wooden pellets, classified as a waste product by the NSW EPA, into fuels). Under this characterisation both project components would be permissible with a relatively wide range of land use zones including RU1, RU2, IN1, IN3 and SP1, and SP2 under the provisions of State Environmental Planning Policy (Infrastructure) 2007.

Depending on the capital cost of each site the application pathway could be assessed through local Council via a Designated Development or though the NSW Department of Planning, Industry, and Environment via a State Significant Development Application pathway.

The MECC plant would be amongst the first of its kind in New South Wales (potentially the first worldwide) as such there is limited precedent for how the government agencies will consider and respond to the project, in particular its characterisation and the required level of assessment. The final planning pathway and assessment requirements will need to be confirmed with the relevant government agencies when final sites and locations are chosen.

j) Commercial Risk Factors

Commercial risk factors, their impacts and identified mitigation actions

The commercial risk related to the development of a full scale MECC plant fall into 2 broad categories; a) Project Establishment and Innovation Risks, and b) ongoing operational risks

Project Establishment and Innovation Risks

In general, all new capital projects contain inherent risks in items such as regulatory approval, capital cost, schedule delays and commissioning issues and there are a wide range of standard industry mitigation tools and processes available to manage these. The innovative nature of this project, being the first full scale MECC facility of its kind, will see the above risks magnified. The following outlines additional risk mitigation processes that may be adopted:

Funding:- This project has so far adopted a gated approval process for pre-feasibility and feasibility activities to prevent an up front over-commitment of funds for the project. Funding is likely to have two further gated approvals - a) final design, site selection and regulatory approval, and b) order placement, construction and commissioning.

Capital Risk:- The project team have done significant preliminary design and costing work during the Feasibility Study. It is likely the final design and costing will be completed in the next funding stage before final project approval and will include a detailed review of contingency.

Commissioning Risk:- The project team will consider constructing the MECC plant in a modular fashion so that the plant can be fully tested during construction stage. The plant would then be disassembled, transported and reassembled on site in a shorter time frame and with less commissioning risk.

Ongoing Operational Risks

There are several ongoing operational risks associated with this project.

Procurement of Raw Materials:- Boral has in place a long term supply contract with the NSW Government for sustainably certified hardwood sawlogs to our existing facilities. Procurement of the other raw materials will be sought within normal supplier contractual arrangements.

Excise Treatment:- The definition of Renewable Diesel is currently a DRAFT determination and is expected to be considered in October 2019. Once gazetted, submissions to the Federal Government Treasury Department will commence in order for Renewable Diesel to seek an equivalent excise treatment as Biodiesel.

Demand for diesel transport fuel:- The proposed plant will produce ~0.05% of the current market for diesel in Australia (26,539 million litres in 2018 - source: Australian Government Department of the Environment and Energy. *Australian PetroleumStatistics July 2017*.2017). The commissioning of this plant will have negligible effect on the demand/supply of the diesel market and the model expects to sell the full output of the plant.

CONCLUSION

Boral Timber through undertaking the activities of the Feasibility Study have determined the following:

- The MECC process can successfully convert hardwood sawmill residues into a range of renewable energy and other industry feedstock products

- The Renewable Diesel produced through the MECC plant with the appropriate post treatment satisfies the DRAFT Fuel Quality Standard (Automotive Diesel) Determination 2019 definition for Renewable Diesel

- Laboratory testing shows that the Renewable Bituminous Products is blendable with fossil fuel derived bitumen for the production of asphalt.

- The Proof of Concept LCA report identifies that the renewable diesel has less than 25% of the carbon intensity of fossil fuel derived diesel.

- The business case modelling shows that the project is financially viable on a preliminary capital estimate of ~$85M.

APPENDIX 1 - Test Results - Pre desulphurised renewable diesel

CALTEX REFINERIES (Qld) LTD
ABN 46 008 425 581
P.O Box 40
Wynnum Qld 4178
Telephone: +61 7 3362 7291
Fax: +61 7 3362 7295

