Natural Resources Canada
Ressources naturelles Canada

Report on the Technical Feasibility of Integrating an Annual Average 2% Renewable Diesel in the Canadian Distillate Pool by 2011

October 2010

Canada

Executive Summary

Context

The Government of Canada is committed to expanding the production and use of a range of cleaner, renewable biofuels, including renewable diesel. The intent is to reduce greenhouse gas (GHG) emissions resulting from fuel use and provide new market opportunities for agricultural producers and rural communities. In December 2006, as part of its renewable fuels strategy, the Government announced its intention to regulate an annual average of 2% renewable content in diesel fuel and heating oil by 2012, upon successful demonstration of renewable diesel use under the range of Canadian conditions. In 2009, the Government announced that it would be advancing this date to 2011 or earlier, subject to technical feasibility.

Comparison to Ethanol

As a result of provincial ethanol mandates that have been in force for several years (Saskatchewan, Manitoba, Ontario, and more recently in British Columbia), Canadian refiners and marketers have a considerable amount of experience with blending ethanol into the gasoline pool. Lessons learned and blending taking place as a result of provincial mandates will help to reduce the risk associated with implementing a federal mandate requiring an average 5% renewable content in the gasoline pool.

Experience with biodiesel is much more limited in Canada (Manitoba's mandate came into force on November 1, 2009, British Columbia's on January 1, 2010, and recently Alberta's mandate on July 1, 2010). Due to flexibility included in the provincial regulations, biodiesel blending in these jurisdictions has been limited to date. As a result, industry will not have the same opportunity to build on lessons learned and existing provincial mandates as they have had with respect to ethanol.

Purpose of this Report

Due to Canada's cold and variable climate, a number of stakeholders raised the issue that the introduction of biodiesel into the domestic marketplace could prove challenging.

To address this and other questions about the technical feasibility of renewable diesel use in Canada in advance of the intended regulation, in 2008 the Government of Canada launched the National Renewable Diesel Demonstration Initiative (NRDDI). The NRDDI actively communicated with fuel producers and end-user organizations to determine their remaining questions and identify opportunities to address them. In consultation with Environment Canada, Agriculture and Agri-food Canada and Transport Canada, seven demonstration projects were delivered by stakeholders with funding assistance from the NRDDI. A study of the readiness of Canadian petroleum distribution infrastructure was also conducted.

It is important to note that the NRDDI demonstrations were designed by industry proponents to respond to their sector's questions about renewable diesel use in their Canadian operations. The projects were not exhaustive in their scope and in many cases were done under controlled conditions. Multi-stakeholder steering and/or technical committees helped develop and implement the projects, as well as interpret and report on the results.

The results of the NRDDI projects and other applicable research and experience in Canada and the United States have been included in this report to inform the development and implementation of the proposed regulation by Environment Canada.

Technical Feasibility of the Proposed Regulation

The technical feasibility of an average 2% renewable content in diesel and heating oil mandate in Canada has been assessed using four key factors:

- Fuel technology readiness
- Technology/end-user application readiness
- Infrastructure readiness
- Market acceptance

The following is a summary of the key findings of the NRDDI projects and other applicable research with respect to the four key factors. More detailed information can be found in the body of the report.

Fuel technology readiness

Renewable diesel blends can be made to conform to the latest industry accepted standards for a large variety of Canadian conditions.

Fuel supply is an ever-evolving field. With decreasing traditional fuel sources and increasing interest in reducing transportation's carbon footprint, future fuel sources will become increasingly diversified. As such, there is a constant need for continuous evolution of our understanding of fuel technologies to address new and emerging issues. All stakeholders, including fuel suppliers, users and regulators, have a role to play in ensuring the fuels being sold in Canada are fit for purpose.

Technology/End-user application readiness

Under the specific conditions encountered in the studied projects, operation on a 2% to 5% blend level (B2-B5) was not shown to cause any significant loss-of-service incidents for the on-road, off-road, and stationary genset sectors. Results for stationary furnaces indicate negligible impact on operation and performance with fuel up to B10.

End-user application issues such as biodiesel’s cleansing effect and incompatibility with some materials are known and predictable and can be mitigated through adequate training and maintenance. Older equipment and vehicles may contain materials that are not compatible with biodiesel. It is difficult to precisely estimate the extent of the negative effect on these materials due to low-level biodiesel blends. Any potential negative effects on materials due to low-level biodiesel blends are not expected to be extensive nor sudden.

Infrastructure Readiness

The most significant infrastructure requirements for biodiesel blending will be found at the refinery and terminal points in the network. Transportation of diesel will also be affected.

The lead times for the required upgrades to a terminal or refinery site are as little as one year in regions where provincial mandates have been finalized. In other regions of the country, these upgrades could take up to three years. Significant logistical and infrastructure planning must be undertaken to ensure that consumers are not affected by the transition to biodiesel blends. In cases where permitting is required before construction can begin, permit approval processes will have a significant impact on timing.

Due to the nature of the required infrastructure, accelerating lead times in order to meet a mandated regulatory start date can lead to significantly increased costs and may not be possible in some cases.

Market acceptance

For the most part, fuel producers and end-users have not identified any remaining questions regarding the technical feasibility of the use of an average B2 blend in middle distillate in their operations. Almost all engine manufacturers endorse up to B5 in their engines as long as the fuel meets the appropriate quality standards.

Conclusion

The technical information and experience gathered through the NRDDI projects and other cited research and experience in Canada and the United States provide a useful assessment of the technical feasibility of the intended regulation.

This information demonstrated the possibility for renewable diesel to meet industry accepted standards. It also provided the necessary data for industry representatives from most Canadian end-use sectors to provide their views on the technical feasibility of a 2% mandate. Stakeholders are generally satisfied that technical issues related to an average B2 blend in distillate fuel in their operations have been addressed. In order for a seamless transition to renewable diesel blends in the Canadian marketplace, it is important to provide adequate lead times for infrastructure upgrades, as well as flexibility should unexpected complications arise.

Glossary of Terms

Additive: Material added in small amounts to finished fuel products to improve certain properties or characteristics

Antioxidant: Substance that inhibits reactions promoted by oxygen

ASTM: Standards from ASTM International

Base fuel: The fuel before renewable diesel is added

Biodegradable: Capable of being broken down by the action of micro-organisms

Biodiesel: Methyl esters of fatty acids meeting the requirements of ASTM specification D6751

B100: 100% fatty acid methyl ester

Bxx: Finished blends of biodiesel with ultra-low sulphur diesel, where xx refers to the percentage of biodiesel in the blend

Cetane number: A measure of the ignition quality of diesel fuel based on ignition delay in an engine; the higher the cetane number, the shorter the ignition delay and the better the ignition quality

Cloud point: The temperature at which a sample of a fuel just shows a cloud or haze of wax (or in the case of biodiesel, methyl ester) crystals when it is cooled under standard test conditions, as defined in ASTM D2500 (see Appendix 1)

CME: Canola methyl ester

CSFT: Cold soak filtration test (see Appendix 1)

EN: European standards

Energy content: The heat produced on combustion of a specified volume or mass of fuel; also known as heating value or heat of combustion

FAME: Fatty acid methyl esters; a mono alkyl ester of long-chain fatty acids from naturally occurring plant oils, animal fats, and recycled greases

Fatty acid: Any of the saturated or unsaturated monocarboxylic acids that occur naturally in the form of triglycerides (or mono or diglycerides) or as free fatty acids in fats and fatty oils

Flash point: The lowest temperature at which vapours from a fuel will ignite when a small flame is applied under standard test conditions

FBT: Filter blocking tendency (see Appendix 1)

HC: Hydrocarbon, a compound composed of hydrogen and carbon. Hydrocarbons can refer to fuel components and to unburned or poorly combusted components in vehicle exhaust

HDRD: Hydrogenation-derived renewable diesel

Kerosene: A high value petroleum distillate with superior low temperature operability properties

Lubricity: The ability of a fuel to lubricate

Microbial contamination: Containing deposits or suspended matter formed by microbial degradation of the fuel

Neat biodiesel: 100% biodiesel

Oxidation: Loosely, the chemical combination of oxygen to a molecule

Oxidative stability: The ability of a fuel to resist oxidation during storage or use

Pour point: The lowest temperature at which a fuel will just flow when tested under standard conditions, as defined in ASTM D97 (see Appendix 1)

Renewable diesel: An umbrella term referring to any sort of diesel fuel from a renewable source

Saturation or saturated compound: A paraffinic hydrocarbon or fatty acid, i.e. one with only single bonds and no double or triple bonds

SME: Soy methyl ester

SMG: Saturated monoglycerides, a type of naturally occurring impurity found in most biodiesel, which can form precipitates

Solvent: A liquid capable of dissolving another substance to form a solution, which is a homogeneous mixture, composed of two or more substances

Splash blending: The fuels to be blended are delivered separately into a tank truck

Storage stability: The ability of a fuel to resist deterioration due to oxidation during storage

TME: Tallow methyl ester

ULSD: Ultra low sulphur diesel

ULSK: Ultra low sulphur kerosene

Viscosity: A measure of the resistance to flow of a liquid

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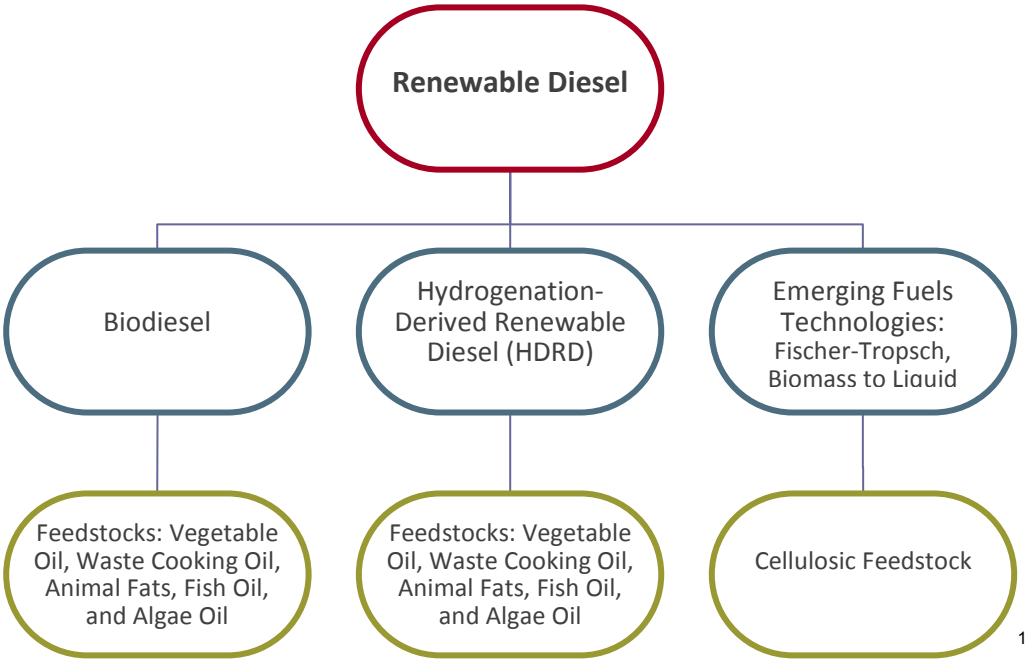
1 Introduction

1.1 Background

The Government of Canada is committed to expanding the production and use of a range of cleaner, renewable biofuels, including renewable diesel. The intent is to reduce greenhouse gas (GHG) emissions resulting from fuel use and provide new market opportunities for agricultural producers and rural communities. As part of its Renewable Fuels Strategy, in December 2006 the Government announced its intention to regulate an annual average of 2% renewable content in diesel fuel and heating oil by 2012, upon successful demonstration of renewable diesel use under the range of Canadian conditions. In 2009, the Government moved ahead this date to 2011 or earlier, subject to technical feasibility.

For the purpose of this report, renewable diesel is defined as a diesel fuel substitute made from renewable materials such as vegetable oil, waste cooking oil, animal fat and fish oil and potentially from cellulosic feedstock consisting of agriculture and forest biomass. Biodiesel is one common example of a renewable diesel. Biodiesel is produced from these feedstocks through a process called transesterification and consists of fatty acid methyl esters (FAME). Hydrogenation-derived renewable diesel (HDRD) is another type of renewable diesel produced by hydrotreating of similar fat or oil based biodiesel feedstock. Other technologies to turn biomass into renewable diesel are being developed.

Figure 1: Renewable Diesel Types and Feedstocks



[1] National Renewable Diesel Demonstration Initiative; Background. April, 21, 2009. Natural Resources Canada. <http://oee.nrcan.gc.ca/transportation/fuels/biodiesel/NRDDI/background.cfm?attr=16>
Alternative and Advanced Fuels. February 10, 2009. US Department of Energy. <http://www.afdc.energy.gov/afdc/fuels/index.html>

Past studies and demonstrations have shown that low-level renewable diesel blends, a mixture of petroleum diesel and renewable diesel, can be used with some precautions in diesel engines in many sectors, including on-road and off-road mobile equipment and vehicles, and stationary equipment. The use of renewable diesel blends can reduce life-cycle GHG emissions and some tailpipe emissions, including air toxics such as particulate matter, hydrocarbon and carbon monoxide.[2] However, a key area of concern to Canadian stakeholders is the use of renewable diesel blends in cold Canadian winters and over four seasons with high temperature variability.

As renewable diesel can be blended with diesel in any concentration, the blend level depends on economics, availability and end-use requirements. An increasing number of Original Equipment Manufacturers (OEMs) are endorsing the use of low-level renewable diesel blends, e.g., 5%, in their engines (see section on Market Acceptance), provided the fuel meets applicable standards. Some manufacturers also provide new vehicles pre-filled with renewable diesel blends[3].

The Government of Canada created the National Renewable Diesel Demonstration Initiative (NRDDI) with the aim of addressing remaining stakeholder questions related to the technical feasibility of an average 2% renewable content in the Canadian distillate pool. The NRDDI provided non-repayable contributions to approved projects that demonstrate how renewable diesel fuel will perform under Canadian conditions in advance of implementing the proposed target. The NRDDI actively communicated with end-user organizations including the following to determine these remaining questions and identify opportunities to address them:

- Canadian Coast Guard
- Canadian Federation of Agriculture
- Canadian Independent Petroleum Marketers Association
- Canadian Marine Advisory Council
- Canadian Oil Heat Association
- Canadian Petroleum Products Institute
- Canadian Renewable Fuels Association
- Canadian Shipowners Association
- Canadian Trucking Alliance
- Canadian Urban Transit Association
- Chamber of Marine Commerce
- Canadian Construction Association
- Department of National Defence
- Engine Manufacturers Association
- FPInnovations (forestry)
- Mining Association of Canada
- Railway Association of Canada

The NRDDI was managed by Natural Resources Canada (NRCan), in consultation with Environment Canada, Agriculture and Agri-food Canada and Transport Canada. NRDDI projects were developed and implemented under the guidance of multi-sectoral steering/technical committees to ensure that appropriate methodologies were used and results were presented in a scientifically sound manner.

[2] National Renewable Energy Laboratory, "Biodiesel Handling and Use Guide", Fourth Edition, Revised December 2009.
[3] The Office of Energy Efficiency; Biodiesel. March 25, 2010. Natural Resources Canada. <http://oee.nrcan.gc.ca/transportation/fuels/biodiesel>

1.2 Objective

The primary objective of this report is to inform the development and implementation of the proposed regulation to require an average 2% renewable content in the distillate pool by 2011. This information will be used to assess the technical feasibility of the proposed regulation through a review of four key factors:

- Fuel technology readiness
- Technology/end-user application readiness
- Infrastructure readiness
- Market acceptance

1.3 Structure of this Report

The report is divided into seven sections:

- Section 1 is an introduction to the report, and defines background, objectives, scope, and approach used to produce this report. It also reviews the terminology used to form the basis of the content described in the following sections.
- Sections 2 to 5 present the key technical feasibility factors, the main findings and an analysis of potential issues and remaining gaps regarding each of the four factors.
- Section 6 covers important issues that are not directly discussed in Sections 2 to 5, e.g., mandates in other jurisdictions and any other issues that need to be noted.
- Section 7 provides a conclusion to this report.

1.4 Scope of Information Presented in this Report

The information presented in this report is based on the specific results obtained from projects funded by the NRDDI program and selected information sources from outside the NRDDI program and is described below.

1.4.1 Fuels Considered in this Report

The fuels considered in this report are renewable diesel from a range of feedstock, petroleum diesel and heating fuel oil.

Renewable diesel refers to a fuel derived from renewable sources with properties similar to petroleum diesel, allowing it to be used in a diesel engine. Renewable diesel can be derived from a range of feedstock including corn, canola, soy, tallow, yellow grease and palm. In the NRDDI demonstrations, wherever possible, several types of feedstocks were used, mostly those that were regionally available.

There are two main commercial types of renewable diesel: biodiesel and HDRD. Biodiesel is the most common and by definition “is a fuel comprised of mono-alkyl esters of long chain fatty

acids derived from vegetable oils or animal fats, designated B100"[4]. The European standard (EN 14214) refers to biodiesel as Fatty Acid Methyl Ester (FAME)[5]. HDRD is formed through a hydrotreating process whereby the feedstocks are the same as those used to make biodiesel but the product is similar in composition to petroleum diesel, characterized largely by saturated straight chain hydrocarbons. Both FAME and HDRD are considered in this study.

Petroleum diesel fuel is by definition "a middle distillate fuel composed of hydrocarbons, including naturally occurring, petroleum-derived, non-hydrocarbons, boiling in the range of 150 to 400 °C, intended for use as a fuel in traditional compression-ignition engines."[6] In Canada petroleum diesel fuel is usually classified as:

- Light diesel fuel: Type A - for special applications; or
- Seasonal diesel fuel: Type B - the most commonly used diesel fuel.

Heating fuel oil for domestic, liquid-fuel-burning equipment is similar to the above-defined petroleum diesel fuel, but a different nomenclature is used (Types 0, 1 and 2).

Biodiesel blends are commonly designated by the term BXX where XX refers to the volumetric percentage of neat biodiesel in the blend. Thus, B100 and B5 mean neat biodiesel and diesel with 5% biodiesel content, respectively. In this report, a number of projects are referenced which have tested up to B20. The NRDDI and other renewable diesel demonstration projects have used different blends, depending on the end-use type function and material compatibility, as well as climate and seasonal considerations.

HDRD is produced in smaller quantities and is expected to continue to be less available than biodiesel in the foreseeable future. Fewer operational concerns have been linked to HDRD blends, which is another reason none of the NRDDI projects tested HDRD.

