CARBON INTENSITY OF PROPEL BIOENERGY PROPOSED DIESEL FROM WOOD RESIDUE PROCESS

Prepared For:

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EXECUTIVE SUMMARY

The Government of British Columbia has introduced the Renewable and Low Carbon Fuel Requirements Regulation (RLCFRR) to reduce British Columbia's reliance on non-renewable fuels, help reduce the environmental impact of transportation fuels and contribute to a new, low-carbon economy.

The RLCFRR provides a regulatory framework that enables the Province to set benchmarks for the amount of renewable fuel in B.C.'s transportation fuel blends, reduce the carbon intensity (CI) of transportation fuels, and meet its commitment to adopt a low-carbon fuel standard.

The RLCFRR is designed to help diversify B.C.'s transportation fuel supply, decrease GHG emissions and establish a market for low-carbon fuels by:

- Encouraging suppliers to determine how best to meet the requirements in accordance with consumer demand and market forces;
- Reducing reliance on non-renewable fuels; and
- Enabling requirements that encourage emerging cleaner fuel technologies.

The RLCFRR is designed to reduce the carbon intensity of transportation fuels through two major requirements:

- The Renewable Fuel Requirement (RFR) (5 percent renewable content in gasoline beginning in 2010 and 3 percent renewable content in diesel in 2010, 4 percent in 2011 onward); and
- The Low Carbon Fuel Requirement (LCFR) (10 percent reduction in carbon intensity by 2020).

The RFR requirement has no direct GHG emission performance requirement but the LCFR does require the obligated parties to determine the carbon intensity of the pool of products that they produce or import into BC. In order to do this, the carbon intensity of each unique fuel used in BC must be determined and reported on annually. Over time, the regulation will require a reduction in the GHG emissions of each primary supplier's pool of transportation fuels. The period up to July 1, 2013 was a reporting only period but as noted above the reduction expected in 2020 is 10% below the established baseline.

The modelling of GHG emissions for the production of diesel fuel from the Propel Bioenergy process that will be installed near Fruitvale BC in the West Kootneys has been undertaken using version 4.03a of the GHGenius model. The model has been set up using the 2007 GWPs as specified in the BC Regulations.

The process to be used produces diesel fuel (#1 and #2 grades), as well as some biochar. The diesel fuel is considered to be the primary product and a CI with and without the biochar is calculated.

The lifecycle emissions for the fuel produced from wood residue at a plant near Fruitvale, BC are shown in the following table. All emissions are from running the model for the BC region and for the year 2016.

Table ES- 1 CI Propel Bioenergy Diesel Fuel

Source	Propel Bioenergy Diesel Fuel	
	g CO_2eq/GJ	
	Diesel Fuel	
	Without Bio-char	With Bio-char Credit
Fuel dispensing	35	35
Fuel distribution and storage	667	667
Fuel production	5,448	5,448
Feedstock transmission	744	744
Feedstock recovery	0	0
Feedstock upgrading	0	0
Land-use changes, cultivation	0	0
Fertilizer manufacture	0	0
Gas leaks and flares	0	0
CO_2, H_2S removed from NG	0	0
Emissions displaced	0	-27,110
Total	6,894	-20,216
Fuel Use	1,736	1,736
Grand Total	8,640	-18,480
CI Grand Total, g CO_2eq/MJ	**8.64**	**-18.48**

The BC Government has published the CI of some alternative fuels in their Information Bulletin RLCF-002 (2010); however these were calculated with an earlier version of GHGenius and the 1995 GWPs. The diesel value from GHGenius 4.03a are compared to Propel Bioenergy values in the following table.

Table ES- 2 Comparison to Baseline CI Values

		CI, g CO_2eq/MJ
Diesel	Default Value	94.29
Propel Bioenergy	Wood Residue	8.64
Propel Bioenergy	Wood Residue and bio-char	-18.48

The CI of the Propel Bioenergy product is very low and offers about an 88% reduction over the CI of fossil gasoline and diesel fuel.