Quality Certificate
MSF Raw Diesel

CALTEX

Date: 16/07/2019 **Tank:** 5
Batch No: Raw

METHOD	TEST	SPECIFICATION	RESULT	UNITS	
ASTM D4176	Appearance @ 25°C	1 max	**5**		#
ASTM D4737A	Cetane Index (Calculated)	46 min	**67.0**		
ASTM D5773	Cloud Point (D2500 equivalent)	Report	**8.6**	°C	
ASTM D1500	Colour (ASTM)	2.0 max	**4.5**		#
ASTM D130	Copper Corrosion (3 hrs @ 50°C)	1 max	**1a**		
ASTM D4052	Density @ 15°C	0.820 - 0.850	**0.8519**	kg/L	#
ASTM D86	Distillation - 10% recovered	Report	**274.1**	°C	
ASTM D86	Distillation - 50% recovered	Report	**372.3**	°C	
ASTM D86	Distillation - 90% recovered	Report	**398.2**	°C	#
ASTM D86	Distillation - 95% recovered	360 max	**403.0**	°C	#
ASTM D86	Final Boiling Point	Report	**403.0**	°C	#
ASTM D93	Flash Point (PMCC)	64.0 min	**<22.0**	°C	#
IP 450	Lubricity @ 60°C (wsd 1.4)	0.460 max	**0.260**	mm	
IP 391	Aromatics (Total)	15 min	**12.3**	mass %	#
IP 391	Polyaromatic Hydrocarbons	11 max	**1.2**	mass %	
ASTM D2622	Sulfur (Total)	10 max	**1938**	mg/kg	#
ASTM D2709	Water and Sediment	0.05 max	**<0.01**	vol %	
ASTM D974	Acid Number (Strong)	Nil	**<0.02**	mg KOH/g	
ASTM D974	Acid Number (Total)	0.30 max	**3.2**	mg KOH/g	
ASTM D482	Ash	100 max	**1**	mg/kg	
ASTM D4530	Carbon Residue (10% bottoms)	0.20 max	**0.21**	mass %	
ASTM D2274	Oxidation Stability	25 max	**>25**	mg/L	*#
ASTM D445	Viscosity @ 40°C	2.0 - 4.5	**10.23**	mm^2/s	#
ASTM D7111 mod	Arsenic	Report	**<0.10**	mg/kg	
ASTM D7111 mod	Iron	Report	**>2.00**	mg/kg	
ASTM D7111 mod	Nickel	Report	**<0.10**	mg/kg	
ASTM D7111 mod	Phosphorous	Report	**>2.00**	mg/kg	
ASTM D7111 mod	Silicon	Report	**>2.00**	mg/kg	
ASTM D7111 mod	Vanadium	Report	**<0.10**	mg/kg	
ICP MS	Calcium	Report	**<0.10**	ug/kg	
ICP MS	Sodium	Report	**0.75**	ug/kg	
ASTM D4629	Nitrogen	Report	**132**	mg/kg	

# Denotes result off-specification
* Test not completed as sample could not pass through the 0.8 µm filter as per test method requirements
All tests have been performed with the latest revision of the methods indicated. The accuracy of the results is within the limits of the precision shown in the methods.

Date testing completed: 16/07/2019

ID : 793016

Approved Signatory :

Name : Grant Mason

Dated: 17/07/2019

APPENDIX 2 - Test Results - Post desulphurised renewable diesel

CALTEX REFINERIES (Qld) LTD
ABN 46 008 425 581
P.O Box 40
Wynnum Qld 4178
Telephone: +61 7 3362 7291
Fax: +61 7 3362 7295

Quality Certificate

MSF Delsulfurised Diesel

Date: 16/07/2019 **Tank:** 5
Batch No: Desulfurised

CALTEX

METHOD	TEST	SPECIFICATION	RESULT	UNITS	
ASTM D4176	Appearance @ 25°C	1 max	1		
ASTM D4737A	Cetane Index (Calculated)	46 min	69.0		
ASTM D5773	Cloud Point (D2500 equivalent)	Report	-9	°C	
ASTM D1500	Colour (ASTM)	2.0 max	L0.5		
ASTM D130	Copper Corrosion (3 hrs @ 50°C)	1 max	1a		
ASTM D4052	Density @ 15°C	0.820 - 0.850	0.8304	kg/L	
ASTM D86	Distillation - 10% recovered	Report	210.3	°C	
ASTM D86	Distillation - 50% recovered	Report	352.4	°C	
ASTM D86	Distillation - 90% recovered	Report	391.2	°C	#
ASTM D86	Distillation - 95% recovered	360 max	398.1	°C	#
ASTM D86	Final Boiling Point	Report	398.1	°C	#
IP 387	Filter Blocking Tendency	1.41 max	1.05		
ASTM D93	Flash Point (PMCC)	64.0 min	60.5	°C	#
IP 450	Lubricity @ 60°C (wsd 1.4)	0.460 max	0.497	mm	#
IP 391	Aromatics (Total)	15 min	9.3	mass %	#
IP 391	Polyaromatic Hydrocarbons	11 max	1.3	mass %	
ASTM D7039	Sulfur (Total)	10 max	6.8	mg/kg	
ASTM D2709	Water and Sediment	0.05 max	<0.01	vol %	
ASTM D974	Acid Number (Strong)	Nil	Nil	mg KOH/g	
ASTM D974	Acid Number (Total)	0.30 max	<0.02	mg KOH/g	
ASTM D482	Ash	100 max	<1	mg/kg	
ASTM D4530	Carbon Residue (10% bottoms)	0.20 max	<0.01	mass %	
ASTM D2274	Oxidation Stability	25 max	3	mg/L	
ASTM D445	Viscosity @ 40°C	2.0 - 4.5	5.918	mm^2/s	#
ASTM D5185 mod	Arsenic	Report	<0.10	mg/kg	
ASTM D5185 mod	Iron	Report	0.14	mg/kg	
ASTM D5185 mod	Nickel	Report	<0.10	mg/kg	
ASTM D5185 mod	Phosphorous	Report	<0.10	mg/kg	
ASTM D5185 mod	Silicon	Report	<0.10	mg/kg	
ASTM D5185 mod	Vanadium	Report	<0.10	mg/kg	
ICP MS	Calcium	Report	<0.10	ug/kg	
ICP MS	Sodium	Report	<0.10	ug/kg	
ASTM D4629	Nitrogen	Report	<0.3	mg/kg	

# Denotes result off-specification

All tests have been performed with the latest revision of the methods indicated. The accuracy of the results is within the limits of the precision shown in the methods.

Date testing completed: 16/07/2019

ID : 793017

Approved Signatory :

Name : Grant Mason

Dated: 17/07/2019