1.4.2 Regional and Seasonal Coverage of Renewable Diesel Blends Considered in this Report

The geographical reach of the demonstration projects and studies that were used to inform this report covers a spectrum of Canadian climatic conditions. Under the NRDDI, demonstration locations were selected by the project proponents so that they provided the most suitable environment for addressing their remaining questions including regions in colder Canadian climate zones such as northern Quebec, northern British Columbia and northern Manitoba (related to forestry operations and remote electricity generation), as well as Saskatchewan and Alberta (related to agricultural and rail operations).

A proper assessment of cold weather operability required that field tests be run during the coldest winter period. Long-term storage tests required testing during all seasons to study the effect of temperature changes on renewable diesel blend properties. It should be noted that the petroleum diesel commercially available is itself seasonally adjusted for optimal operability.

1.4.3 Sector and End-Use Coverage of Renewable Diesel Applications Considered in this Report

The end-use applications considered in the report are the main diesel and heating oil users in Canada.

[4] American Society for Testing and Materials (ASTM), "ASTM D6751: Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels", 2009.
[5] European Committee for Standardization, "EN 14214: Automotive Fuels – Fatty Acid Methyl Esters (FAME) for Diesel Engines – Requirements and Test Methods", November 2008.
[6] Canadian General Standards Board, "CAN/CGSB-3.520: Automotive (On-road) Diesel Fuel Containing Low Levels of Biodiesel Esters (B1-B5)", 2005.

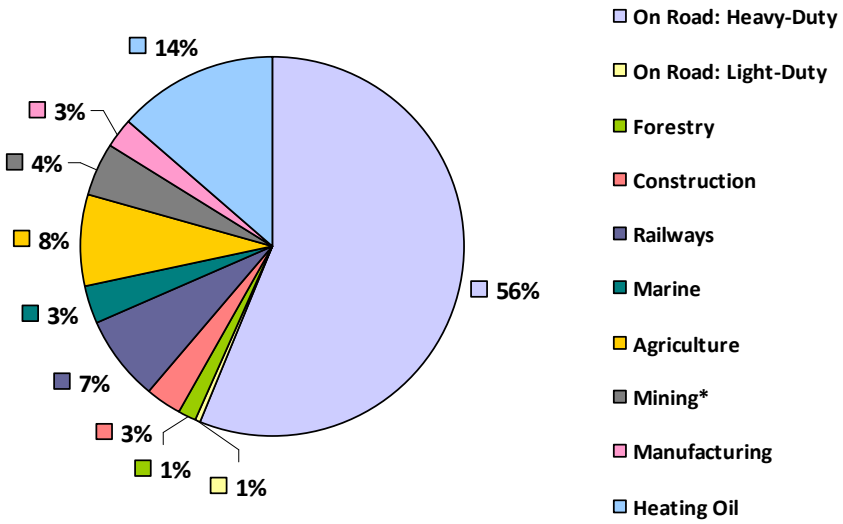
On-road:
- Fleet vehicles
- Heavy-duty trucks
- School buses
- Urban transit buses

Off-road:
- Agricultural equipment
- Construction equipment
- Forestry equipment
- Locomotives
- Marine vessels
- Mining equipment

Stationary:
- Electricity generators (gensets)
- Furnaces

Figure 2 shows 31.9 billion litres of distillate products were consumed in 2007 across Canada. Road transport accounted for 57% (heavy-duty vehicles accounting for 56%), commercial and residential heating 14%, agriculture 8%, rail 7%, and all other sectors combined 14%.

Figure 2: Distillate Products Consumption by Sector in Canada – 2007; 31.9 billion litres



**Includes Oil and Gas Extraction*
Sources: Statistics Canada Catalogue No. 57-003-X; Natural Resources Canada, Transport Model, Ottawa, June 15, 2010 (by Stéphane Leblanc)

1.5 NRDDI Projects and Studies Considered in this Report

The NRDDI funded projects proposed by stakeholders that addressed their remaining questions with respect to renewable diesel use in Canada. Projects were designed by stakeholders to address their industry-specific questions and included input from a range of industry experts to ensure appropriate methodologies and standards were used. The NRDDI also funded a study to examine infrastructure readiness. These projects and studies were executed by the following organizations (Exhibit 1):

Exhibit 1

Project	Scope
Canadian Pacific Railway *- "Canadian Pacific Railway Biodiesel Project"*	**Technology/end-user application readiness** The impact of renewable diesel on locomotive operations between Calgary and Edmonton; in particular, cold weather operability and direct-to-locomotive fuelling, engine components, heating systems
FPInnovations *-"Demonstration of the Potential Use of Biodiesel for Off-Road Construction and Forest Operations"*	**Fuel technology readiness** – the impact of biodiesel use on engine lube oil dilution **Technology/end-user application readiness** The impact of renewable diesel use on equipment and operations for: off-road and logging road construction; material handling in a saw mill; and harvesting and processing of timber in isolated locations in some of Canada's most challenging environments
Imperial Oil Limited *- "Imperial Oil-Canadian Petroleum Products Institute Biodiesel Research Project"*	**Fuel technology readiness** – cold flow performance and stability under long-term storage **Technology/end-user application readiness** – performance in furnaces
Manitoba Hydro *- "Demonstration of the Use of Biodiesel in Electric Generators in Remote Canadian Locations and Long-Term Storage in Fleets and Gensets"*	**Fuel technology readiness** **Technology/end-user application readiness** The impact of long-term storage on dispenser filter plugging in a vehicle fleet application and alternative measures for testing for minor impurities in the fuel and how these impurities may relate to long-term storage Blending for, and use in, gensets in extreme cold temperatures in remote locations in Northern Manitoba
Prairie Agricultural Machinery Institute *- "Effect of Storage on Biodiesel Quality and Performance"*	**Fuel technology readiness** The impact of long-term storage on fuel quality – testing of renewable diesel blends that had been stored in harvesting equipment tanks for up to ten months and renewable diesel blends that had been stored for two years in outdoor tanks
Royal Military College of Canada *- "Formation kinetics of saturated monoglyceride (SMG) based particles in biodiesel and petrodiesel blends"*	**Fuel technology readiness** The kinetics of formation of SMG-based particles at various temperatures starting from the cloud point by monitoring sediments in the fuel against time; the chemical composition of the sediments was determined and compared to the base fuel
Saskatchewan Research Council *- "Off-road Biodiesel Demonstration in the Agricultural Sector"*	**Technology/end-user application readiness** The impact of renewable diesel use on agricultural equipment The impact of off-season storage of renewable diesel in equipment and storage tanks on fuel quality

Study	Scope
EcoRessources *- "National Renewable Diesel Demonstration Initiative Infrastructure Project"*	**Infrastructure readiness** A study to examine infrastructure readiness for the addition of an average 2% renewable diesel to diesel and heating oil in Canada in 2011

1.6 Other Sources of Information Considered in this Report

Other sources of information considered in this report include the following:

- Interviews with government specialists
- Consultations with industry experts and associations (see Market Acceptance)
- A series of published reports on the study of various aspects of suitability of renewable diesel in various applications (see Exhibit 2).

Exhibit 2

Other Information Sources (Outside NRDDI) Considered in this Report

Project	Scope
Alberta Renewable Diesel Demonstration *– "Final Report", 2009*	Cold weather operability of heavy-duty trucks, school buses, and industrial heavy-duty fleets; Experience with blending infrastructure
Climate Change Central *– "Renewable Diesel Characterization Study", 2008*	Characterizing cold climate applicability of biodiesel blends; Test renewable diesel blends from a variety of feedstock; Identify the most promising cold climate renewable fuel feedstock and blend
National Renewable Energy Laboratory *– "Biodiesel Handling and Use Guide", 2009*	A guide for proper and safe use of biodiesel and biodiesel blends in compression-ignition engines and boilers
Washington State Ferries *– "Biodiesel Research & Demonstration Project", 2009*	Test current fuel specifications for biodiesel blends; Develop biodiesel product handling guidelines for use in a marine environment; Demonstrate that biodiesel can be successfully used in marine applications in the Pacific Northwest
Environment Canada *– "Review of Literature and Assessment Studies on Bioheat® Use in Canada", 2008*	Review of the literature on the status of biodiesel use for space heating (Bioheat)
Natural Resources Canada *– "Assessment of the Biodiesel Infrastructure in Canada", 2007*	Infrastructure challenges and barriers related to the distribution of biodiesel blends
Saskatoon Biobus *– "Final Research Report", 2006*	Determine the long-term effect of a biodiesel blend on engine wear and fuel economy of 2- and 4-stroke transit bus engines
Montreal Biobus *– "Biodiesel Demonstration and Assessment with the Société de Transport du Montréal (STM)", 2003*	Test the use of biodiesel as a source of supply for public transit; Assess the viability of the fuel as part of the routine operation of a bus fleet, particularly in cold weather; Measure biodiesel environmental and economic impact

BioMER *– "Biodiesel Demonstration and Assessment for Tour Boats in the Old Port of Montreal and Lachine Canal National Historic Site", 2005*	Test the use of B100 as an alternative for tour boats of various sizes; Assess the economic viability and benefits of biodiesel in that industry's routine operations; Measure the environmental impacts
BioShip *– "Biodiesel Seaward Bound", 2006*	Operability and emissions of marine vessel power generators using biodiesel
BioTractor *– "On-Farm Evaluation of Biodiesel Use in Agricultural Equipment", 2007*	Evaluate some of the practical problems associated with on-farm biodiesel use
PAMI Tractor Study *– "Effect of Biodiesel Blends on Tractor Engine Performance", 2009*	Operability and tailpipe emissions of tractors using a wide range of biodiesel blend levels
Transport Canada *– "Biodiesel as a Locomotive Fuel in Canada", 2003*	Literature survey to evaluate the potential of biodiesel, or biodiesel blends with petroleum diesel fuel, as a suitable alternate fuel for medium-speed diesel engines used by Canadian railways
DEEP *– "Evaluation of Biodiesel Fuel and Oxidation Catalyst in an Underground Mine", 1998*	Evaluate the impact of blended biodiesel fuel and modern diesel oxidation catalyst (DOC) on air quality and diesel emissions in underground mines
Flint Hills Resources – *"Effect of Biodiesel Impurities on Filterability and Phase Separation from Biodiesel and Biodiesel Blends, 2007"*	Evaluate biodiesel impurities and filterability and phase separation from biodiesel and biodiesel blends
Renault – *"Diesel Fuel B7 Specifications Need to be Reinforced for Cold Weather Conditions", 2009*	Identifying additional need for specifications for B7 in cold weather conditions
Shell – *"A Winter Experience with FAME in Sweden", 2007*	Identification of precipitate found in depot storage tanks containing Swedish Klass1 B5 fuels
Conservation of Clean Air and Water in Europe (CONCAWE) – *"Guidelines for Handling and Blending FAME", Report 9, 2009.*	Guidelines for handling and blending biodiesel (FAME)

1.7 Approach

This sub-section describes the approach taken to accurately characterize and synthesize information collected for the purposes of this report. In order for renewable diesel blends to be able to successfully replace conventional petroleum diesel in the Canadian cold climate context, it is vital to assess the appropriate blend levels and conditions at which the fuel can be stored, handled and used without causing any issues different in type and extent than those normally associated with conventional diesel.

The approach used for this report included the following tasks:

1. Define the key factors to assess technical feasibility of the proposed target;
2. Describe the main findings based on the available test results and actual testing conditions that could inform the decision-making process; and
3. Provide an analysis of the main findings.

1.7.1 Key Factors: Technical Feasibility

Technical feasibility was defined as follows:

The addition of renewable content in blends averaging 2% into the distillate pool will be deemed technically feasible when it has met the requirements of fuel technology readiness, technology/end-user application readiness, infrastructure readiness and market acceptance.

A definition for each of these four technical feasibility factors was established and is given below. Each of the four technical feasibility criteria is linked to a set of key factors. These factors could be certain physical, chemical, operational or societal criteria that are required to be met or potential concerns that need to be addressed. These factors are discussed and assessed based on the results of studies accomplished inside and outside the NRDDI. The findings are analyzed and any remaining gaps and other issues are discussed.

Key Factor 1: Fuel Technology Readiness

Fuel technology readiness means that properties of renewable diesel required to operate under the range of Canadian conditions are assessed and demonstrated including an assessment of the fuel properties of renewable diesel in relation to conventional diesel. Fuel properties include oxidative stability during long-term storage and cold weather operability, including the crystallization of renewable diesel blends in fine fuel filters (as measured by the cloud point, pour point and cold soak filtration test). Note that, where possible, a range of Canadian conditions means extreme winter conditions of down to -37°C and, where appropriate and possible, seasonal temperature variations. The assessment of these properties would be performed for renewable diesel from a variety of feedstocks at blend levels of up to B5.

Key Factor 2: Technology/End-User Application Readiness

Technology/end-user application readiness means identifying methods to mitigate any negative impacts on engines and equipment related to renewable diesel use in Canada. An assessment to confirm technology/end-user application readiness includes identified potential negative impacts, the end-users and locations where these impacts occur and the magnitude or severity of these impacts. Note that the mitigation measures will address the action taken to overcome the negative impact, the end-user responsible for implementing the measures and the anticipated duration of each measure. Where available, the associated costs for each measure will be noted. Note: it may not be possible in all cases to identify and apply mitigation measures.

Key Factor 3: Infrastructure Readiness

Infrastructure readiness means that the fuel handling industry (refiners, distributors and retailers) is demonstrated to have the capacity to install the needed infrastructure to store and blend biodiesel, and distribute and retail the blended fuel. An analysis to demonstrate infrastructure readiness would include a determination of the state of readiness for primary suppliers (petroleum fuel producers and importers) and other affected stakeholders, assuming they would have to comply with a 2011 implementation date. The assessment will also consider how the primary suppliers would plan to comply at different time intervals (during 2011 and beyond). In addition, the analysis will assess options based on possible blending schedules. All analyses will consider existing provincial mandates with a focus on requirements to meet a 2% national mandate.

Key Factor 4: Market Acceptance

Market acceptance means that fuel users are consulted on demonstration projects and have indicated no further need for demonstrating the use of an average 2% blend in their operations. An assessment to confirm market acceptance includes consulting fuel users in the on-road, off-road and heating oil sectors to obtain feedback on issues to be addressed through demonstration work with regard to the use of B2 average in their industries. Following the demonstration of such issues, fuel users have provided their feedback on the use of an average B2 blend in the distillate pool in Canada and the resulting likelihood of issues in their sector.

1.8 Information by Key Factors

Project/Study	Fuel Technology Readiness	Technology/End-User Application Readiness	Infrastructure Readiness
NRDDI			
Canadian Pacific Railways		x	
EcoRessources			x
FPInnovations	x	x	
Imperial Oil Limited	x	x	
Manitoba Hydro	x	x	
Prairie Agricultural Machinery Institute	x		
Royal Military College of Canada	x		
Saskatchewan Research Council		x	
OTHER NON-NRDDI			
Alberta Renewable Diesel Demonstration		x	
Renewable Diesel Characterization Study	x		
National Renewable Energy Laboratory (NREL) Biodiesel Handling and Use Guide	x	x	
Washington State Ferries	x	x	
Review of Literature and Assessment Studies on Bioheat® Use in Canada		x	
Assessment of the Biodiesel Infrastructure in Canada			x

Saskatoon Biobus		x
Montreal Biobus		x
BioMER		x
BioShip		x
BioTractor		x
PAMI Tractor Study		x
Biodiesel as a Locomotive Fuel in Canada		x
Evaluation of Biodiesel Fuel and Oxidation Catalyst in an Underground Mine		x
Diesel Fuel B7 Specifications Need to be Reinforced for Cold Weather Conditions	x	
Effect of Biodiesel Impurities on Filterability and Phase Separation from Biodiesel and Biodiesel Blends	x	
A Winter Experience in Sweden	x	
Guidelines for Handling and Blending FAME	x	

2 Fuel Technology Readiness

For the purposes of this report, fuel technology readiness is defined as properties of renewable diesel required to operate under the range of Canadian conditions having been assessed and demonstrated including an assessment of the fuel properties of renewable diesel in relation to conventional diesel. Fuel properties include oxidative stability during long-term storage and cold weather operability, including the crystallization of renewable diesel blends in fine fuel filters (as measured by the cloud point, pour point and cold soak filtration test). Where possible, a range of Canadian conditions means extreme winter conditions of down to -37°C, and where appropriate and possible, seasonal temperature variations. The assessment of these properties would be performed for renewable diesel from a variety of feedstocks at blend levels of up to B5.

Fuel Quality

High quality fuel is a key requirement in order to avoid operational issues. The quality requirements for fuels are set through specifications defined by stakeholders through technical committees and adopted by standards-setting bodies.

2.1 Key Factors

A detailed study of the available literature and results obtained from the NRDDI projects, supplemented with consultations with industry, have shown that the following factors need to be considered before confidence in renewable diesel fuel technology readiness can be established:

- Cold flow operability;
- Long-term storage;
- Formation of sediments;
- Microbial growth; and
- Engine lube oil dilution.

These key factors are described below.

2.1.1 Cold Flow Operability and Formation of Sediments

The low temperature properties of the fuel are extremely important for proper operability in the Canadian climate. Unlike gasoline, petroleum diesel and renewable diesel can freeze or gel as the temperature drops. If the fuel begins to gel, it can clog fuel filters and could eventually become too thick to pump. The cold flow requirements of diesel fuel vary considerably by season and region. Important low temperature performance metrics for handling diesel and blends with renewable diesel are as follows:

- Cloud point: The temperature at which small solid crystals are first visually observed as the fuel is cooled. Below cloud point, these crystals might plug filters or could drop to the bottom of a storage tank. However, fuels can usually be pumped at temperatures below cloud point.

- Pour point: The temperature at which the fuel contains so many agglomerated crystals that it is essentially a gel and will no longer flow. Distributors and blenders use pour point as an indicator of whether the fuel can be pumped, even if it would not be suitable for use without heating or taking other steps.[7]

Tests commonly used to characterize the low temperature operability of middle distillate fuels are described in more detail in Appendix 1 (Section 8). Petroleum companies and fuel distributors manage cold flow requirements of all middle distillate fuels by adding low cloud point fuels, such as kerosene or arctic diesel, to ensure the final fuel blend meets the cold temperature requirements, based on regional historical weather data. In Canada there are two types of diesel fuels used in transportation: Types A and B. In general, Type B diesel fuel will cloud at warmer temperatures than Type A.