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1. INTRODUCTION

The Government of British Columbia has introduced the Renewable and Low Carbon Fuel Requirements Regulation (RLCFRR) to reduce British Columbia's reliance on non-renewable fuels, help reduce the environmental impact of transportation fuels and contribute to a new, low-carbon economy.

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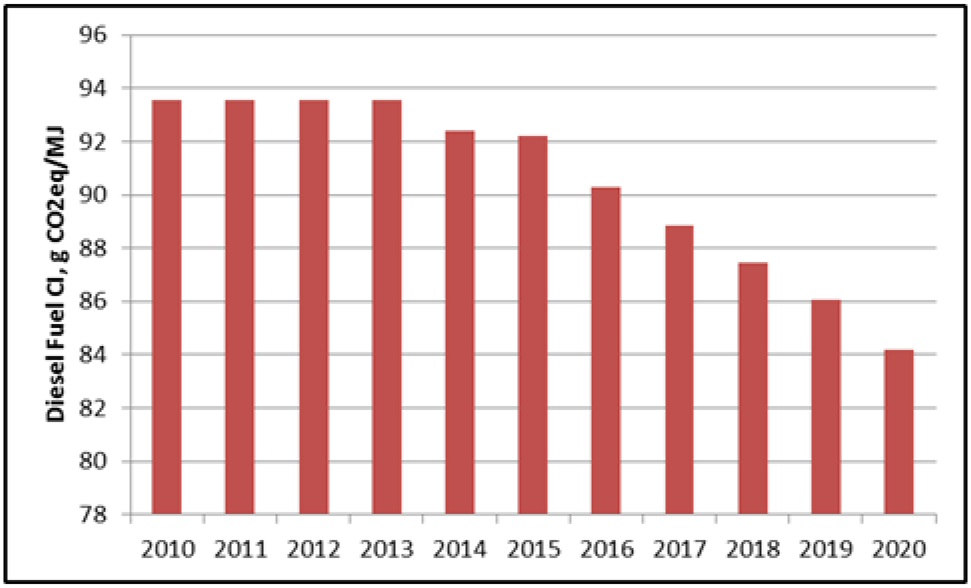
Figure 1-1 BC LCFS Carbon Intensity Profile - Diesel



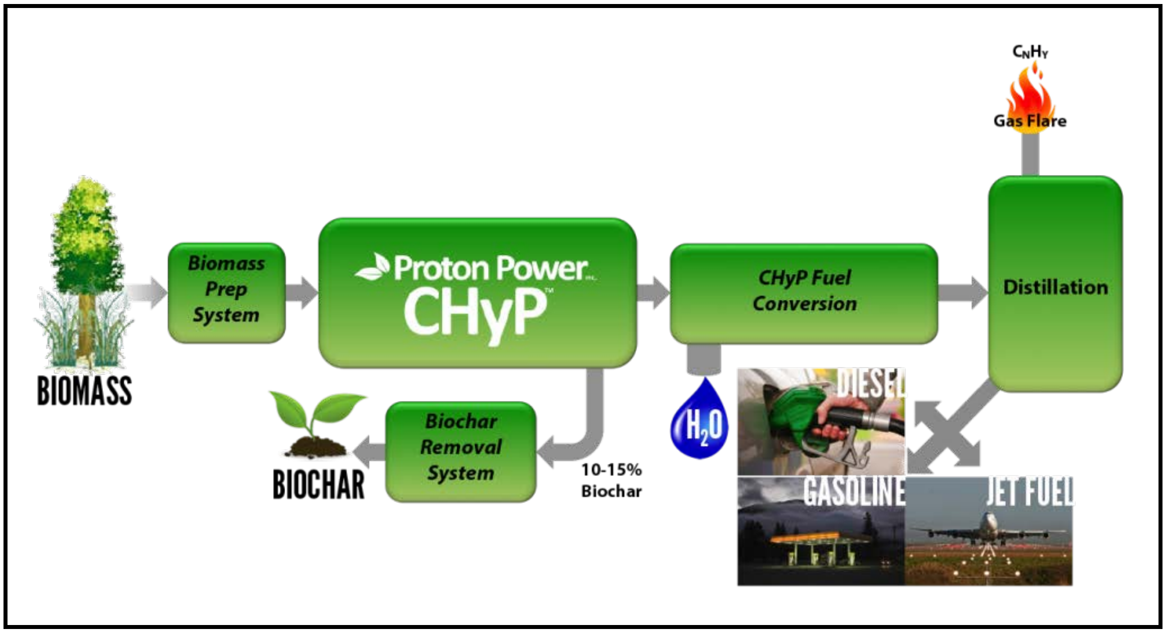
The primary suppliers have begun to ask their renewable fuel providers for the carbon intensities of their products. Under the regulations, this CI must currently be calculated using version 4.03a of GHGenius. GHGenius is a spreadsheet tool that implements lifecycle assessment for transportation fuels. It is used to calculate the amount of greenhouse gases generated from the time a fuel is extracted or grown to the time that it is combusted in a motive energy vehicle to produce power. GHGenius has been developed by $(S\&T)^2$ Consultants Inc. and is supported by Natural Resources Canada.