In the case of biodiesel, the cloud point is significantly higher than that of petroleum diesel. Due to this higher cloud point, B100 is commonly stored in heated tanks for blending in winter. Blending biodiesel with diesel will therefore increase the cloud point of the blended fuel. Naturally, the higher the biodiesel blend level, the more the cloud point will be raised. The same applies to HDRD. However, commercially available HDRD generally has a much lower cloud point than biodiesel. As is the case with petroleum diesel fuel, the cloud point of a biodiesel blend should be adjusted to meet the recommended Canadian General Standards Board (CGSB) cloud point temperature. Low temperature cloud point fuels, such as kerosene or arctic diesel, must be considered depending on the base fuel properties to ensure the final fuel blend meets the requirements in cold conditions.

Precipitate formation above the cloud point is considered an important factor for the assessment of biodiesel blend suitability use in cold climates. Over time, insoluble materials can form and sediments can build up at the bottom of the fuel tank, from where the fuel is drawn. A fuel filter is normally present between the tank and the engine to prevent unwanted material from reaching the engine. These sediments can plug the fuel filter and may result in the engine not receiving any fuel and shutting down. For this reason, OEMs recommend fuel filter changes for their vehicles at pre-defined intervals. Reports of field issues with biodiesel blends in cold conditions in the United States and Europe underscore the need to better understand the phenomena associated with the formation of sediments. Standard-setting bodies are currently evaluating testing methodologies to identify potential problematic biodiesel blendstock characteristics to prevent their use in winter season blends.

2.1.2 Long-term Storage

All fuels have a limited shelf life. Long-term storage and storage with temperature variations lead to fuel oxidation, causing the fuel to degrade. Although biodiesel has been known to have a shorter shelf life than most petroleum diesels, fuel standards specify long-term stability requirements for both B100 and blended fuels to ensure all fuels have adequate long term performance.

2.1.3 Microbial Growth

Regardless of how well a fuel storage system is maintained, water will accumulate in the storage tank, forming a water bottom. As a general rule, wherever fuel and water come into contact in a fuel storage or distribution system, microbial contamination is likely to occur. For many of the species present in the water bottom, liquid hydrocarbon fuels represent an

[7] National Renewable Energy Laboratory, "Biodiesel Handling and Use Guide", Fourth Edition, Revised December 2009.

excellent nutrient source. As a result, microorganisms proliferate at the fuel/water interface, surviving in the water phase while feeding on the fuel. Microbial contamination is not specific to any one fuel type; marine, aviation, automotive and home heating fuels are all susceptible, although certain applications pose a higher risk for contamination. Similarly there is no single specific organism that can be identified as being responsible for degradation and spoilage. Possible problems that might arise as a result of microbial growth include increased filter plugging[8] and tank metal corrosion[9].

Concerns have been raised about the potential for greater microbial contamination with biodiesel blends because biodiesel attracts water more than petroleum diesel. Biocides have been recommended in certain reports as a remedy for both conventional fuels and renewable fuel blends wherever microbial growth has been problematic.

2.1.4 Engine Lube Oil Dilution

Engine lubrication is an important factor for engine reliability and durability. Maintaining lube oil quality is a key consideration when introducing changes in engine technology systems. Due to the severe operating load, speed and temperature of diesel engines, the introduction of unwanted substances into the lube oil system will gradually lower the lube oil quality resulting in harmful engine operation. At a minimum, oil dilution could impact the interval requirements for oil changes, the effectiveness of additive packages, sump capacity and performance of after-treatment systems. Therefore, it is always necessary to identify and analyze the possible sources of contamination and monitor them. Possible sources of contamination include unburnt fuel, carbon, water, acid, solid impurities, etc. Biodiesel has a higher flash point than petroleum diesel, which can lead to an increased level of unburnt fuel in the lube oil.

2.2 Main Findings

The findings below have incorporated information from demonstrations and research identified in Exhibits 1 and 2 to gather evidence regarding cold flow operability, sediment formation due to long-term storage, microbial growth and engine lube oil dilution. The most significant findings are summarized below.

2.2.1 Cold Flow Operability and Formation of Sediments

Several projects described in the literature have demonstrated that renewable diesel blends can be made to conform to the latest CGSB standards and cloud point schedules for a large variety of Canadian conditions. The Renewable Diesel Characterization Study (RDCS) carried out by Climate Change Central[10] and partners aimed to evaluate the feasibility of obtaining CGSB compliant renewable fuel blends, with primary emphasis on cold weather operability, and to provide more baseline information on renewable diesel blends compared to petroleum diesel. The analysis included blends of biodiesels from a variety of feedstocks and HDRD, with Ultra-Low Sulphur Diesel (ULSD) as the base fuel. However, not all biofuels or ULSD fuels available in Canada were investigated. All fuels were tested in their neat form as well as in renewable diesel fuel blends from 2 to 5%. The biodiesel blends were evaluated against the latest CGSB B1-5 specification. This study provided no 'rules of thumb' for changes in cold weather fuel characteristics attributable to the renewable diesel, ULSD, or kerosene, but rather

[8] Washington State Ferries, "Biodiesel Research & Demonstration Project", April 2009.
[9] Conservation of Clean Air and Water in Europe (CONCAWE), "Guidelines for Handling and Blending FAME", Report 9, November 2009.
[10] Climate Change Central, "Renewable Diesel Characterization Study", August 2008.

presented the actual results of tests conducted on available fuel samples. The study showed that a variety of renewable diesels, both methyl esters and HDRD fuels, made from a variety of feedstocks, can be blended with petroleum diesel components to produce CAN/CGSB-3.520 compliant fuels that meet all quality criteria including cloud points.

In addition to the RDCS study, data from several cold weather operability demonstration projects were used to inform this section. The Alberta Renewable Diesel Demonstration (ARDD) project[11] and the NRDDI Manitoba Hydro project[12] found that winter season operability was achieved by reducing the biodiesel content of the biodiesel blend in the seasonally adjusted petroleum diesel to B5 or B2 in various feedstocks, and by adding Ultra-Low Sulphur Kerosene (ULSK) to adjust the finished fuels' cloud point. The ARDD project found that in order to meet the CGSB cold operability specifications from December 2007 to March 2008, for a B2 canola methyl ester (CME) blend, additional ULSK was required. Less ULSK was found to be required for the 2% HDRD since the cloud point of this renewable diesel was significantly lower. In the NRDDI Manitoba Hydro study on B5 blend usage in gensets with outdoor fuel storage tanks in northern Manitoba, it was also demonstrated that kerosene can be used to achieve the CGSB cold operability specifications. Other NRDDI projects[13,14] used low cloud point ULSD, instead of ULSK, to achieve CGSB cloud point compliant biodiesel blends which worked well in cold weather.

Imperial Oil carried out a laboratory test program under the NRDDI[15] assessing low temperature storage stability of 57 biodiesel blends (primarily B5 and B20). Results showed that precipitates form in some of the fuel blends after ten days of storage at 2-4^{o}C above its cloud point. These precipitates were found to be enriched in saturated monoglycerides (SMGs), and the sediment did not easily re-dissolve. The results confirmed previous reports[16,17,18] in literature regarding the potential filter plugging impacts of SMGs formed above the cloud point during low temperature operations. The study led to the suggestion to use a modified filter blocking tendency (FBT) test as a means to evaluate the potential of this type of sediment formation. The project also concluded that additional work to improve the correlation between SMG and the FBT as well as a fundamental study of the kinetics of SMG precipitation and re-dissolution, including the impact of base fuel aromatic content, would be very valuable.

The NRDDI Manitoba Hydro Fleet project performed additional work on the subject and found that the correlation between SMG and FBT is not as strong as suggested in the Imperial Oil study, but that the modified FBT test is useful to monitor fuel quality for biodiesel blends. It also found that for the blends investigated in the project, any precipitate formed re-dissolved after one hour at room temperature.

[11] Alberta Renewable Diesel Demonstration, "Final Report", February 2009.
[12] Manitoba Hydro, "Demonstration of the Use of Biodiesel in Electric Generators in Remote Canadian Locations and Long Term Storage in Gensets", June 2010.
[13] Saskatchewan Research Council, "Off Road Biodiesel Demonstration Agricultural Sector", Interim Report, May 2010.
[14] Manitoba Hydro, "Long Term Storage and Use of Biodiesel in Fleets", June 2010.
[15] Imperial Oil, "Low Temperature Storage Test, Phase II - Identification of Problem Species", November 2009.
[16] M. Brewer, "Identification of Precipitate Found in Depot Storage Tanks Containing Swedish Klass1 B5 Fuels", International Congress on Biodiesel, Vienna, Austria, November 2007.
[17] R. Faucon, A.Gendron, and O. Cottalorda, "Diesel Fuel B7 Specifications Need to be Reinforced for Cold Weather Conditions", World Refining Fuels Conference, Brussels, May 2009.
[18] Charley Selvidge, Scott Blumenshine, Kurt Campbell, Cathy Dowell and Julie Stolis, "Effect of Biodiesel Impurities on Filterability and Phase Separation from Biodiesel and Biodiesel Blends", IASH 2007, the 10th International Conference on Stability, Handling and Use of Liquid Fuels, Tucson, AZ, October 5-11, 2007.

In the NRDDI Royal Military College (RMC) project, particle formation kinetics for B100 CME and tallow methyl ester (TME) as well as their B20 and B5 blends were studied[19] following a cold soak at 3°C above the fuel blends' cloud point. Gas chromatography performed on the particulate collected showed that they contained SMG, glycerol and biodiesel. The project found that the interaction between the biodiesel and the diesel is a contributor to the formation of these sediments. The project also found that agitation can significantly improve re-dissolution of precipitates formed above the cloud point.

Results from the NRDDI Imperial Oil project, in particular, has led CGSB to investigate a new test method, based on the FBT with a pre cold-soak, to evaluate biodiesel suitability for cold weather operability. The Imperial Oil and Manitoba Hydro Fleet projects showed that base diesel aromaticity affects solubility of biodiesel trace components such as SMG.

A recent issue in Minnesota[20] regarding fuel filter plugging in cold weather resulted in the temporary suspension of the B5 mandate for No. 1 (Type A in Canada) ULSD from January 15, 2010 through March 31, 2010. The B5 mandate remains in effect for No. 2 ULSD (Type B in Canada). Prior to increasing the state mandate to the 5% level, 2% biodiesel blends were successfully used in both No. 1 and No. 2 diesel all year round. The temporary waiver was in response to a request by the Minnesota Biodiesel Council after some rare incidences of filter clogging were observed with fuel containing 5% biodiesel and 95% No. 1 ULSD. These incidences occurred during a cold temperature spell in the Great Lakes region, only in tank dispensing filters and with this particular fuel blend. The fuel met the appropriate standards at the time of the incident and the filter plugging precipitates formed at temperatures significantly higher (~ -28°C) than the cloud point of the fuel blend (~ -38°C). The precipitate formation is suspected to be linked to the level of aromaticity of the petroleum diesel fuel, due to aromaticity being a main difference between No. 1 and 2 ULSD. Work is ongoing to determine the cause, however, it does not seem to be linked to the sediment formation described above and the issue does not appear to be feedstock specific. Conclusions from laboratory work currently being undertaken in Minnesota to identity the possible causes of the filter plugging is pending.

2.2.2 Long-term Storage

Results from NRDDI studies indicate that low-level biodiesel blends could still meet current fuel standards' specifications after several months of storage.

The Prairie Agricultural Machinery Institute (PAMI) conducted a biodiesel demonstration involving farmers in Manitoba in 2008[21]. Soy methyl ester (SME) blends were used in harvest equipment for the 2008 farming season with fuel left in the equipment over the non-harvesting season (about nine months). Under the NRDDI, low-level biodiesel blends from three combines were analyzed after this storage period. All samples met the current CGSB biodiesel specifications for B1-5 blends. More detailed analysis was performed on all samples to further evaluate their quality and no concerns were raised. PAMI also investigated un-additized CME blends of B5, B10 and B20, which had been stored for approximately two years in outdoor above-ground storage tanks. These fuels also met applicable standards. These results suggest that storing biodiesel blends for periods of up to two years, under real world conditions, does not necessarily adversely impact the quality of the biodiesel to the point where it fails to meet fuel specifications.

[19] The Royal Military College of Canada, "Particles Formation Kinetics in Biodiesel and Petrodiesel Blends above the Cloud Point", May 2010.
[20] Natural Resources Canada's Communication with MEG Group Fuel Consultant, May 2010.
[21] Prairie Agricultural Machinery Institute, "Effects of Long Term Storage on Biodiesel Quality", March 2010

The NRDDI Imperial Oil thermal/oxidative storage stability test program[22] investigated the oxidative stability of 54 biodiesel blends (primarily B5 and B20) with and without an antioxidant additive during 12-weeks of accelerated storage, simulating 12 months of storage at 17°C, without temperature variations, according to ASTM test method D-4625. Oxidative stability was assessed before and after the storage term, and total insolubles and FBT were assessed after the storage term. The study showed that the use of antioxidant additives improved the long-term storage stability as measured by the test methods. The results confirm that antioxidants can be used to ensure adequate long-term storage stability of biodiesel fuels. The research[23,24] also indicates that limiting the level of sediments in biodiesel is important for low-temperature storage and operating furnaces as well as motor vehicles.

The NRDDI Manitoba Hydro Genset project also investigated storage stability by accelerated testing, using the same methodology as the Imperial Oil thermal/oxidative storage stability test program and also concluded that one year of biodiesel blend storage could be achieved. This project also examined the real world effects of long-term cold temperature biodiesel storage. Phase one of the demonstration project was conducted prior to the NRDDI. SME B5 blends made in January 2008 were shipped to Brochet, Manitoba in February via ice roads and stored in outside storage tanks from February 2008 to November 2009. Phase two of the project was conducted at the same location from November 2009 to May 2010, using a CME B5 blend made in November 2009. The fuel quality was monitored throughout the project for potential degradation and the B5 blends remained suitable for use following long-term storage over the course of the project. This project did not identify any operability issues or additional maintenance requirements for operation on B5 blends.

2.2.3 Microbial Growth

Biodiesel testing in marine applications has demonstrated that severe microbial growth can occur using B20 in these applications. For example, during the Washington State Ferries biodiesel project[25], excess sludge formed in the fuel purifier of one of the three vessels operating after one month with a B20 blend. Researchers found active bacteria present in the sludge samples from the purifier, and bacteria was found to play a key role in the sludge formation that resulted in filter clogging. Discussions with operators uncovered that sludge formation from microbial growth has been encountered with conventional diesel fuel also. The excessive sludge problem was solved by the application of biocide in the fuel during the studied period.

British Columbia (BC) Ferries launched a marine biodiesel demonstration project in September 2009 running B5 CME blends in their Queen Alberni vessel for six weeks. Since no problems were encountered, the demonstration project was expanded and currently most of their vessels are running on B5. Closer monitoring of water levels and fuel handling practices has been a focus, but overall, operators have hardly noticed any difference from operation with diesel fuel. It was reported that to date[26] none of the fleet running on B5 has experienced problems with the solvent effect of biodiesel or increased microbial growth.

[22] Imperial Oil, "Thermal/Oxidative Storage Stability of Bio-diesel Fuels", November 2009
[23] Imperial Oil, "Low Temperature Storage Test, Phase II - Identification of Problem Species", November 2009
[24] Important Research Provides Assurances for Bio Heating and Transportation Fuels, January 2010 Press Release, Canadian Petroleum Products Institute.
<http://www.cppi.ca/userfiles/file/CPPI_IOL_NRCan_Biodieselresearch%20_Eng.pdf>
[25] Washington State Ferries, "Biodiesel Research & Demonstration Project", April 2009.
[26] Natural Resources Canada's Communications with BC Ferries, April 2010.

2.2.4 Engine Lube Oil Dilution

A National Renewable Energy Laboratory (NREL) study[27] investigating B20 blends in engines with advanced after-treatment systems showed that there were "no obvious biodiesel specific effects on used lube oil properties, and most changes appeared to be consistent with normal lube oil aging", even though some biodiesel oil dilution was detected.

The NRDDI FPInnovations project[28] included a minor engine lube oil dilution testing component. Selected forestry equipment, running on B5 blends, were monitored for lube oil deterioration through engine oil sampling and testing. The protocol involved sampling engine oil several months prior to the use of biodiesel blends (during routine oil change), halfway through the service life of the oil, and once again at the time of the next oil change. Wear metals (from engine part friction or oxidization) and oil condition were tracked before and after the use of biodiesel blends. The results indicated that all oil samples were still fit for service, with no significant differences between engines running on ULSD and B5, even after a few unintentional extended oil drain intervals of 450 to 600 hours in a few instances. Based on these results, it was shown that B5 and lower blend ratios are perfectly acceptable with regular oil services every 300 hours.

2.3 Analysis

Several projects have shown that renewable diesel blends can be made to conform to the latest industry accepted standards under a variety of Canadian conditions.

Care must be taken with regard to managing the cloud point of all fuels and fuel blends. Fuel blendstock components need to be chosen and adjusted to meet the CGSB recommended temperature specifications for the season and region of use.

As such, in cases where the fuel distribution chain involves more than just the main fuel supplier, it is essential to ensure that key information on properties of the base diesel fuel is considered. The dealer may not always have full access to information regarding the properties of their diesel fuel supply, and may rely on its supplier to ensure that the fuel received meets the required specifications. Depending on the point of blending, independent dealers may need to become better informed about certain biodiesel and base diesel fuel properties.

NRDDI studies have shown that the use of commercially available additives can improve the long-term storage oxidative stability of the fuel, but are not always necessary to achieve adequate storage stability. Additive suppliers should be consulted to evaluate the additives needed and to establish dosage rates that are appropriate for the application.

Work is on-going to improve the understanding of sediment formation during storage of renewable diesel blends, including the base fuel interaction and impact of aromatic content. Investigations of precipitate formation above the cloud point, through a more comprehensive understanding of the scientific basis, are being conducted by standards-setting bodies with the aim of assessing what type of new specifications will be needed in renewable diesel blend standards.

[27] National Renewable Energy Laboratory, "Impacts of Biodiesel Fuel Blends Oil Dilution on Light-Duty Diesel Engine Operation", presented at the 2009 SAE International Powertrains, Fuels, and Lubricants Meeting, June 2009.
[28] FPInnovations, "Demonstration of the Potential Use of Biodiesel for Off-Road Machinery in Canadian Highway Construction and Forest Operations", June 2010.

The nature of the Minnesota incident (described in section 2.2.1) is being actively investigated by the authorities and is being monitored in Canada to avoid similar occurrences. The diesel aromatic level and use of Type A versus Type B USLD in the Canadian diesel pool is also an important consideration pertaining to this issue.

Controlling free water levels can help prevent incidences of microbial growth. The use of biocides can mitigate problems with microbial growth should they arise, and is a practice that has been around for some time.

For low-level biodiesel blends, no obvious biodiesel specific effects on lube oil properties are expected.