At this time, the expectation of the BC Government is that suppliers will calculate their CI using GHGenius and only make changes to the input cells in the model (identified by a yellow background) and suppliers will document the changes so that an independent party can duplicate the results.

1.1 Scope of Work

Propel Bioenergy is proposing to install a pyrolysis based process in the West Kootenay region of BC. The process to be used produces diesel fuel (#1 and #2 grades), as well as some biochar and combustible gas. The system is manufactured by Proton Power. The Proton Power fuel system is shown in the following figure.

Figure 1-2 Proton Power Fuel System



The diesel fuel is considered to be the primary product and a CI with and without the biochar is calculated. The gas is used in the process to dry the feedstock. The only other input for the process is electricity that is supplied from the grid.

1.2 GHGENIUS

The GHGenius model has been developed for Natural Resources Canada over the past thirteen years. It is based on the 1998 version of Dr. Mark Delucchi's Lifecycle Emissions Model (LEM). GHGenius is capable of analyzing the energy balance and emissions of many contaminants associated with the production and use of traditional and alternative transportation fuels.

GHGenius is capable of estimating life cycle emissions of the primary greenhouse gases and the criteria pollutants from combustion and process sources. The specific gases that are included in the model include:

- Carbon dioxide (CO_2),
- Methane (CH_4),
- Nitrous oxide (N_2O),
- Chlorofluorocarbons (CFC-12),
- Hydro fluorocarbons (HFC-134a),
- The CO_2-equivalent of all of the contaminants above.
- Carbon monoxide (CO),
- Nitrogen oxides (NOx),
- Non-methane organic compounds (NMOCs), weighted by their ozone forming potential,
- Sulphur dioxide (SO_2),
- Total particulate matter.

The model is capable of analyzing the emissions from conventional and alternative fuelled internal combustion engines or fuel cells for light duty vehicles, for class 3-7 medium-duty trucks, for class 8 heavy-duty trucks, for urban buses and for a combination of buses and trucks, for light duty battery powered electric vehicles, and for marine vessels. There are over 200 vehicle and fuel combinations possible with the model.

GHGenius can predict emissions for past, present and future years through to 2050 using historical data or correlations for changes in energy and process parameters with time that are stored in the model. The fuel cycle segments considered in the model are as follows:

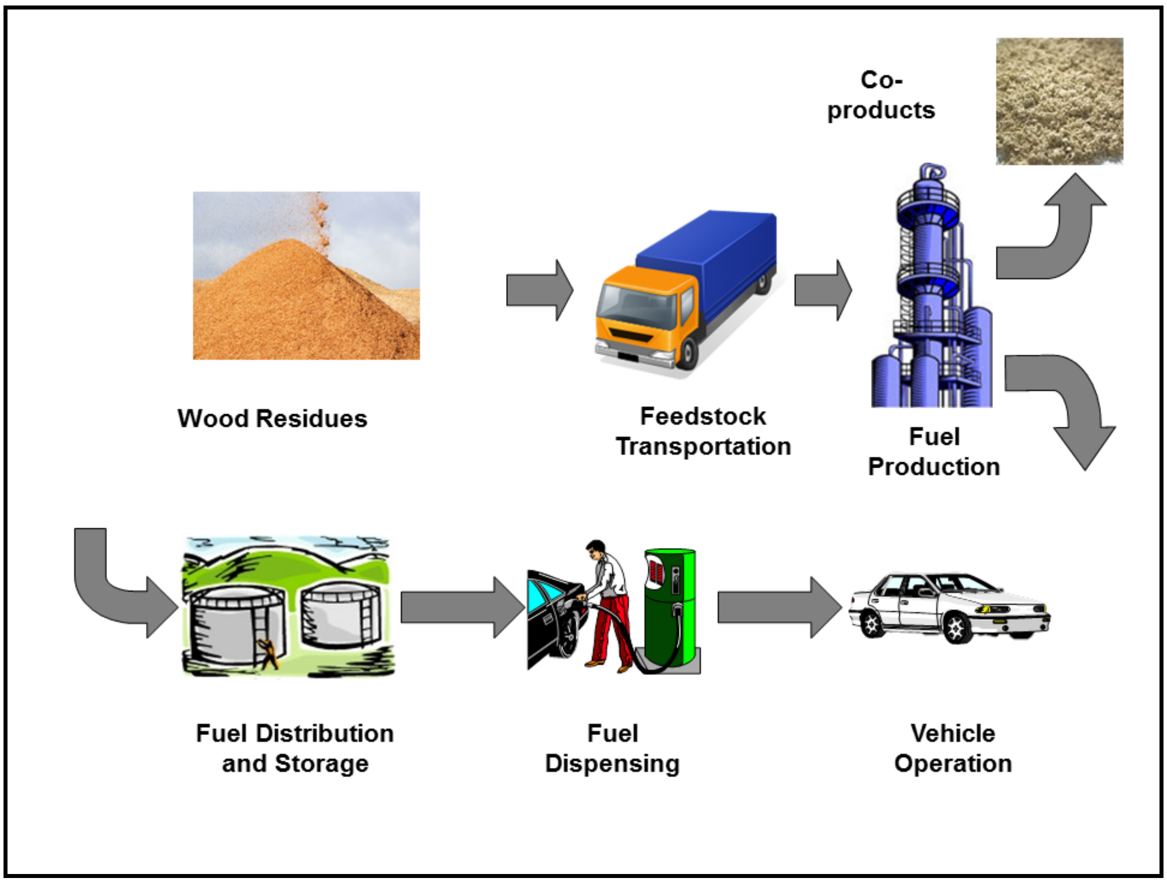
- Vehicle Operation
  Emissions associated with the use of the fuel in the vehicle. Includes all greenhouse gases.
- Fuel Dispensing at the Retail Level
  Emissions associated with the transfer of the fuel at a service station from storage into the vehicles. Includes electricity for pumping, fugitive emissions and spills.
- Fuel Storage and Distribution at all Stages
  Emissions associated with storage and handling of fuel products at terminals, bulk plants and service stations. Includes storage emissions, electricity for pumping, space heating and lighting.
- Fuel Production (as in production from raw materials)
  Direct and indirect emissions associated with conversion of the feedstock into a saleable fuel product. Includes process emissions, combustion emissions for process heat/steam, electricity generation, fugitive emissions and emissions from the life cycle of chemicals used for fuel production cycles.
- Feedstock Transport
  Direct and indirect emissions from transport of feedstock, including pumping, compression, leaks, fugitive emissions, and transportation from point of origin to the fuel refining plant. Import/export, transport distances and the modes of transport are considered. Includes energy and emissions associated with the transportation infrastructure construction and maintenance (trucks, trains, ships, pipelines, etc.)
- Feedstock Production and Recovery
  Direct and indirect emissions from recovery and processing of the raw feedstock, including fugitive emissions from storage, handling, upstream processing prior to transmission, and mining.
- Feedstock Upgrading
  Direct and indirect emissions from the upgrading of bitumen to synthetic crude oil at a standalone facility, including fugitive emissions.
- Fertilizer Manufacture
  Direct and indirect life cycle emissions from fertilizers, and pesticides used for feedstock production, including raw material recovery, transport and manufacturing of chemicals. This is not included if there is no fertilizer associated with the fuel pathway.
- Land use changes and cultivation associated with biomass derived fuels
  Emissions associated with the change in the land use in cultivation of crops, including N_2O from application of fertilizer, changes in soil carbon and biomass, methane emissions from soil and energy used for land cultivation.
- Carbon in Fuel from Air
  Carbon dioxide emissions credit arising from use of a renewable carbon source that obtains carbon from the air.