Finally, fuel supply is an ever-evolving field. As fuel sources are increasingly diversified, there is a need for continuous evolution of fuel standards to address new and emerging issues. All stakeholders, including fuel suppliers, users and regulators, have a role to play in ensuring the fuels being sold in Canada are fit for purpose.

Currently in Canada, there is one approved renewable diesel standard: CGSB standard for 1 to 5% biodiesel blends[29]. This standard relies on the requirements described in the ASTM[30] or CEN[31] B100 standards for the biodiesel blendstock used to create the low-level blend. There is ongoing work at CGSB to develop a Canadian B100 blendstock standard as well as one for 6% to 20% biodiesel blends. An updated CGSB heating oil standard[32], allowing for up to 5% biodiesel, is expected to be published next year.

Although there are no current standard development projects in North America for HDRD (or other emerging diesel fuel replacements), the European Committee for Standardization has released a Workshop Agreement that specifies requirements and test methods for marketed and delivered paraffinic diesel fuel, such as HDRD, from synthesis or hydrotreatment processes for use in diesel engines. The document describes the quality for use as automotive fuel at 100% concentration. This “pre-standard” can be used on a voluntary basis for engine clearance, fuel acceptance and fuelling station allowance, supporting both local regulations and international trade. In the longer term, further work in this area, including the move toward a more formal standard, will depend on whether paraffinic diesel becomes widely available as a general automotive fuel. Therefore there may potentially be the need for modifications to the CGSB diesel standards to allow for the use of this product as a blendstock.

[29] Canadian General Standards Board, “CAN/CGSB-3.520; Automotive (On-road) Diesel Fuel Containing Low Levels of Biodiesel Esters (B1-B5)”, 2005
[30] American Society for Testing and Materials (ASTM), “ASTM D6751: Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels”, 2009.
[31] European Committee for Standardization, “EN 14214: Automotive Fuels – Fatty acid methyl esters (FAME) for diesel engines – requirements and test methods”, November 2008.
[32] Canadian General Standards Board, “CAN/CGSB-3.2: Heating Fuel Oil”, 2007

3 Technology/End-User Application Readiness

For the purposes of this report, technology/end-user application readiness means that methods to mitigate any negative impacts on engines and equipment related to renewable diesel use in Canada are identified. An assessment to confirm technology/end-user application readiness includes identified potential negative impacts, the end-users and locations where these impacts occur and the magnitude or severity of these impacts. Note that the mitigation measures will address the action taken to overcome the negative impact, the end-user responsible for implementing the measures and the anticipated duration of each measure. Where available, the associated costs for each measure will be noted. Note: it may not be possible in all cases to identify and apply mitigation measures.

3.1 Key Factors

The end-user is the last link in the renewable diesel supply chain and technology/end-user application readiness looks at their ability to use a renewable diesel blended fuel in their conventional diesel operations. A literature review and discussion with stakeholders identified the following factors which were raised as areas of concern where the properties of biodiesel could have an effect on the ability of the user to seamlessly use renewable diesel blended fuel in their operations:

- End-user Operability
- Solvent Effect
- Materials Compatibility
- Effect on Diesel Exhaust After-Treatment Equipment

3.1.1 End-User Operability

End-user operability is difficult to precisely define as it can have a different meaning for each end-user depending on many factors, including the user's familiarity with renewable diesel. Generally, it could be expected that end-users would anticipate a B2 to B5 blend to have performance characteristics comparable to petroleum diesel. End-user operability is generally related to overall performance and loss of service. Some operability challenges, which users might experience, could be fuel gelling and filter plugging leading to vehicles stalling or not starting.

3.1.2 Solvent (or Cleansing) Effect

With continued use of petroleum diesel, certain materials can accumulate and form deposits which permanently stick to the bottom of storage and vehicle fuel tanks. Biodiesel has a solvent effect[33] that will re-dissolve the deposits into the fuel blends and can carry them into the filter. The use of biodiesel blends in vehicles and storage tanks that have previously used only petroleum diesel can lead to the requirement for a "cleansing period" where more frequent filter changes will be required. The extent of this requirement will depend on the length of time the diesel deposits have had to form, as well as on the level of biodiesel blend.

3.1.3 Materials Compatibility

B100 is not compatible with some metals, plastics and rubbers. It may soften and degrade certain types of rubber compounds used for hoses and gaskets (buna-N, nitrile, natural rubber)

[33] Assessment of the Biodiesel Distribution Infrastructure in Canada, 2007.

and may cause them to leak. B100 will degrade and form high sediment levels if in contact for long periods with copper or copper-containing metals (brass, bronze) or with lead, tin or zinc (galvanized surfaces). These high sediment levels may clog filters. B100 may also permeate some common plastics (polyethylene, polypropylene) over time.[34]

Potential issues with the use of biodiesel in furnace equipment have been described to be: altered injection systems and nozzles due to material incompatibility, different flame luminosity leading to the incapacity of sensors to detect the flame, and increased stack temperature.

The impact of biodiesel's incompatibility with certain materials decreases with decreasing blend levels.

3.1.4 Effects on Diesel Exhaust After-Treatment Equipment

There could be interactions between the products of biodiesel combustion and the diesel exhaust after-treatment systems installed in 2010 model-year on-road vehicles to meet more stringent requirements for reduced tailpipe emissions. Traces of inorganic compounds contained in biodiesel may have a potentially negative impact on after-treatment devices, decreasing their efficiency and lifetime. The quantitative impact of biodiesel on these devices has yet to be fully determined, but as ASTM on-road diesel standards allow up to 5% biodiesel in regular diesel, it is expected that engine manufacturers will remain on top of this issue to ensure their products perform satisfactorily with the fuels available on the market. The NRDDI is relying on work accomplished by NREL to determine the key considerations with regard to this issue.

3.2 Main Findings

Numerous projects have been carried out in Canada and the United States to evaluate renewable diesel in specific applications of which several are listed in Exhibit 2. In addition, NRDDI worked with numerous end-users to demonstrate and evaluate renewable diesel blends in their Canadian operations (see Exhibit 1). The key findings are divided into the following end-user categories and presented below:

- On-road: trucking and industrial fleets, urban transit
- Off-road: construction, agriculture, marine, rail/locomotive, forestry, mining
- Stationary: space-heating furnaces, gensets

[34] National Renewable Energy Laboratory, "Biodiesel Handling and Use Guide" Fourth Edition, December 2008

3.2.1 *On-Road: Trucking and Industrial Fleets*

Alberta Renewable Diesel Demonstration[35]

Application/Conditions	Results
▪ 59 vehicles (trucking and bus fleets) used FAME and HDRD ▪ 16 control vehicles running on ULSD ▪ B2 in winter and B5 in shoulder/summer seasons ▪ All fuels were acquired and maintained to meet quality specifications ▪ Model-years 2002 - 2008 ▪ Lowest temperature tested was -33 °C versus -44 °C originally expected	▪ Confirmed operability of 2% renewable diesel/ULSD blends in winter in regards to vehicle performance under the conditions tested ▪ No meaningful difference in fuel economy among biodiesel blends, HDRD blends and diesel fuel

British Columbia (BC) Trucking Association[36]

Application/Conditions	Results
▪ A 2009 survey ▪ Out of 29 valid responses, a total of 21 companies used biodiesel in 1,762 vehicles ▪ B5 used in 1,054 vehicles ▪ B20 or higher in 680 vehicles ▪ Blend unreported for eight vehicles	▪ 13 fleets (62 %) experienced some type of operability issues. ▪ The most commonly reported problem was fuel filter plugging. Of the companies that reported fuel filter plugging, one used B5, two used B20, two used B20+, and one was unsure of the blend level. ▪ One company that reported other operability problems (fuel injectors) used B20. ▪ Companies that reported fuel gelling (n=3) were all using B20 in winter. One indicated fuel gelling occurred at -5°C (wind chill -18°C). This company, as well as another that reported gelling, primarily operated on biodiesel in the South region. The third primarily operated on biodiesel in Northern BC.

[35] Alberta Renewable Diesel Demonstration, Final Report, February 2009.
[36] BC Trucking Association, "Biodiesel Operability Survey", 2009.

	▪ One company indicated that the issue could not be resolved and that use of B20 had to be discontinued during the winter (switched to B5).

NRDDI - Manitoba Hydro Project: Fleets[37]

Application/Conditions	Results
▪ Manitoba Hydro has been running biodiesel at one of its fleet sites in Winnipeg since the fall of 2006. ▪ The Manitoba Hydro fleets used B20 in the summer, B10 in the fall, B5 in the winter, and B15 late spring/summer. ▪ Vehicles parked in partially heated garage.	▪ There have been no recorded operational or dispenser plugging issues as a result of biodiesel use. ▪ This applies to both the period of the NRDDI project from August 2009 to April 2010 and the prior two years of biodiesel use.

3.2.2 On-Road: Urban Transit

BioBus - Montreal Project [38]

Application/Conditions	Results
▪ Bus operability tests used B5 and B20 biodiesel blends ▪ 155 buses ▪ Overnight temperatures dropped to -20°C to -30°C during three cold spells ▪ Vehicles were either parked indoors at night or were kept idling when outside for long periods of time. Therefore, the fuel remained relatively warm.	▪ No incident compromising continuity of service was experienced. ▪ No bus-related mechanical problems, notably to the fuel injection system, nor any degradation of elastomer components in contact with the fuel. ▪ No variation in fuel consumption can be substantiated from the data. ▪ The cleansing period was longer than foreseen for buses with the finest (10-µm) filters, longer still because B5 was used for three months before cutting over to B20. ▪ Sporadic filter plugging incidents occurred that were caused by the finest (10-µm) filters located farthest

[37] Manitoba Hydro "Long Term Storage and Use of Biodiesel in Fleets", Final Report, June 2010.
[38] BioBus – Montreal, "Biodiesel Demonstration and Assessment with the Société de Transport du Montréal (STM), Final Report , May 2003

	from sources of heat in the engine compartment of buses. The project report concluded that these incidents had no real impact on operability and resulted in no significant unforeseen costs. ▪ It was discovered that temperature increases in the fuel system, due to fuel recirculation, made it possible to use a fuel with a cloud point higher than the ambient temperature. The tendency for fuel to be heated to up to 30°C above the ambient temperature (including in buses with electronic fuel injection) was confirmed by sampling tank temperatures for the various types of buses on a cold March 2002 morning following an overnight low of -20°C.

BioBus - Saskatoon Project[39]

Application/Conditions	Results
▪ Two older 6V-92 and two newer D-50 powered buses were selected for city route testing over a two-year period (model years were not reported). ▪ Fuels were alternated between B5 and seasonal low sulphur diesel. ▪ Controlled highway tests were performed on a fifth bus in summer to measure fuel economy and wear in highway driving, using petroleum fuel, as well as B0.1, B2 and B5. ▪ Tested to –44°C	▪ The addition of the CME improved lubricity by decreasing wear areas and coefficients of friction for all seasons. The lubricity of the B5 had a good influence on engine wear rates and fuel economy with 7.8% to 23.4% lower engine wear and 2.7% to 4.3% better fuel economy in city driving with the same intact engines. ▪ Ferrographic, magnetic and oil filter analysis of larger wear particles indicated only small differences between the various fuels tested. ▪ The fuel injectors remained clean for all fuels and no fuel related problems were encountered. ▪ The application of B5 conserved the acid neutralization capability of the used motor oil as indicated by its higher Total Base Numbers. ▪ The oil viscosity remained acceptable whether or not biodiesel was being burned.

[39] Bio-Bus Saskatoon Phase II, “Final Research Report”, March 2006

3.2.3 *Off-Road: Construction*

NRDDI - FPInnovations Project: Construction[40]

Application/Conditions	Results
▪ Equipment worked 8 hours/ day ▪ B10 – this location experiences milder temperatures year-round ▪ Fuel quality was demonstrated to have been maintained	▪ The 13,000 hours of operation were reported to be problem free. ▪ In-tank blending was found to have significant variability in the blend ratio, and while this did not adversely impact operations, it is an area of concern. ▪ This study provides evidence that biodiesel blends in the B2 to B10 blend ratio can be used with little to no preparation on the part of the end-user in the highway construction sector. ▪ No changes to current fuelling practices with regard to delivery and short-term storage were needed, including remote locations and areas. ▪ Equipment that is well maintained with oil and fuel filters replaced at the OEM specified interval should encounter no issues.

3.2.4 *Off-Road: Agriculture*

NRDDI - Saskatchewan Research Council Project[41]

Application/Conditions	Results
▪ B3 (winter) and B10 (fall/ spring) CME blends were tested ▪ August 2009 to May 2010 ▪ Fuel in half the farming equipment that was stored over winter had stability enhancers added to see how the fuel degraded under each	▪ Producers indicated (via conversations and survey) that no equipment operational problems were experienced in the project and no changes with respect to operating on diesel were noted. ▪ The adoption of low-level blends into this demonstration did not require changes on the part of agricultural producers in relation to on-farm bulk fuel storage practices. ▪ During winter off-season storage of equipment, no

[40] FPInnovations, "Demonstration of the Potential Use of Biodiesel for Off-Road Machinery in Canadian Highway Construction and Forest Operations". Final Report, June 2010.
[41] Saskatchewan Research Council, "Off Road Biodiesel Demonstration Agricultural Sector", Interim report, May 2010.

scenario; error resulted in 20 times the amount of additives being added to the B5 ▪ Tanks not cleaned or prepared for biodiesel blends ▪ Unheated sheds for equipment; unsheltered and unheated fuel storage tanks over all seasons ▪ Farm equipment; 12,000 litres of biodiesel. ▪ This demo did not make any changes to producer practices related to bulk tank storage throughout the monitoring period. ▪ Fuel quality was demonstrated to have been maintained.	substantive benefits were identified related to filling equipment fuel tanks to minimize fuel contact with air during storage. ▪ Although oxidative stability enhancers demonstrated improvements to the stability of the CME blended fuel used in this demonstration, the quality of non-treated fuel in farm equipment remained sufficient over the winter storage period.

3.2.5 Off-Road: Marine

BC Ferries Project[42]

Application/Conditions	Results
▪ In September 2009, BC Ferries ran B5 in their Queen Alberni vessel for six weeks. ▪ No biocides were used in the project. ▪ Water accumulation in the storage tanks was monitored. ▪ Fuel samples were taken and checked for microbes and water content. There was no microbe count in the fuel samples.	▪ Where a substantial amount of free water was found in the fuel samples, some vessels decided to more frequently drain watery fuel from the tanks as a preventative measure; others did not change their usual practices. ▪ The fleet has not experienced problems with the solvent effect of biodiesel or increased microbial growth.

[42] Natural Resources Canada, Meeting minutes from discussion with BC Ferries, April 2010.

Note: As of April 2010, 31 out of 36 ferries are using B5. BC Ferries worked with its fuel supplier for over a year before implementing the new product in order to ensure that the safety and reliability of the vessels would not be compromised.[43]

BioMer Montreal Project[44]

Application/Conditions	Results
▪ Examined the use of B100 as a petrodiesel replacement; evaluated its' economic viability and advantages; and measured various environmental aspects ▪ Primarily cooking oil-based B100, but also B5, B10 and B20 blends ▪ 12 tourist cruise boats ▪ May to October 2004	▪ Minor operational incidents due to filter plugging problems that were deemed predictable. ▪ Engine performance was not diminished; however, a 3% increase in fuel consumption was noted for B100.

Washington State Ferries Biodiesel Project[45]

Application/Conditions	Results
▪ B5 and B20 blends in three marine vessels in the Pacific Northwest area of the United States	▪ Occasional incidents where ferry engineers reported that there were elevated levels of sludge found in the fuel purifiers. Excessive microbial growth was suspected to have caused the problem. ▪ Biocides were used effectively to mitigate the problem.

[43] BC Ferries Press Release, April 21, 2010.
[44] BioMer, "Biodiesel Demonstration and Assessment for Tour Boats in the Old Port of Montreal and Lachine Canal National Historic Site", Final Report, May 2005.
[45] Washington State Ferry Biodiesel Research & Demonstration Project, Final Report, April 2009

3.2.6 *Off-Road: Rail/Locomotives*

NRDDI - Canadian Pacific Railways Project[46]

Application/Conditions	Results
▪ Five-month test cycle (November 2009-March 2010) ▪ B5 (SME and ULSD) ▪ Between Calgary and Edmonton ▪ Four GE AC4400CW diesel-electric locomotives with FDL-16 engines on a continuous basis ▪ Lowest temperature: -40°C ▪ The company conducted detailed mechanical examinations of the locomotives before and after the tests. ▪ Locomotives were fuelled directly from the fuel delivery vehicle which is the standard practice. (There was no intermediate storage.)	▪ No operability issues were encountered and no loss-of-service events were noted. ▪ Engine inspections demonstrated no negative mechanical effects from the use of B5 ▪ Successfully demonstrated the viability of B5 use in cold weather freight service

3.2.7 *Off –Road: Forestry*

NRDDI - FPInnovations Project: Forestry[47]

Application/Conditions	Results
▪ Three sites: a sawmill in Prince George and a logging site in Merritt, BC; and a logging site in Saint-Ludger-de-Milot, Quebec ▪ Six months at Prince George; three	▪ Machine operators could tell no difference in machine power and were positive on the project as a whole. The monitoring devices also showed the ratio of motion time to engine runtime, also referred to as utilization ratio, and from

[46] Canadian Pacific Railway, "Biodiesel Demonstration Final Report", June 2010
[47] FPInnovations, "Demonstration of the Potential Use of Biodiesel for Off-Road Machinery in Canadian Highway Construction and Forest Operations". Final Report, June 2010.

weeks at Saint-Ludger-de-Milot and two weeks at Merritt. ▪ 45 machines ▪ Tested in environments as cold as -31.4°C; temperatures below -20°C for three to four days on three occasions ▪ At Prince George most of the machinery was stored in a heated garage when not operating. ▪ Sawmill machine shifts ranged from 10 to 17 hours, and the logging sites worked 11 hours/day at Merritt and 20 hours/day at Saint-Ludger-de-Milot. Monthly machine hours at the sawmill ranged as high as 350 hours for one machine to a low of 8 hours for machines that are used on a backup basis. ▪ Preventative measures prior to biodiesel use were employed at only one site (tank cleaning and the installation of a vent-dryer as well as a filter on the dispensing pump). In other situations, where smaller storage tanks were used, only standard filters were fitted to the dispensing pumps, and at one site no filters were fitted to the dispensing pumps.	this data, it was readily apparent that productivity of machinery running biodiesel was the same as machinery running ULSD. ▪ Blends in the B2 to B5 range can be used with little to no preparation on the part of the end-user forest operation sector.

3.2.8 *Off-Road: Mining*

Evaluation of Biodiesel Fuel and Oxidation Catalyst in an Underground Metal Mine[48]

Application/Conditions	Results
▪ A multilateral study in an Ontario mine in 1997 ▪ Evaluated the potential to reduce diesel particulate matter and other diesel exhaust emissions by using biodiesel.	▪ All of the polluting species including particulate matter were at lower or equal levels compared to the same equipment operating with seasonal diesel.

[48] University of Minnesota, NIOSH, CANMET, ORTECH, Michigan Technological University and Inco, "Evaluation of Biodiesel Fuel and Oxidation Catalyst in an Underground Metal Mine", September 1998.

- The blend consisted of 58% (by mass) SME biodiesel and a low sulphur seasonal diesel.

3.2.9 *Stationary: Space-Heating Furnaces*

NRDDI - Imperial Oil Project: Bio Furnace Fuel Test[49]

Application/Conditions	Results
▪ Aimed to evaluate the long term performance of late-model furnaces using bio-furnace fuel. ▪ Blends of B5, B10 and B20 were tested in three identical late-model high efficiency furnaces for periods of 3x40 day cycles to simulate spring/fall, moderate severity and winter cold snap operations. ▪ As there is currently no Canadian standard in place for bio-furnace fuel oil, fuel was tested against the Heating Fuel Oil Standard CAN/CGSM-3.2. All bio-furnace fuels used in the tests met this standard. ▪ Furnace operation and performance were evaluated by weekly monitoring of furnace operating parameters as well as a furnace system inspection after each 40-day test cycle. ▪ Inspections of the furnace system after each test cycle included inspections of the filters, burners, pumps, burner nozzles and heat exchangers. Furnace inspection and tuning and maintenance were performed by an independent, qualified furnace technician who was unaware of the fuel compositions being tested.	▪ Negligible impact on furnace operation and performance with furnace fuel up to B10. ▪ Bio-furnace fuel should not exceed B10 in order to be compatible with existing seals in the fuel pump. ▪ Deposits were observed in the drain lines of two of the three fuel tanks after the test carried out over the coldest period; however this did not affect the performance and operability as defined by the evaluation criteria.

[49] Imperial Oil, "Bio Furnace Fuel Test", Final Report, November 2009

3.2.10 *Stationary: Gensets*

NRDDI - Manitoba Hydro Project: Gensets[50]

Application/Conditions	Result
▪ B5 in gensets for power generation ▪ Remote northern Canadian location where fuel is delivered on ice-roads in January and must remain fit-for-purpose until the next January. ▪ Before entering the gensets, the fuel stored outside of the powerhouse was pumped into two indoor parallel 750L tanks, where the diesel was warmed up for 12 to 18 hours, depending on the load demand. In this particular case, the normal diesel fuel is handled in the same manner.	▪ Operated without any issues, without requiring additional maintenance.

3.3 Analysis

3.3.1 *End-User Operability*

On-Road Sector

No additional on-road demonstrations were carried out under NRDDI, as industry stakeholders had just completed the ARDD and saw no further need for another real-world demonstration in advance of the intended regulation. The ARDD confirmed operability of B2 in winter and B5 in shoulder/summer seasons under the conditions tested, without any significant loss-of-service incidents.

The vast majority of documented engine impacts and operability problems reported have been related to B20 and above. In general, the most notable outcome was occasional filter plugging.

Most on-road stakeholders confirm that blends of up to B5 should not cause major issues. The certainty with which this statement can be made increases for newer truck models and decreases for older ones. A tentative definition of "newer" as it relates to biodiesel use would appear to be model year 2002 and newer.[51]

[50] Manitoba Hydro, "Demonstration of the Use of Biodiesel in Electric Generators in Remote Canadian Locations and Long Term Storage in Gensets", Final Report, June 2010
[51] British Columbia Trucking Association, "Biodiesel Operability" 2009

Off-Road Sector

During the NRDDI demonstrations projects, operation on B5 was not shown to cause any significant loss-of-service incidents. Vehicle age varied from model years 1967 to 2010. Most of the vehicles were of model year 1994 or newer.

Measures were taken to account for the unique properties of biodiesel. These included tank cleaning, fuelling directly to the vehicle (no storage of the fuel), ensuring the cloud point of the diesel fuel was appropriate for the location/temperature, and parking the vehicles indoors.

Stationary

Results indicated negligible impact on furnace operation and performance with fuel up to B10.

The use of B5 in gensets for power generation in remote northern Canadian locations has been demonstrated in both warm and cold seasons without any issues or requiring additional maintenance.[52]

Fuel Economy

Although not an aspect of technical feasibility, many projects reported on fuel consumption with varying results. As the blend level is lowered, differences in energy content become proportionally less significant; blends of B5 or lower cause no easily noticeable differences in fuel consumption in comparison to Type B diesel.[53]

3.3.2 Solvent Effect

The biodiesel solvent or cleansing effect is most often manifested in plugged filters and generally B100 exhibits the most pronounced effects.

The early stage of switching from petroleum diesel to biodiesel blends has been demonstrated to be the most vital phase during which filter plugging related to the biodiesel solvent effect can occur. The risk and time of onset of filter clogging increases with biodiesel blend, and naturally depends on time allowed for build-up of deposits during petroleum diesel usage. Incidents were deemed as predictable and not having an impact on operations or leading to significant costs, except new filters and the related labour costs.

In its research, NREL found the cleansing effect should not be an issue with B5 and lower blends. Most users did not clean their tanks before B20 use, although it is still wise to keep some extra filters on hand and monitor potential filter clogging a little more closely. The cleansing effect of biodiesel at a B20 level is sufficiently diluted that most problems are insignificant, but the fuel filter could plug quickly when the fuel is first used.

As this is a known and predictable problem, the risk of filter plugging can be mitigated by providing adequate training, more frequent filter changes, and the availability of sufficient filter supplies.

[52] Manitoba Hydro, "Demonstration of the Use of Biodiesel in Electric Generators in Remote Canadian Locations and Long Term Storage in Gensets", Final Report, June 2010.
[53] National Renewable Energy Laboratory, "Biodiesel Handling and Use Guide" Fourth Edition, December 2008.

3.3.3 Materials Compatibility

The propensity for biodiesel to degrade certain materials is most pronounced for B100. This tendency has been found to decrease as the blend level decreases. Issues regarding higher-level blends are more likely to arise for storage, transportation and dispensing equipment for B100 prior to final blending to B5 (or lower).

An increasing number of OEMs are endorsing use of up to B5 in their equipment. As such, NRDDI projects did not generally examine long term effects, like wear, materials compatibility or longevity and did not find any issues which could be specifically attributed to it. However, the NRDDI Imperial Oil study suggests, in space-heating furnace applications, biofuel should not exceed B10 in order to be compatible with existing seals in fuel pumps for late-model equipment. In the case of NRDDI CP Rail's locomotive demonstration, engine inspections demonstrated no negative mechanical effects from the use of B5.

In the BioBus Montreal project, biodiesel caused neither bus-related mechanical problems, notably to the fuel injection system, nor any degradation of elastomer components in contact with the fuel. In the BioBus Saskatoon project, ferrographic, magnetic and oil filter analysis of larger wear particles indicated only small differences between the various fuels tested. The fuel injectors remained clean for all fuels and no fuel related problems were encountered, even at –44°C.

NREL has found there have been no significant material compatibility issues with B20 (unless the B20 has been oxidized). NREL found B20 or lower blends minimize most issues associated with materials compatibility. This conclusion provides even more confidence in the minimal effects which can be expected with B5.

Like the solvent effect, materials compatibility is a known and predictable issue with biodiesel. Effects can be mitigated by replacing incompatible materials exposed to higher-level blends.

3.3.4 Effect on Diesel Exhaust After-Treatment Equipment

The evaluation of engine exhaust emissions requires specialized equipment and testing procedures. NREL is conducting extensive work on biodiesel's impact on: the performance of selective catalytic reduction systems; emissions and durability of light and heavy duty vehicles operating with advance emission controls; and after-treatment durability. This work has focused on B20 blends and recommended practices arising from this work will provide further guidance for use of B5 blends in Canada. Therefore, special measures may not be needed for blends of B5 and lower.

In any case, the Engine Manufacturers' Association (EMA) has stated "an average annual 2% renewable content in diesel fuel is technically feasible for existing heavy-duty engines and anticipated 2010 heavy-duty engines in Canada" (see Market Acceptance for the full statement). As ASTM on-road diesel standards allow up to 5% biodiesel in regular diesel, it is expected that engine manufacturers will remain on top of this issue to ensure their products perform satisfactorily with the fuels available on the market.

Given NREL's work and the EMA statement, the examination of effects of biodiesel on exhaust after-treatment systems was not an element of the NRDDI projects.

4 Infrastructure Readiness

For the purposes of this report, infrastructure readiness means that the fuel handling industry (refiners, distributors and retailers) has demonstrated a capacity to install the needed infrastructure to store and blend biodiesel, and distribute and retail the blended fuel. An analysis to demonstrate infrastructure readiness would include a determination of the state of readiness for primary suppliers (petroleum fuel producers and importers) and other affected stakeholders assuming they would have to comply with a 2011 implementation date. The assessment will also consider how the primary suppliers would plan to comply at different time intervals (during 2011 and beyond). In addition, the analysis will assess options based on possible blending schedules. All analyses will consider existing provincial mandates with a focus on requirements to meet an average 2% national mandate.

This section provides a description of the type, timing and cost of required infrastructure upgrades for the blending and distribution of renewable diesel blends in the context of an average 2% federal requirement for renewable content in diesel and heating oil.

The majority of this section is based on a report, *National Renewable Diesel Demonstration Initiative Infrastructure Project*, prepared by EcoRessources Consultants for NRCan and assumes an average 2% national renewable content in distillate mandate as has been proposed by Environment Canada.

There are presently 19 refineries[54] in Canada, located in all provinces except for Manitoba, Prince Edward Island and the Territories. Once refined, petroleum products leave the refinery and are delivered to a primary terminal where they are stored before being distributed either to a secondary terminal (bulk plant), a cardlock or a retail station. There are 76 primary terminals in Canada[55]. In general, western refineries supply petroleum product demand from Vancouver to Thunder Bay; Ontario refineries supply Sault Ste. Marie, northern Ontario and south-western Ontario; Quebec refineries supply the St. Lawrence River corridor from Toronto to the Gaspé Peninsula. Atlantic refineries generally supply local demand as well as the Arctic and Hudson Bay regions and export significant quantities of product to the United States. To supply petroleum products to end-users, the distribution infrastructure is composed of pipelines, ships, railways and trucks.

Renewable diesel fuel distribution in Canada is not always achieved by the same means as fossil fuels; infrastructure must be modified for the transportation and distribution of first generation biodiesel. Since the biodiesel industry is still at an embryonic phase and its development is fast, the best practices are not always used for the different distribution activities. As a result, special infrastructure must be built in order to ensure that integrity of the fuel is maintained throughout the distribution system.

4.1 Key Factors

4.1.1 Timing

In most cases, planning, permitting, construction and commissioning will have to take place before companies can start blending and marketing renewable diesel blends. Depending on

[54] Refineries in this context refer to those that produce gasoline/distillate, heating oil, lube oil and asphalt.
[55] MJ Ervin and Associates, 2007, and Canadian Petroleum Products Institute, 2009

the type of facility, type of infrastructure and region of the country, timing for these investments could be significantly different.

4.1.2 Regional Requirements

Depending on the region of the country in which companies operate, there will be different infrastructure requirements. Renewable diesel availability, market share, population density and existing provincial mandates will all affect the ability of fuel producers and importers to comply with the proposed federal regulation.

4.1.3 Seasonal Requirements

As the cloud point of biodiesel is much higher than that of petroleum diesel, blenders will need to take into account Canada's climate when deciding what time of year they will blend biodiesel.

4.1.4 Sources of Renewable Diesel

The source of the renewable diesel used in Canada will depend on availability, price and quality. In addition, some companies may choose to use HDRD with properties similar to petroleum diesel. The proposed regulation does not prescribe the origin of renewable diesel.

4.1.5 Capacity to Reduce Cross-Contamination

The use of biodiesel blends could be more challenging in some applications than others which may require the segregation of products. There may be some cases where biodiesel blends must be kept separate from petroleum diesel.

4.1.6 Infrastructure Requirements

Refiners, blenders, retail site operators and transportation companies will all require some level of new or modified infrastructure in order to blend renewable diesel into petroleum diesel. The cost, type and timing for all of these infrastructure operators will vary significantly.

4.2 Main Findings

For the purpose of this analysis and to preserve commercially sensitive information provided by petroleum producers and blenders, the country has been divided into three regions. The region defined as "West" includes British Columbia, Alberta, Saskatchewan and Manitoba. There is a central region that includes only the province of Ontario and is therefore referred to simply as "Ontario" throughout the text. The region defined as "East" includes Quebec and the Atlantic provinces. In addition, refiner and terminal operations have been combined due to the similarity of the changes.

4.2.1 Timing

The lead times for the required upgrades to a terminal or refinery site are approximately one to three years. Longer lead times are usually associated with larger investments, such as truck, rail and/or marine receipt facilities. Permitting and planning are typically the most time-intensive steps in the process, totaling 9 to 18 months. Infrastructure that is expected earlier in this period is already in the detailed planning or construction phase. Accelerating lead times at

refineries or terminals in order to meet a mandated regulatory start date, although possible, can lead to significantly increased costs due to plans and permitting being rushed.

The lead times for retail site upgrades are very short, three to six months, since the types of modifications are minor (tank cleaning, new filters, inspections). These modifications are typically done on an as-needed basis and are not an issue in terms of industry preparedness for the proposed federal regulations.

4.2.2 Regional Requirements

Due to the regional nature of their operations, regional producers/blenders will have less flexibility in terms of where and when they blend with renewable diesel.

Because of existing provincial mandates (see Section 6), the situation in the West is unique. The marginal volume of renewable diesel that will need to be blended in order to meet the proposed federal requirements is relatively low (notably because the regional producers/blenders in the West would already be meeting the proposed federal requirement via their blending for provincial regulations).

The situation is quite different in Ontario and the East. Since there are no existing or planned provincial regulations for renewable content in diesel/heating oil in these regions, the volumes of renewable diesel that will need to be blended in order to meet the federal mandate will be higher.

4.2.3 Seasonal Requirements

In both the West and the East, blenders will seek to minimize blending during the winter months by blending higher biodiesel concentrations in the summer months.

In the absence of provincial regulations, national refiner/marketers operating in the West would choose to blend in high concentrations (B5) only during the warmer months, mostly April to September, in order to help them meet their national 2% average. However, it is important to note that in order for some companies to meet provincial requirements, they will have to blend biodiesel during part or all of the winter.

Some refiners/blenders in Ontario and the East have indicated that they will have to blend significant volumes of biodiesel during the winter months, which typically requires large volumes of kerosene.

The increased volume of kerosene required to blend biodiesel in the winter months will add significant costs to the blender. It has been estimated, based on projections for 2013 diesel fuel demand, that the incremental volume of kerosene will be approximately 530 million cubic metres at a cost $25.9 million dollars per year. It is also important to note that as Canada is already a net importer of kerosene, it is unclear where this incremental volume will be sourced.

4.2.4 Sources of Renewable Diesel

It is likely that the majority of product will come from the United States and Canada. However, in some cases it is predicted that companies will use Hydrotreated Vegetable Oil (HVO) in order to meet the mandate. Initially this product is predicted to be sourced from Singapore, the USA and Finland.

4.2.5 *Capacity to Reduce Cross-Contamination*

There may be some cases where biodiesel blends must be kept separate from petroleum diesel (this is particularly true in the case of jet fuel). A variety of safeguards are possible to reduce the likelihood of cross-contamination: 1) Biodiesel receipt facilities (marine, rail or truck) are to be kept entirely separate from facilities for receipt of distillates; 2) Biodiesel and biodiesel blends are kept in separate tanks from other distillates; 3) Segregated facilities are used for blending, whether it is for bulk blending or for blending at the rack.

Monitoring and testing procedures are put in place in order to keep track of acceptable levels of biodiesel content (of particular importance with regards to jet fuel). Some contamination can occur through shared piping/lines; however these volumes are small and not expected to have a significant impact.

4.2.6 *Infrastructure Required: Refineries/Terminals*

Existing infrastructure at refineries and terminals has continually been upgraded over the years to comply with more stringent provincial or federal regulations. Recent investments to specifically adapt infrastructure requirements for storage and blending of biodiesel due to provincial mandates have taken place at two western refineries, seven western terminals and three eastern terminals.

The types of investments that have been made at terminals in order to accommodate renewable content are listed below:

- Truck offload facilities for B100 and/or BXX;
- Rail offload facilities for B100 and/or BXX;
- Marine offload facilities for B100 and/or BXX;
- Installation of new tanks and/or modification of existing tanks (cleaning, treating and installation of filters) for the dedicated storage of B100 and/or BXX;
- Procedural changes in tank inventory management for B100, BXX or HVO;
- Installation of temperature control equipment for tanks containing B100 or BXX: heating coils/elements, nitrogen blankets, etc.;
- Installation of in-line blending equipment;
- Installation of blending equipment on the rack;
- Line tracing to the rack and back to the tank for B100 and BXX;
- Re-programming of rack ordering software for BXX;
- Modification to systems;
- Customer education.

In order to meet the proposed new federal regulations, new infrastructure would be required at a total of 21 additional refineries and terminals in Canada: eight in the West, six in Ontario and seven in the East. It should be noted that the proposed new projects in the West are predominantly in order to meet provincial regulations. However, some projects would have been put in place, even in the absence of provincial regulations (or at least the nature of the investments would not have changed much), in order to meet the federal regulations. Not surprisingly, most of the infrastructure additions are being made at the refinery and/or terminal sites serving large markets (i.e., near large urban centres) and capable of handling high volumes. The types of investments to be made at these refineries and terminals are similar to those made for existing infrastructure as laid out above.

The costs for the upgrade of one refinery or terminal site ranged from $0.5 million to $16.3 million, the average being around $7.5 million. Terminal sites that require marine and/or rail offloading infrastructure for biodiesel had the highest costs, usually in the $7 million to $16 million range. Truck offloading equipment, new tanks, equipment for heating and in-line blending at the rack on a terminal site are all also significant expenses, ranging from $1 million to $7 million.

Proper blending is critical as it impacts the cold flow properties of the finished blend. The blending process is usually done by splash blending or in-line blending. Cold weather blending is a concern when the diesel fuel temperature falls below the cloud point of the B100 being blended. Therefore infrastructure has to be in place to bring the temperature of fuels up to the right temperature.