- Leaks and flaring of greenhouse gases associated with production of oil and gas
  Fugitive hydrocarbon emissions and flaring emissions associated with oil and gas production.
- Emissions displaced by co-products of alternative fuels
  Emissions displaced by co-products of various pathways. System expansion is used to determine displacement ratios for co-products from biomass pathways.
- Vehicle assembly and transport
  Emissions associated with the manufacture and transport of the vehicle to the point of sale, amortized over the life of the vehicle.
- Materials used in the vehicles
  Emissions from the manufacture of the materials used to manufacture the vehicle, amortized over the life of the vehicle. Includes lube oil production and losses from air conditioning systems.

There are two pathways in GHGenius that could be used for this analysis, a wood to diesel process and a two stage pyrolysis and upgrading pathway. Both give similar results and the wood to diesel (BTL) pathway has been used here.

The main lifecycle stages for wood residue to diesel system in GHGenius are shown in the following figure.

Figure 1-3 Lifecycle Stages – Wood to Diesel Fuel



The GHGenius model version 4.03a has been set to 2016 and the 2007 IPCC GWPs in accordance with the BC Regulations. The modelling data has been supplied by Propel Bioenergy and is estimated based on the design data.

2. FEEDSTOCK SUPPLY

Propel Bioenergy will use wood residue from a number of mills in the West Kootenay region. This is the material that will be used as feedstock for the process. Wood residue is a waste so it has no upstream emissions associated with it. The wood residue button on the Input sheet ~A116 should be pushed.

2.1 TRANSPORTATION

The wood residues will be moved by truck and by rail to the processing site. The transportation distances are very short. The model inputs are shown below. These are the weighted average values from four different suppliers.

Table 2-1 Wood Distribution Scenarios

Processing Location	Near Fruitvale, BC	
	Input Sheet Cell	Value
Average km shipped		
Rail	J78	7
Truck	J82	43
Tonnes-shipped/tonne-produced		
Rail	J84	0.18
Truck	J88	0.82

This material is all currently being transported greater distances for use in a biomass power plant in Washington State. However, since we don't know how the power plant will replace this fuel, no credit for avoided transportation emissions is taken.

3. FUEL PRODUCTION

The fuel production information has been supplied by Propel Bioenergy and is based on design work. The base year for the fuel production in the model has been set to 2016 (cell D 234 on the Input sheet).

3.1 MASS AND ENERGY INPUTS

The process data used for modelling the fuel production in GHGenius is summarized in the following table. Sixty-five percent of the energy in the feedstock is captured in the diesel fuel produced.

Table 3-1 Process Data

	Inputs		Output	
Wood	6,250 kg/h			
Electricity	3,092 kW	3,092 kWh/h		
Diesel			1,729 kg/h	2,245 L/h
BioChar			797 kg/h	0.355 kg/litre

We have used the biomass to liquid pathway in the model. This is a single step process and while the chemistry inside the process is likely different than the Proton Power process it is more straightforward to model than the two stage pyrolysis process in GHGenius. The input data in the following table produces inputs equivalent to the Proton Power data.