Splash blending can be appropriate for locations where the biodiesel and diesel fuel are loaded separately and where the fuels are loaded at the same time through different incoming sources but at a high enough fill rate that the fuels are sufficiently mixed. However, in some cases the tank may need to be re-circulated or further mixed to thoroughly blend the two fuels. If mixing is not complete, the slightly denser biodiesel will settle to the bottom. This is generally enough mixing except in cold weather, when the ambient temperature is significantly below the B100 cloud point. Then the two fuels mix poorly or not at all.[56]

It should be noted that while splash blending was used for a number of the demonstration projects under NRDDI, these projects were very small in scale. Due to the issues associated with splash blending, refiners/importers have indicated that they will use in-line blending techniques to mix biodiesel with petroleum diesel. In-line blending occurs when the biodiesel is added to a stream of diesel fuel as it travels through a pipe or hose in such a way that the biodiesel and diesel fuel become thoroughly mixed by the turbulent movement through the pipe. The biodiesel is added slowly and continuously into the moving stream of diesel fuel via a smaller line inserted in a larger pipe, or it can be added in small slug or pulsed quantities spread evenly throughout the time the petroleum diesel is being loaded. This is similar to the way most additives are blended into diesel fuel today, and it is most commonly used at pipeline terminals and racks.

4.2.7 Infrastructure Required: Retail Sites

As of May 2010, infrastructure at approximately 400 retail sites had already been upgraded to accommodate biodiesel blends. Sites in the West were primarily put in place in order to meet the provincial regulations. In Ontario and Quebec, some biodiesel is being blending in the absence of provincial or federal regulations. This is due to some demonstration initiatives taking place with public transportation and government service vehicles in a number of jurisdictions. There have also been some initiatives in Quebec to incent agricultural producers to use biodiesel blends for their equipment, given that using these fuels supports their industry.

Relative to the volumes being blended in the West for provincial regulations, however, the volumes blended in Ontario and the East remain small. It is estimated that approximately 1500 additional retail sites (service stations, truck stops, bulk plants, etc.) will need to be converted in order to meet the federal regulations.

The types of infrastructure upgrades that have been put in place at retail sites include cleaning mechanisms for underground and above ground tanks as well as installation of new filters (compatible with biodiesel).

[56] National Renewable Energy Laboratory, “Biodiesel Handling and Use Guide”, Revised December 2009.

The cost of upgrading a retail site is quite low, from $400 to $2000 on average. Based on estimates, it is expected that a total of $1.8 million will need to be spent on upgrading retail sites across the country in order to sell biodiesel blends due to the proposed federal regulations.

4.2.8 Infrastructure Required: Transportation

Petroleum products are most commonly received at primary terminals by pipeline (for major terminals), marine (for coastal terminals), truck and in a few cases by rail. The advantage of transporting fuels by pipeline is that it is much faster and cost-effective. In one region in the West, it is possible that B5 will be transported by pipeline, requiring pipeline testing and protocol changes. Given the need for further pipeline testing and protocols, it is likely that for the most part biodiesel and biodiesel blends will continue to be transported by truck. Tanker truck operators are already carrying out regular tank cleanings, whereas this is not common practice for rail tankers. Transportation infrastructure upgrades include heated and/or insulated tanks.

4.3 Analysis

The most significant infrastructure requirements for renewable diesel blending will be found at the refinery and terminal points in the network. Infrastructure requirements for retail facilities and transportation equipment as well as associated costs are anticipated to be relatively low. Note that in some instances, infrastructure upgrades have already taken place to meet provincial requirements. Regarding anticipated new infrastructure, some companies have not yet fully planned what new infrastructure investments they would make in order to conform to the proposed federal requirements. Some are waiting for a definitive signal from the federal government before they begin this planning process. Therefore, the results presented regarding anticipated new infrastructure should be regarded as neither a complete nor a definitive portrait of future investments but rather estimates of what could be possible.

In terms of new operational requirements to accommodate blending infrastructure, additional monitoring and testing procedures must be put in place in order to keep track of acceptable levels of biodiesel content.

Facilities will likely vary their production goals and blending depending on the season and the region to fulfill the national average 2% blend.

With regards to the sources of biodiesel, the majority will most likely come from sources in the United States and Canada. Blenders credits will influence the market for biodiesel and it is likely that significant volumes of Canadian biodiesel will be exported to the United States. In instances where volumes of hydrotreated product are used, they are predicted to be sourced from Singapore, the United States and Finland (although these volumes are predicted to be low in the short term due to availability and price).

The incremental volumes of kerosene required for a 2% mandate should not be overlooked. A number of other policies have either recently been put in place, or are planned for the near future, that could have an impact on the distillate pool in Canada. Given that Canada is already a significant importer of kerosene, further analysis would be useful to better understand how this regulation and others could impact the availability and security of Canada's fuel supply.

5 Market Acceptance

Market acceptance means that fuel users are consulted on demonstration projects and have indicated no further need for demonstrating the use of an average 2% blend in their operations. An assessment to confirm market acceptance includes consulting fuel users in the on-road, off-road and heating oil sectors to obtain feedback on issues to be addressed through demonstration work with regard to the use of B2 average in their industries. Following the demonstration of such issues, fuel users have provided their feedback on the use of an average B2 blend in the distillate pool in Canada and the resulting likelihood of issues in their sector.

5.1 Introduction

From Fall 2008 to June 2010, the NRDDI consulted with end-users in the on-road, off-road and heating sectors, as well as petroleum and biodiesel producers, on the technical feasibility of the intended regulation to require an average 2% renewable content in the distillate pool. These consultations identified outstanding questions regarding renewable diesel use in Canada and resulted in the development of seven NRDDI demonstrations to address these questions (see Exhibit 1). The results of these projects have been described in the preceding sections.

5.2 Stakeholder Feedback on the Technical Feasibility of the Intended Regulation

With the knowledge and experience gained through the seven NRDDI projects and from other sources, the NRDDI once again consulted with end-users and producers on the technical feasibility of the intended regulation. Feedback received from these stakeholders is detailed below in Table 1.1. In cases where the Table provides an excerpt of the full response, the complete statements can be found in Appendix 2.

Table 1.1

End-Use Sector	Association/ Organization	Feedback on the Technical Feasibility of the Intended Regulation
Heavy-duty on-road engines	Canadian Trucking Alliance (CTA), Canadian Petroleum Products Institute (CPPI), Canadian Renewable Fuels Association (CRFA), Engine Manufacturers Association (EMA) and several members	NRCan held a multi-stakeholder meeting on February 20, 2009 to discuss renewable diesel use in the Canadian on-road sector. The objectives of the meeting were to achieve agreement on any remaining work to be done to address questions about renewable diesel use in the on-road sector in advance of a regulation and to identify a path forward for completing any work in a timely manner. The following are conclusions from the record of discussion that was approved by participants: "Participants generally agreed that up to B5 is technically feasible with the following caveats: 1) Proper blending/handling 2) Blended fuel meets CGSB B1-B5 standard

		There were no remaining technical issues for which a demonstration could be utilized (including 2010 engine models)."
Trucking	CTA	"Given the fact that heavy truck engine manufacturers will not provide assurances that fuel with biodiesel content over 5% will not cause problems with most of the engines currently in use, recent changes in the biodiesel marketplace, newly reported European research which appears to clearly show that biodiesel could actually increase GHG emissions, and the fact that some provinces have already moved into this regulatory arena, we have difficulty understanding why the Government of Canada would still pursue a national biodiesel regulation. If it is still the federal government's position that it should proceed with a biodiesel mandate, then: ▪ The averaging provision should be removed and it be prescribed that no diesel fuel shall be sold into the general heavy commercial truck marketplace above the B5 level to reduce the risk of operability and durability problems for all heavy trucks and to protect all truck owners' engine warranties. ▪ The regulation should include a provision that will require the identification of regions and calendar dates in which biodiesel blends should not be used due to extreme cold weather. ▪ Regulated quality assurance is essential. ▪ Improper blending practices, even with proper quality standards, can lead to problems. Environment Canada must develop regulatory controls regarding proper blending processes. ▪ A properly conducted regulatory impact statement must also be conducted to clearly isolate the cost impact of biofuel on the price of on-road diesel fuel. ▪ Environment Canada should establish an office to monitor and analyze problems associated with the biodiesel mandate and to establish a help-line to receive information and provide answers to heavy-duty engine users during the introduction of biodiesel into their fleets and beyond." *[Excerpt from the statement submitted to NRCan May 2010]*
Urban Transit	Canadian Urban Transit Association (CUTA)	CUTA surveyed their membership in May 2010 and provided the following results (25 transit systems out of a total of 67 responded to the survey): ▪ "7 respondents currently use biodiesel blends up to 10% and reported issues with cold weather mixing and use of biodiesel blends in winter blocking the filter systems. Filters were added at filling stations

		and they did ongoing maintenance and replacement of filters on buses and filling stations. ▪ 2 respondents indicated that they had used biodiesel in the past, but do not use it now due to its higher cost. ▪ 16 respondents indicated they have not used biodiesel; 11 due to fuel availability, 7 due to fuel cost and 9 due to maintenance requirements; there was a general lack of knowledge among this group of effects on warranty and older engines and cold weather operations." Cummins is the only manufacturer of new heavy-duty engines for the transit industry. Cummins is a member of EMA (see EMA statement below) and supports up to B5 in their engines, but recommends care and management in using blends from B6-20. Blends greater than B20 are not recommended. *[Excerpt from the statement submitted to NRCan June 2010]*
Engine Manufacturers	EMA	"An average annual 2% renewable content in diesel fuel is technically feasible for existing heavy-duty engines and anticipated 2010 heavy-duty engines in Canada, as long as: (i) the renewable diesel fuel and petroleum diesel fuel components comply with recognized national or international diesel fuel standards; (ii) mono-alkyl esters (biodiesel) used for blending must comply with ASTM D6751 or EN 14214; (iii) fuel blended with mono-alkyl esters (biodiesel) meets CAN/CGSB-3.520 "Automotive Low-Sulphur Diesel Fuel Containing Low Levels of Biodiesel Esters (B1-B5)"; (iv) proper blending/handling practices are implemented so as to achieve a homogeneous blended fuel containing no free water; and (v) finished fuel blends meet the requirements of CAN/CGSB-3.517 "Automotive (On-road) Diesel Fuel" or recognized international diesel fuel standards. Any fuel not meeting the aforementioned requirements must be appropriately labelled so that operators can make an informed choice." *[Submitted to NRCan on April 14, 2009; reconfirmed statement April 16, 2010]*
Commercial and Residential Heating	Canadian Oil Heat Association (COHA)	"While COHA acknowledges the environmental benefits of renewable fuels, COHA also wants to ensure the quality and operability of any new fuels blended with traditional #2 heating distillate oil. COHA supports the introduction of the renewable fuels regulations in Canada subject to the approval of the appropriate CAN/CGSB standard." *[Excerpt from the statement submitted to NRCan May 2010]*

Agriculture	Canadian Federation of Agriculture (CFA)	"The CFA is encouraged by the results of the NRDDI projects. The available results from these projects indicate that a 2% biodiesel blend is technically feasible for the operation of machinery in the agricultural sector. From the limited sample size within the research, it appears that biodiesel can be integrated easily into farming operations and that the quality of the fuel and equipment performance can be maintained at current standards. However, if the 2% mandate is to be successful, the CFA feels that increased focus must be placed on quality control and management of diesel supply chain, particularly the cloud point of biodiesel blended fuel. If the regulations are to be successfully implemented, it is essential that the many independent dealers that farmers rely on for their fuel are given the knowledge, tools and diesel fuel necessary to ensure that biodiesel blends meet cloud point specifications." *[Excerpt from the statement submitted to NRCan May 2010]*
	Canadian Canola Growers Association	"The Canadian Canola Growers Association (CCGA) strongly encourages the government of Canada to adopt a low-level biodiesel mandate in Canada. Numerous studies have shown that biodiesel blends are effective in every season, and in a wide range of equipment that is powered by diesel engines, including equipment used in transportation and agriculture. We recognize there are small switch over costs for diesel engine operators, for example changing fuel filters which may become clogged due to the engine cleaning properties found in biodiesel. However, these transition costs and minor delays are tiny compared to the long term benefits created for the environment and the economy when biodiesel use is mandated in Canada." *[Excerpt from the statement submitted to NRCan June 2010]*
	Canola Council of Canada	"Feedback we have received from our growers is that they are aware of biodiesel and its properties and where it has been available in the Canadian market have used the product at different blend levels with success. The confidence in the use of biodiesel by agriculture equipment manufacturers is reflected in their engine warranties. Some manufacturers allow up to B100 to be used, while almost all now approve the use of a B20 blend. At the same time, actual in the field use by farmers and measured studies of biodiesel use by independent research organizations like PAMI and the SRC have confirmed there have been no operability issues with canola based biodiesel in the agriculture sector. We believe there are no technical reasons why a B2 blend can't be successfully used across Canadian agriculture." *[Excerpt from the statement submitted to NRCan June 2010]*

	Grain Growers of Canada	"We wish to express our strong support for the adoption of a low-level biodiesel mandate in Canada. Studies have shown these blends to be effective in every season and in a wide range of diesel equipment used in agriculture. While we recognize there may be some minor transition costs for diesel engine operations, they are small compared to the economic and environmental benefits we gain from increased use of all biofuels, including biodiesel." *[Excerpt from the statement submitted to NRCan June 2010]*
Rail	Rail Association of Canada (RAC)	"Natural Resources Canada (NRCan) funded a biodiesel demonstration that was lead by Canadian Pacific Railways (CP). The demonstration was conducted in a cold weather environment, on a specified CP service between Calgary and Edmonton. The biodiesel blend that was used was 5% (B5). With regard to the demonstration, CP summarized the preliminary findings as: no service interruptions; no adverse impact to locomotive engine performance or components. It should be noted that fuel efficiency has not been assessed to date. The demonstration results are promising; however, there are a number of concerns that require resolution. First, the supply of biodiesel is not mature or sufficient in Canada. It is the opinion of the RAC that commercial scale distribution infrastructure is not available to meet the demands of the Canadian railway industry including quality, volume and geographic availability. It should be noted that CP had a limited response to a Request for Proposal to supply B5 blend fuel that met CP's fuel specification (particularly cloud and pour points) and the applicable ASTM/CGSB standards in the Calgary/Edmonton market place. Fuel blending infrastructure was also not available resulting in less than desirable "splash blending" being used for the demonstration, which does not lend itself to providing a consistent and controllable blend. Secondly, there is a risk that higher blends than B5 may be required in some markets for fuel suppliers to meet the pool average of 2%. Blends of higher than B5 have not been approved for use in locomotives and may pose an unacceptable risk to railway operations. In fact the RAC is aware that GE Transportation is not supporting any biodiesel blends greater than B5 for their locomotives under warrantee. In addition, the GE warrantee, for their locomotives, requires the use of biodiesel which meets the ASTM 6751-09 standard." *[Submitted to NRCan June 2010]*
	General Electric (locomotive engine manufacturer)	GE's published position statement regarding the use of alternative fuels in their locomotives: "The results of testing indicate that a blend rate of 5% (B5) will not have a detrimental impact on the ability of the locomotive to produce its rated horsepower and comply

		with current US EPA regulatory requirements for emissions. Furthermore, the impact on fuel consumption at this blend level will be minimal. At this point in the biodiesel validation effort, GE is able to approve the use of biodiesel in GE's family of locomotives powered by FDL and Evolution engines at a maximum blend rate of 5% (B5) by volume, providing the biodiesel fuel used is fully compliant to ASTM D975 - 09a Standard Specification for Diesel Fuel Oils, and the biofuel (B100) used to make the B5 meets ASTM D6751 – 09 Standard Specification for Biodiesel Fuel Blend Stock (B100 for Middle Distillate Fuels." *[Excerpt from the position statement dated May 2010]*
Mining	Mining Association of Canada (MAC)	"Given the fact that the government is aware of the cold temperature gelling issues, and that engine manufacturers are supportive of a biodiesel blend, the Mining Association of Canada is comfortable that a 2% biodiesel blend should not present technical issues for the mining industry. MAC supports the concept of new cleaner fuel standards being applied across the breadth of Canadian society." *[Submitted to NRCan on May 12, 2010]*
Marine	Canadian Shipowners Association	"Our members are not concerned about the 2% regulatory standard and do not feel that additional demonstration of these fuels will be necessary for our business sector." *[Submitted to NRCan on June 2, 2009]*
	Shipping Federation of Canada	"The Shipping Federation of Canada would like to acknowledge the work undertaken by NRCan as part of the NRDDI … We would like to think that biodiesel offers a promising avenue in reducing air emissions and greenhouse gases from the marine sector, and we are pleased to see that the body of research on this topic is growing. Unfortunately, the work did not include any experiments on oceangoing vessels, which would have addressed some of the concerns we have with respect to the operations of such vessels. While there have been several studies involving biodiesel on-board ships, none of these experiments are transferable due to the differences in engine sizes and overall operational environments. We have stated in our comments to Environment Canada that the proposed regulations lack specific information as to how the regulations would be applied to the marine sector. More specifically, the proposed regulations do not offer insight as to whether their provisions would be aligned with the ISO *Petroleum products -- Fuels (class F)* -- Specifications of marine fuels, which has been developed to ensure fuel quality. The newly completed standard, ISO 8217:2010 *Petroleum products -- Fuels (class F)* -- Specifications of marine fuels published on June 15, 2010, specifically excludes biodiesel products … Working Group 6 under the Technical

		Committee 28/SC4, which specifically addresses marine fuel standards, recommends that the possibility of including biodiesel in marine fuels be debated at the next revision. It is of the utmost importance to our industry that fuel purchases are tested for compliance with these specifications, since non-conformity will effectively void the warranty on the ships' engine. … Given that biodiesels were excluded from the new ISO 8217 norm ... we cannot endorse a 2% renewable diesel use for use in the Canadian marine sector." *[Excerpt from the statement submitted to NRCan June 2010]*
	Chamber of Shipping of B.C.	"The only concern expressed by our members has been one of the biodiesel content potential price differential, however this does not currently appear to be a factor. In researching this subject I did come up with the following article on ISO standardization which was a concern well expressed by the Shipping Federation of Canada during the recent teleconference." See feedback from the Shipping Federation of Canada above with respect to the ISO standardization issue. *[Excerpt from the statement submitted to NRCan June 2010]*
Construction	Canadian Construction Association	"Our Environment and Research and Innovation Committees were treated to a presentation by FPInnovations on their study: Demonstration of the Potential Use of Biodiesel for Off-Road Machinery in Canadian Highway Construction and Forest Operations. The study focused on biodiesel use in off-road operations and found no technical issues exist with regard to widespread substitution of B2 for conventional diesel fuel. While the use of higher content biodiesel presented some performance issues (such as poor engine performance due to the solvent properties of biodiesel and the circulation of dislodged build-up throughout the fuel system), these performance issues were overcome with thorough fuel tank cleanings prior to biodiesel use. Long-term storage of higher content biodiesels in remote areas were also raised as a potential concern, however, given that most remote construction occurs on a seasonal basis (spring to fall), any storage challenges (even in remote areas) can be overcome by a change in fuel procurement policies. Therefore, CCA's concerns with regard to the mandated use of B2 are not technical in nature." *[Excerpt from the statement submitted to NRCan June 2010]*
Forestry	Forest Product Association of Canada (FPAC)	"The forest products industry is a sizable consumer of diesel fuel, particularly in the forestry and logging operations, but also for some on-site mill operations. We are pleased that FPInnovations has been able to identify no technical operational barriers to the potential substitution of biodiesel alternatives in the forest products industry. There are two other considerations to realize this potential. An

		assessment of the market supply chain dynamics in remote and rural areas where the industry operates is needed. An important consideration of that supply chain could be the industry's future ability to produce its own biofuels, as evidenced in FPAC's recent Future BioPathways report. Also, the Renewable Fuels regulations as currently proposed restricts the regulated pool of distillates to diesel substitutes and domestic home heating fuels which is excessively narrow and may slow the development of a number of potentially impactful industrial biofuel applications. Including industrial applications would also enhance the socio-economic impacts the government hopes to generate by implementing these regulations." *[Submitted to NRCan June 2010]*
Fuel Producers/ Marketers	**Association/ Organization**	**Feedback on the Technical Feasibility of the Intended Regulation**
Petroleum Products	CPPI	"CPPI and its members have participated to a series of programs under the National Renewable Diesel Demonstration Initiative, led by Natural Resources Canada. During the course of the programs, valuable insight has been gained, on the impact of various biodiesel types and renewable diesel blends, under Canadian conditions. In some cases, the gap between experimentation and practical application remains substantial and must be adequately addressed in the final decision-making to ensure a seamless introduction of biodiesel blends into the market place. Those findings need to be taken under consideration by the Standards setting organizations, such as CGSB, to develop and adopt the required standards that will ensure consumers that the new products are fit for intended purpose, when introduced into the market. CPPI does not support the introduction in the market place, of a new fuel product, without the appropriate standard. The introduction of Renewable diesel and Biodiesel blends requires extensive and careful planning, as it impacts on many segments of the supply chain, from Refinery to storage, blending and distribution. Sufficient time must be available, from regulatory certainty, to allow proper infrastructure design, construction and commissioning. … The NRDDI Biodiesel Distribution Infrastructure Analysis is expected to provide additional insight on these important aspects. CPPI members have provided detailed information on the specific requirements and associated timelines and therefore shall be considered a key element in assessing the technical readiness.

		In closing, CPPI stresses that these three aspects must be taken into consideration; that is: - understanding the conditions and limitations, - having appropriate standards in place, and - providing sufficient time to implement the necessary infrastructure. Only when those three aspects are present, one can consider the supply chain is technically ready for a seamless transition to the end consumer." *[Excerpt from the statement submitted to NRCan June 2010]*
Renewable Fuels	CRFA	"The CRFA believes that all of the NRDDI projects have successfully demonstrated the full operability of renewable diesel fuels under Canadian conditions in a variety of applications that are representative of the renewable diesel fuels are likely to be used in Canada. In many cases these projects were designed to test the fuels in operating conditions far more severe than most users will experience and yet no significant issues were identified in the programs. The CRFA supports the use of renewable fuels that are commercially proven, produced under industry best practices, and distributed under established fuel specification standards. All of these criteria have been well documented for biodiesel use in Canada and there are no reasons not to proceed with the 2% renewable requirement in the Canadian distillate pool." *[Excerpt from the statement submitted to NRCan June 2010]*

5.3 Analysis

5.3.1 On-road vehicles

Heavy-duty engine manufacturers have publicly endorsed the use of up to B5 in their engines. In February 2009, the CTA, representing the Canadian heavy-duty trucking industry, agreed that up to B5 is technically feasible as long as the fuel is properly blended and handled and the blended fuel meets the CGSB B1-B5 standard. The CTA has, however, proposed modifications to the intended regulation to address their concerns about blends above B5, use of B5 in extreme cold weather conditions and consistent fuel quality. The heavy-duty trucking sector represents about 56% of distillate fuel use in Canada (see Figure 2).

5.3.2 Off-road equipment

Industry associations representing stakeholders in the forestry, construction, mining, rail and agriculture sectors have indicated they have no further technical concerns related to an

average 2% renewable content in diesel fuel mandate. These sectors represent a further 23% of Canadian distillate users.

Distillate use in the marine sector is approximately 3% of the total pool and is used by some of Canada's domestic fleet to power their main propulsion engines, as well as in on-board power generators of many domestic and international carriers. The Canadian Shipowners Association, representing the domestic marine industry, has no concern regarding the proposed 2% mandate and sees no further need for demonstrations given the results of previous demonstrations of low-level biodiesel blends in domestic marine vessels. International marine carriers, represented here by the Shipping Federation of Canada and the Chamber of Shipping of BC, use bunker fuel for their main propulsion systems, which is not covered by the proposed regulation. However, they have noted that there is coming Canadian legislation that may require them to use distillate fuel for their main propulsion system when in Canadian waters, through a North American Marine Emissions Control Area, and that the current international fuel standard for marine fuel does not allow for biodiesel content due to remaining questions about impacts on these large marine vessels. They are, therefore, asking for a coordinated approach between the requirements of this regulation and the proposed marine emissions control area regulations. A demonstration to determine any potential impacts of biodiesel use in large ocean-going vessels is expected to conclude in 2012.

5.3.3 Stationary equipment

Heating oil furnaces use about 14% of the Canadian distillate pool. The oil heat sector, represented by the COHA, has indicated its support for the introduction of the renewable fuels regulations in Canada subject to the approval of the appropriate CAN/CGSB standard. The heating oil standard is currently being revised to allow up to B5 in Type 2 heating fuel oil and is expected to be published in 2010/11.

5.3.4 Fuel producers

CPPI members and other independent petroleum fuel producers would have to comply with the intended regulation once it comes into effect. CPPI has developed a consensus statement that sets out three areas that its members believe need to be addressed before the supply chain will be technically ready to seamlessly implement the regulation: 1) understanding the conditions and limitations; 2) having appropriate standards in place; and 3) providing sufficient time to implement the necessary infrastructure. While the NRDDI has contributed to the body of knowledge about the use of renewable diesel blends under Canadian conditions, CPPI believes that, in some cases, there is still a substantial gap between experimentation and practical application of renewable diesel blends in the marketplace. With respect to appropriate standards, CPPI is supporting the development of a Canada-specific B100 standard with tighter requirements for cold flow properties. This standard is expected to be ready for balloting at CGSB in 2010. CPPI has also stressed the importance of providing adequate lead time for installation of the appropriate infrastructure to ensure a seamless transition to renewable diesel blends.

CRFA represents many of the leading Canadian producers of biodiesel. They have stated that the NRDDI projects have demonstrated that there are no operability issues with the use of renewable diesel blends in Canada. They believe that it has been well documented in Canada that the use of renewable diesel is commercially proven and renewable diesel is being produced under industry best practices and distributed under established fuel specification standards. As such, they have stated that there should be no delay in implementing the intended regulations.

6 Other Considerations

6.1 Jurisdictional Context

The background and context in which legislation for biodiesel and other biofuels have been or are being introduced are different from one jurisdiction to another. The accuracy and breadth of data to inform potential legislation also varies. The next subsections describe the context and status of biodiesel regulation in selected jurisdictions, including BC, Manitoba, USA and Europe. A comparison with context for ethanol legislation is also given.

6.1.1 BC Regulatory Elements

In its 2007 *BC Energy Plan*, the province announced that it would adopt a 5% biodiesel requirement. In April 2008, the province enacted Bill 16: *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act* which provided the province the legislative authority to develop the renewable fuel regulations. The 5% biodiesel regulation was approved in December 2008 but modified in late 2009 to a phased-in approach requiring 3% biodiesel in 2010, 4% in 2011, and 5% in 2012.

BC's biodiesel regulation applies to diesel fuel that is used in both motive and stationary applications.[57] Regulated parties can meet the requirement using traditional biodiesel (fatty acid methyl esters) or renewable diesel (diesel fuel replacement made from plant or animal matter using a hydrogenation process). In all cases, the biodiesel used must meet the ASTM International standard *ASTM D6751 Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels* in order to qualify as biodiesel under the regulation.

According to the Ministry of Energy, Mines and Petroleum Resources, the reason behind the phased-in approach is to "…provide industry with the time to put the necessary Canadian supply infrastructure in place, and address technical issues regarding the cold weather properties of biodiesel and engine manufacturer warranties, which may limit the use of biodiesel."[58]

6.1.2 Alberta Regulatory Elements

Effective April 2011, the Alberta Renewable Fuel Strategy requires 2% renewable content by volume in diesel fuel.

6.1.3 Manitoba Regulatory Elements

Effective November 1, 2009, the *Biodiesel Mandate for Diesel Fuel Regulation* requires a 2% biodiesel blend in motive diesel and excludes diesel used in locomotives until December 31, 2012. The regulation provides flexibility in meeting the mandate including a first reporting period of November 2009 to December 2011 so that experience can be gained.

[57] Generally excluding fuel that is sold to the Department of National Defence, and excluding fuel that would be used in locomotive or other rolling stock prior to January 1st, 2013.
[58] Renewable & Low Carbon Fuel Requirements Regulation, March 2010. BC Ministry of Energy, Mines and Petroleum Resources, http://www.empr.gov.bc.ca/RET/RLCFRR/Pages/default.aspx

6.1.4 United States (U.S.) Renewable Diesel Experience

The U.S. Energy Policy Act of 2005 established the Renewable Fuels Standard (RFS), requiring 7.5 billion gallons of renewable fuels to be blended into gasoline by 2012. The Energy Independence and Security Act of 2007 expanded the program and established what is commonly referred to as RFS2, with annual volume requirements that increase to 36 billion gallons by 2022. RFS2 also created various renewable fuel categories, including a requirement for biomass-based diesel, with each category having lifecycle greenhouse gas performance threshold standards and specific volume requirements.

Five states and one city have renewable diesel mandates in effect. Minnesota has mandated B5 in all #2 diesel fuel sold in the state. The mandate increases to B10 in 2012 and B20 in 2015, but only from April through October. Oregon currently has a B2 mandate, but when annual in-state production of biodiesel reaches 15 million gallons, all diesel fuel sold in the state must contain B5. As of July 1, 2010, the city of Portland, Oregon, requires all diesel fuel sold in the city to contain B10. Washington State has mandated 2% biodiesel or renewable diesel content. This would increase to 5% once in-state feedstock and oil-seed crushing capacity can meet a 3% requirement. Pennsylvania requires B2 in all diesel fuel sold in the state. This increases to B5, B10 and B20 once in-state production can meet these levels. Massachusetts currently has a 2% renewable diesel fuel mandate came into effect July 2010 and increases incrementally to 5% by 2013; however, the current mandate has been suspended indefinitely due to concerns that higher costs would be borne by the consumer as a result of the expiration of the biodiesel federal tax credit.

Two additional states have enacted biodiesel mandates that have not yet taken effect. New Mexico's B5 mandate for diesel fuel used in motor vehicles will come into effect in 2012. Louisiana's B2 mandate is dependent on in-state annual production of 10 million gallons from domestically grown feedstock.

U.S. production capacity in 2009 was approximately 5,900 million litres, while actual production was approximately 1,672 million litres.

6.1.5 European Union (EU) Biodiesel Experience

The EU Biofuels Directive (Directive 2003/30/EC) set non-binding, biofuels-neutral targets for biofuels use as a percentage of fossil fuel use. In 2005, the target was 2% and in 2010, it is 5.75%. An amendment to the Fuels Quality Directive was voted in December 2008 to allow biodiesel blends of up to 7%. The related diesel fuel quality specification EN 590 was modified in 2009 to align with the directive.

The Renewable Energy Directive (Directive 2009/28) entered into force on June 25, 2009 and one of its core elements is a 10% binding target for renewables in the transportation sector and the introduction of a comprehensive set of sustainability requirements for biofuels in order to be counted towards the target.

Several EU member states have biodiesel or renewable diesel specific mandates, such as Germany (4.4%), Italy (3.5% in 2010; 4% in 2011; 4.5% in 2012), Lithuania (5%), and Portugal (10%).

6.2 Comparison to Ethanol Regulation

The federal government is implementing a 5% renewable alternative to gasoline mandate in 2010. There is a considerable amount of experience in Canada with blending and introducing ethanol into the gasoline pool, due to provincial ethanol mandates that have been in force for several years (Saskatchewan, Manitoba, Ontario, and more recently in British Columbia). The experience will help to reduce the risk associated with implementing a federal mandate, because it can/has inform(ed) the structure of the regulation.

On the other hand, Canadian experience with biodiesel is much more limited; Manitoba's biodiesel mandate came into force on November 1, 2009, and BC's mandate for renewable content in diesel and heating oil came into force on January 1, 2010. To date, the actual quantity of biodiesel consumed is not well known. The provincial regulations were designed with some flexibility for the first years and use could be relatively limited to date. The federal government will not be able to rely on much past experience in order to shape the renewable alternative to diesel regulation.

7 Conclusion

The Government intends to regulate an average 2% renewable content in the middle distillate pool by 2011 or earlier, subject to technical feasibility. The NRDDI was launched to address any remaining questions about the technical feasibility of this regulation in Canada. In consultation and collaboration with other federal government departments and stakeholders, the NRDDI funded projects developed and delivered by stakeholder groups to address these remaining questions.

The NRDDI examined the results of these projects and other information sources to assess technical feasibility using four key factors: i) fuel technology readiness; ii) technology/end-user application readiness; iii) infrastructure readiness; and iv) market acceptance.

Technical information from the NRDDI projects and other sources referenced in this report provides a useful assessment of technical feasibility that will inform the development and implementation of the regulation by Environment Canada.

This information demonstrated the possibility for renewable diesel to meet industry accepted standards. It also provided the necessary data for industry representatives from most Canadian end-use sectors to provide their views on the technical feasibility of an average 2% mandate. Stakeholders are generally satisfied that their remaining technical questions regarding an average B2 blend in their operations have been addressed. Providing adequate lead times for upgrading fuel blending and distribution infrastructure is important for ensuring a seamless integration of renewable diesel blends into the Canadian marketplace.

8 Appendices

8.1 Appendix 1: Physical and Chemical Tests

A number of physical and chemical tests were performed to determine properties of biodiesel blends, and therefore assess fuel technology readiness. A brief description of the purpose of each test is given below[59,60]:

- Cloud Point (CP) – This is the most commonly used measure of low-temperature operability; fuels are generally expected to operate at temperatures as low as their cloud point. The B100 cloud point is typically higher than the cloud point of conventional diesel. Cloud point must be reported to indicate biodiesel's effect on the final blend cloud point.[61] The CP is the temperature at which small solid crystals are first visually observed as the fuel is cooled (ASTM D2500, D5771, D5772, or D5773). Below the cloud point, these crystals might plug filters or drop to the bottom of a storage tank. Cloud point is the most widely used and most conservative estimate of the low temperature operability limit. However, fuels can usually be pumped at temperatures below the cloud point. A related test is for the wax appearance point, ASTM D3117.

- Cold Filter Plugging Point (CFPP) - This is the temperature under a standard set of test conditions, as defined in ASTM D6371, at which a fuel filter plugs. The CFPP test employs rapid cooling conditions. CFPP results more than 10ºC below the cloud point should be viewed with suspicion, because they may not reflect the true low temperature operability limit. The test simulates the performance of an average or typical vehicle and is not protective of the most challenging fuel system designs from a low-temperature operability standpoint, which make up roughly one-third of heavy-duty vehicles or one-fifth of light-duty vehicles.

- Pour point - The temperature at which the fuel contains so many agglomerated crystals that it is essentially a gel and will no longer flow (ASTM D97, D5949, or D5950). Distributors and blenders use the pour point as an indicator of whether the fuel can be pumped, even if it would not be suitable for use without heating or taking other steps.

- Low-Temperature Flow Test (LTFT) - This test also reports a temperature under a standard set of conditions, defined in ASTM D4539, at which a fuel filter plugs. LTFT employs slow cooling at 1ºC/h and simulates the most severe (and common) fuel system designs in North American heavy-duty trucks from the standpoint of low-temperature operability.

- Cold Soak Filtration Test (CSFT)[62] – This is the newest requirement under ASTM D6751. It was added in 2008 in response to data indicating that some B100 could, in blends with petroleum diesel of up to 20%, form precipitates above the cloud point. B100 meeting the cold soak filterability requirements does not form certain types of precipitates.

[59] National Renewable Energy Laboratory. "Biodiesel Handling and Use Guide", Revised December 2009.
[60] Annual Book of ASTM Standards. American Society for Testing and Materials (ASTM). < http://www.astm.org/BOOKSTORE/BOS/index.html>
[61] American Society for Testing and Materials (ASTM), "ASTM D6751-09a: Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels", 2009.
[62] American Society for Testing and Materials (ASTM), "ASTM D7501-09b Standard Test Method for Determination of Fuel Filter Blocking Potential of Biodiesel (B100) Blend Stock by Cold Soak Filtration Test (CSFT)", 2009

- Oxidation stability test – Is also referred to as the Oil Stability Index or the Rancimat test (EN14112, EN15751), involves heating a specified quantity of B100 to 230ºF (110ºC) while air is bubbled through at a specified flow rate. The air then passes through a water bath that collects the volatile acids formed in oxidation. A conductivity meter is used to monitor the water. A stable B100 can go for many hours under these conditions without forming volatile oxidation products. This period of time, before oxidation products form, is called the induction time or induction period.

- Long-term storage stability - The ASTM D4625 test is used to simulate storage in underground storage tanks. The test is accelerated by a factor of 4 for petroleum fuels; that is, one week of storage at D4625 conditions (43ºC or 110ºF, open to air) simulates one month of storage in an underground tank.

- Filter Blocking Tendency (FBT) – The ASTM D2068 test method is intended for use in evaluating distillate fuel cleanliness in those applications that demand a high throughput per installed filter. CGSB is currently investigating a new test method based on the FBT test, with a pre cold-soak, to evaluate biodiesel suitability for cold weather operability.

- Flash point - The flash point temperature is one measure of the tendency of the test specimen to form a flammable mixture with air under controlled laboratory conditions (ASTM D93). It is only one of a number of properties which must be considered in assessing the overall flammability hazard of a material.