Table 3-2 Mass and Energy Inputs

	Propel Bioenergy	
	BTL	
	Input Sheet cell	Value
Net Electricity (kWh)	D236	1.29
Diesel (litres/litre fuel)	D237	0.00
Natural Gas (litres)	D238	0.00
Wood (kg)	D239	2.784

3.2 CO-PRODUCTS

The process produces small amounts of bio-char and some gas. The gas is used in the process to dry the feedstock to the required level.

The bio-char could have a number of potential uses ranging from a fuel to the use as a soil amendment. There is some evidence that bio-char used as a soil amendment is relatively inert and a potential means of sequestering carbon. There is also evidence that the bio-char can enhance biomass growth and accelerate the take up of carbon from the atmosphere. Bio-char carbon sequestration would have to be recognized by the BC Ministry of Energy before it would become part of the CI calculation. We have provided a CI with and without a bio-char credit. In the case of the credit we have taken a conservative approach and just provided a credit for the carbon sequestration of the bio-char, excluding any benefit from enhance biomass growth. The bio-char characteristics from the Proton Power MSDS are shown in the following table.

Table 3-3 Bio-char Characteristics

Property	Value
Moisture	3-8%
Carbon	>80%
Ash	<15%
Volatile matter	<5%

We have assumed a moisture content of 5% and a carbon content of 80%. Each kilogram of bio-char therefore represents 2.79 kg of CO_2. The credit is 27.11 kg CO_2/GJ of diesel fuel. Electricity generation as a coproduct is set to zero in cell R267 on the input sheet.

3.3 DISTRIBUTION

The fuel will be shipped by rail from the plant to Vancouver, a distance of 895 km. From the blending facility in Vancouver the fuel will be shipped 80 km by truck to the retail outlet, a standard distance in GHGenius.

Table 3-4 Fuel Distribution Scenario

Processing Location	Near Fruitvale, BC	
	Input Sheet Cell	Value
Average km shipped		
By Rail	F92	895
Domestic water	F93	0
International water	F94	0
Pipeline, tram, conveyor	F95	0
Truck	F96	80
Tonnes-shipped/tonne-produced		
By Rail	F98	1.00
Domestic water	F99	0.00
International water	F100	0.00
Pipeline, tram, conveyor	F101	0.00
Truck	F102	1.00

4. RESULTS

The results for the various stages of the lifecycle are presented below along with a description of the modelling framework for each stage.

4.1 LIFECYCLE EMISSIONS PROPEL BIOENERGY DIESEL

The lifecycle emissions for the fuel produced from wood at the Propel Bioenergy plant near Fruitvale, BC are shown in the following table.

Table 4-1 CI Propel Bioenergy Diesel

Source	Propel Bioenergy Diesel Fuel	
	g CO_2eq/GJ	
	Diesel Fuel	
	Without Bio-char	With Bio-char Credit
Fuel dispensing	35	35
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Fuel Use	1,736	1,736
Grand Total	8,640	-18,480
CI Grand Total, g CO_2eq/MJ	**8.64**	**-18.48**

4.2 COMPARISON TO OTHER BC CI VALUES

The BC Government has published the CI of some alternative fuels in their Information Bulletin RLCF-002 (2010); however these were calculated with an earlier version of GHGenius and the 1995 GWPs. The diesel value from GHGenius 4.03a are compared to Propel Bioenergy values in the following table.

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The CI of the Propel Bioenergy product is very low and offers about a 91% reduction over the CI of fossil diesel fuel without considering the bio-char credit.

5. REFERENCES

BC Energy Mines and Petroleum Resources. 2010. Information Bulletin RLCF-002. http://www.empr.gov.bc.ca/RET/RLCFRR/SupplierFAQ/Documents/RLCF002%202010%20Carbon%20Intensity.pdf

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