8.2 Appendix 2: Full Statements from Stakeholders

Full statements, from stakeholders on the technical feasibility of an average 2% renewable content, are recorded below when excerpts were used in section 5.2 (Table 1.1).

8.2.1 Canadian Trucking Alliance

Butterworth House
324 Somerset Street West, Suite 100
Ottawa, ON CANADA K2P 0J9
T: (613) 236-9426 F: (613) 563-2701
www.cantruck.ca

Sent Via Email: Nancy.Johns@NRCan-RNCan.gc.ca

May 4, 2010

Nancy Johns
Senior Manager
Natural Resources Canada
580 Booth Street, 18th Floor, Room. C8-2
Ottawa, ON
K1A 0E4

Dear Ms. Johns,

Natural Resources Canada has requested the Canadian Trucking Alliance's current position on the Government of Canada's proposed biodiesel mandate, which I am pleased to provide as follows:

Given the fact that heavy truck engine producers will not provide assurances that fuel with a biodiesel content over 5% will not cause problems with most of the engines currently in use, recent changes in the biodiesel marketplace, newly reported European research which appears to clearly show that biodiesel could actually increase GHG emissions, and the fact that some provinces have already moved into this regulatory arena, we have difficulty understanding why the Government of Canada would still pursue a national biodiesel regulation. We are of the view that the interests of farmers and biofuel producers have to date outweighed the legitimate views and concerns of the primary potential consumer – i.e., Canada's trucking industry.

If it is still the federal government's position that it should proceed with a biodiesel mandate, then:

- Averaging Biodiesel Blends -- The averaging provision in the 2006 Notice of Intent should be removed and it be prescribed that no diesel fuel shall be sold into the general heavy commercial truck marketplace above the B5 level to reduce the risk of operability and durability problems for all heavy trucks and to protect all truck owners' engine warranties. The sale of biodiesel blend higher than B5 should be permitted only as a specialty fuel, protecting on-road consumers from its use. We would accept a clause in the regulation that would allow for the maximum biodiesel blend to be increased over time once a determination has been made that releasing such blends into the general marketplace would not create operability, durability and warranty issues. (CTA cautions that reports of operability for heavy trucks manufactured before 2001 operating on blend higher than B2.) Simply stating on a pump that the fuel may include bio-content over a certain percentage level is unacceptable.

- Cold Climate Mitigation -- The regulation should include a provision that will require the identification of regions and calendar dates in which biodiesel blends should not be used due to extreme cold weather. Since B5 blends may be used on a more regular basis, and this fuel is more likely to gel in colder temperatures compared to B2 blends, the Government of Canada must consider extended periods and geographic territory of winter blend bans.

- Quality Assurance -- Regulated quality assurance is essential. The Engine Manufacturers' Association has stated that biodiesel must meet ASTM standards and BQ 9000 certification for warranty purposes. These standards must be regulated to ensure compliance at all times. Currently, adherence with these standards is only voluntary in Canada.

- Blending Practices -- Improper blending practices, even with proper quality standards, can lead to problems. Environment Canada must develop regulatory controls regarding proper blending processes. AMA and CPPI have clearly stated that splash blending is not desirable and that in-line blending is superior.

- Regulatory Impact Statement -- A properly conducted regulatory impact statement must also be conducted to clearly isolate the cost impact of biofuel on the price of on-road diesel fuel. This will be essential for motor carriers to justify the impact of biodiesel on fuel surcharges to their customers.

- Consumer Help-Line -- Environment Canada should establish an office to monitor and analyze problems associated with the biodiesel mandate and to establish a help-line to receive information and provide answers to heavy-duty engine users during the introduction of biodiesel into their fleets and beyond.

- Fuel Efficiency Credits – (See below). It is imperative that if a biodiesel mandate is introduced the trucking industry must receive substantial credits for biodiesel use under any fuel economy/GHG emission standards/cap & trade system that the Government of Canada may introduce.

In addition, a number of recent developments raise significant questions which require a response from the Government of Canada. Specifically:

1. Would the federal governments proposed new fuel efficiency standards for heavy trucks (GHG regulation) provide the trucking industry with an opportunity, on a micro scale (fleet-by-fleet basis), to get credit for the use of biodiesel. If so what will be the level of credit and will it be cost effective?

2. Has the downsizing of the US biodiesel producing industry, as a result of the federal and state subsidy removal, caused the Government of Canada concern regarding the long term stability and sustainability of this alternative fuel market?

3. What is the Government of Canada's response to the European Commission report on biodiesel, recently released under freedom of information legislation? This report casts further doubt on the environmental benefits of biodiesel – e.g., biodiesel from North American soybeans has four times the carbon footprint of standard diesel.

Finally, it is an accepted fact that biodiesel cannot be pipelined to market. CTA understands that NRCAN has conducted a market analysis of this impact and requests a copy of this report and a summary of the department's recommendation to Environment Canada.

I trust this answers the department's questions about CTA's position on a possible biodiesel mandate in Canada and that the department will work with us to obtain answers to the questions we pose.

Sincerely,

David H. Bradley
President & Chief Executive Officer

DHB/km

8.2.2 Canadian Urban Transit Association

CUTA Biodiesel Survey Results Summary

Transit Systems

- Short questionnaire developed to survey transit systems on their experience with biodiesel and separates them into three categories:
  - Currently use biodiesel
  - Have used biodiesel, but no longer use it
  - Have not use biodiesel

Survey Results

- Survey sent to 67 transit systems across Canada
- 25 of transit systems answered the survey

Transit Systems Currently using Biodiesel

- 7 respondents indicated they currently use biodiesel
- Experiences:
  - Respondents indicated they used blends from 1% to 10%. One respondent indicated that they intend to use B20 in the near future. Another indicated that the BC Government legislated 5% bio diesel Jan 1st, 2010
  - Issues:
    - Cold weather mixing issues.
    - Outside storage area and do not use biodiesel during the winter months since the mix blocks the filter systems.
    - Required the addition of filters at filling stations, requires ongoing maintenance and replacement of filters on buses and filling stations.
    - One respondent indicated using 5% blend and supplier recommended using 2% blend from December to April and diesel from Christmas to New Years.

Transit Systems With Previous Biodiesel Experience

- 2 respondents indicated they had used biodiesel in the past, but do not use it now
- Issues:
  - Both respondents indicated that there was a higher cost than regular diesel forced cancellation.

Transit Systems With No Biodiesel Experience

- 16 respondents indicated they have not used biodiesel
- Issues:
  - Fuel availability (11)
  - Fuel Cost (7)
  - Maintenance requirements (9)
  - Lack of knowledge of effects on warranty and older engines
  - Cold weather operations

Engines

- Cummins Engine provides heavy-duty diesel engines to the transit industry in North America. For new vehicles, Cummins is the only manufacturer of heavy duty diesel engines for transit bus applications.
- See attached presentation from Cummins.
- Cummins provided additional comments:
  - Cummins approves engines up to 20% biodiesel on EPA 02/07/10 engines.
  - Expects the fuel provider to ensure that the fuel does not gel. Additives or other measures need to be taken to ensure no gelling, and these measures will vary climate/temperature.
  - Since the goal is to achieve 2% bio, on average, we feel it would be simpler to use 2% across the board, with proper measures for gelling.
  - As for issues on engines, pre-02, there is potential for leaks due to degradation of seals and gaskets, on pre-02 engines.
  - All of the comments are applicable for on-highway applications.

8.2.3 Canadian Oil Heat Association

CANADIAN OIL HEAT ASSOCIATION

115 Apple Creek Blvd, Suite 202
Markham, ON Canada L3R 6C9
Tel: (905) 946-0264 Fax: (905) 946-0316
Email: oilheat@coha.ca
Website: www.coha.ca

May 31, 2010

Nancy Johns
Senior Manager
Natural Resources Canada
580 Booth, 18th floor, 18C6
Ottawa, Ontario
K1A 0E4

Dear Nancy,

RE: Renewable Fuels Regulations in Canada

I am writing in regard to your request for the Canadian Oil Heat Association's (COHA) position on the proposed renewable fuel regulation.

COHA represents a broad spectrum of the oilheating industry, from producers to small contractors. Our industry looks forward to bringing the environmental benefits of renewable fuels to our end user customer base. COHA Executive Committee members discussed the presentation by Environment Canada with regard to the Renewable Fuels Regulations in Canada. Our understanding is that the regulations do not require 2% biofuel be put in every litre of #2 heating distillate oil; however, it requires an average 2% renewable diesel in the overall volumetric pool of the product, therefore, it is possible not all regions will have access to a blend of #2 heating distillate and biofuel. COHA looks forward to the day when all regions have access to a biofuel blend, but recognizes there will be many technical and supply challenges as the new mandate is implemented.

While COHA acknowledges the environmental benefits of renewable fuels, COHA also wants to ensure the quality and operability of any new fuels blended with traditional #2 heating distillate oil. COHA supports the introduction of the of renewable fuels regulations in Canada subject to the approval of the appropriate CAN/CGSB standard. Our Chairman, Mr. Steven Wilson, is a recent member of CAN/CGSB 3.2 Standard Committee and attended the Middle Distillate Committee in May, 2010 where the subject of an appropriate blended biofuel standard was discussed.

Given the magnitude of the changes being proposed, COHA believes a concerted educational effort must be made to bring all our members up to speed on the new regulations and its possible impact on operations and customers. A proposal for an educational program on renewable fuels regulations was submitted to NRCan for your consideration. This program will help the industry understand the regulations. COHA welcomes the opportunity to discuss the proposal at your earliest convenience.

I look forward to hearing from you soon.

Sincerely,
CANADIAN OIL HEAT ASSOCIATION

Veronica Yu
President & CEO

8.2.4 Canadian Federation of Aariculture

Nancy Johns
Senior Manager
Fuels Policy and Programs
Office of Energy Efficiency
Natural Resources Canada
580 Booth, 18th floor, 18C6
Ottawa, Ontario
K1A 0E4

May 28, 2010

Dear Ms. Johns,

The proposed *Renewable Fuel Regulation*s will require an average annual 2% renewable fuel content in diesel upon successful demonstration of the technical feasibility of such a mandate under Canadian conditions. The Canadian Federation of Agriculture (CFA) was pleased to see Natural Resources Canada's (NRCan) Office of Energy Efficiency commission a series of research projects though the National Renewable Diesel Demonstration Initiative (NRDDI) to assess the technical feasibility of biodiesel within the various conditions experiences in the agriculture sector. For CFA members, there was a clear need to analyze the effect that long-term and winter storage would have on biodiesel quality and equipment performance and what management practices related to blending and storage could be implemented to ensure successful implementation of the regulations.

The CFA is encouraged by the results of the NRDDI projects. The report "Effects on Long-term Storage on Biodiesel Quality" undertaken by the Prairie Agricultural Machinery Institute (PAMI) indicated that the long-term storage of biodiesel blends does not reduce the quality of biodiesel to the point where it fails specification testing. A second project run by the Saskatchewan Research Council (SRC) is currently underway and is continuing the initial work of PAMI by assessing storage effects on biodiesel quality under real world agricultural conditions. This project is evaluating biodiesel blends over a full cycle of farm equipment operations, including all aspects of the blending, distribution and storage of biodiesel. In addition, general operability and maintenance requirements of farm equipment utilizing biodiesel blends will be assessed. While the important spring portion of the equipment cycle has not yet been analyzed, the interim report for this project indicates that the integration of biodiesel blends into farming operations proceeded smoothly and required no changes to farmers standard farm bulk fuel storage practices. There was also little indication from farmers that equipment performance decreased. In addition, biodiesel quality and indicators such as water and sediment build up within the fuel all remained sufficient over the winter storage period. However, a point of concern for the CFA is biodiesel's high cloud point and the increased management requirements during the blending stage to ensure that the fuel meets specification.

The available results from these projects indicate that a 2% biodiesel blend is technically feasible for the operation of machinery in the agricultural sector. From the limited sample size within the research, it appears that biodiesel can be integrated easily into farming operations and that the quality of the fuel and equipment performance can be maintained at current standards. However, if the 2% mandate is to be successful, the CFA feels that increased focus must be placed on quality control and management of diesel supply chain, particularly the cloud point of biodiesel blended fuel. If the regulations are to be successfully implemented, it is essential that the many independent dealers farmers rely on for their fuel are given the knowledge, tools and diesel fuel necessary to ensure that biodiesel blends meet cloud point specifications.

The CFA looks forward to the completed results of the SRC study and any further feasibility studies being conducted by NRCan and offer our continued assistance to help ensure that the *Renewable Fuel Regulation*s can be successfully applied in Canada.

Yours sincerely,

Ron Bonnett
President, Canadian Federation of Agriculture

8.2.5 Canadian Canola Growers Association

CANADIAN CANOLA GROWERS ASSOCIATION

400 - 1661 Portage Ave. Winnipeg, MB R3J 3T7
Ph (204) 788-0090 Fax (204) 788-0039 www.ccga.ca

June 6, 2010

Nancy Johns, Senior Manager
Natural Resources Canada
Fuel Programs
580 Booth Street, 18th Floor, Room C8-2
Ottawa, Ontario K1A 0E4

Re: Canola growers' position on use of low-level biodiesel blends in equipment to use in NRCan report

Background: This statement will be included in a report from Natural Resources Canada to Environment Canada that documents the technical feasibility of an annual average 2% renewable content in the diesel and heating oil pool. This will be part of the statements from key stakeholders on this issue.

The Canadian Canola Growers Association (CCGA) strongly encourages the government of Canada to adopt a low-level biodiesel mandate in Canada. Numerous studies have shown that biodiesel blends are effective in every season, and in a wide range of equipment that is powered by diesel engines, including equipment used in transportation and agriculture.

We recognize there are small switch over costs for diesel engine operators, for example changing fuel filters which may become clogged due to the engine cleaning properties found in biodiesel. However, these transition costs and minor delays are tiny compared to the long term benefits created for the environment and the economy when biodiesel use is mandated in Canada.

Burning biodiesel is good for the health of Canadians and our environment, and making that biodiesel from Canadian feedstocks such as canola is good for our farmers and our rural economies.

The CCGA represents more than 50,000 canola farmers on national and international issues and policies that impact farm profitability.

The CCGA is a member of the Canadian Renewable Fuels Association.

8.2.6 Canola Council of Canada

Innovative. Resilient. Determined to create superior value and a healthier world.

canolacouncil

June 10th, 2010

Ms. Nancy Johns
Senior Manager Fuels Policy and Programs
Office of Energy Efficiency Resources Canada
Natural Resources Canada
580 Booth, 18th floor
Ottawa, ON K1A 0E4

Dear Ms. Johns:

Re: **Support for Agricultural Uses of Biodiesel**

The Canola Council of Canada represents a cross-section of organizations involved with the growing, distribution, crushing, food production and exporting of Canada's largest value agriculture commodity. The Council has had a keen interest in the biodiesel issue for a number of years having closely followed and strongly supported its development in Canada. We see biodiesel especially that produced using canola as a feedstock, as important for bringing added stability to Canadian agriculture while helping to meet Canada's greenhouse gas goals.

Feedback we have received from our growers is that they are aware of biodiesel and its properties and where it has been available in the Canadian market have used the product at different blend levels with success. The confidence in the use of biodiesel by agriculture equipment manufacturers is reflected in their engine warranties. Some manufacturers allow up to B100 to be used, while almost all now approve the use of a B20 blend. This situation in turn, has instilled a confidence in the agriculture sector that a national mandate of a B2 blend is well within the warranty conditions.

At the same time, actual in the field use by farmers and measured studies of biodiesel use by independent research organizations like PAMI and the SRC have confirmed there have been no operability issues with canola based biodiesel in the agriculture sector. Usage of biodiesel in the US and Europe by hundreds of thousands of farmers has evidenced the same conclusion.

We believe there are no technical reasons why a B2 blend can't be successfully used across Canadian agriculture. All the evidence points to the successful application in this sector of a national biodiesel RFS. For these reasons, the Council supports the implementation of a national RFS for biodiesel in Canada.

Yours sincerely,

JoAnne Buth
President
Canola Council of Canada

400 -167 Lombard Ave., Winnipeg, MB R3B 0T6 204.982.2100 Phone 204.942.1841 Fax 866.834.4378 Toll Free www.canola-council.org

8.2.7 Grain Growers of Canada

GRAIN GROWERS OF CANADA
LES PRODUCTEURS DE GRAINS DU CANADA

201- 8 York Street
Ottawa, ON
K1N 5S6
Ph 613-233-9954

www.ggc-pgc.ca

Members:

- Alberta Barley Commission
- Alberta Grain Commission
- Alberta Oat Rye & Triticale Association
- Alberta Pulse Growers
- Alberta Winter Wheat Producers Commission
- Atlantic Grains Council
- British Columbia Grain Producers Association
- Canadian Canola Growers Association
- Manitoba Corn Growers Association
- Prairie Oat Growers Association
- Western Barley Growers Association
- Western Canadian Wheat Growers Association

Nancy Johns, Senior Manager
Natural Resources Canada
Fuel Programs
580 Booth Street, 18th Floor, Room C8-2
Ottawa, Ontario K1A 0E4

June 11, 2010

RE: Support of Low-Level Bio-Diesel Blends

I am writing to you on behalf of the Grain Growers of Canada, who represent over 80,000 successful farmers through its membership organizations who grow wheat, oats, barley, canola, corn, peas, lentils and triticale.

We wish to express our strong support for the adoption of a low-level biodiesel mandate in Canada. Studies have shown these blends to be effective in every season and in a wide range of diesel equipment used in agriculture.

While we recognize there may be some minor transition costs for diesel engine operations, they are small compared to the economic and environmental benefits we gain from increased use of all biofuels, including biodiesel.

Biodiesel is better for our environment in comparison with fossil fuels, and can assist in our goal of reducing of greenhouse gas emissions. Additionally, the production of biodiesel from crops such as canola and soybeans will aid Canadian farmers to make a living through increased demand for our crops and the resulting increased prices.

The Grain Growers of Canada believe that governments do not owe farmers a living, but they must create a policy environment to allow farmers to make a living. Support for biodiesel is an investment in a productive policy environment for Canadian agriculture and agribusiness.

We strongly urge the Government of Canada to adopt a low-level biodiesel mandate in Canada, and look forward to offering any assistance towards that end.

Sincerely,

Doug Robertson,
President
Grain Growers of Canada

8.2.8 General Electric (Locomotive Engine Manufacturer)

GE Transportation

2901 East Lake Road,
Erie, PA 16531
USA
www.transportation.ge.com

May 2010

Position statement regarding the use of alternative fuels in GE's locomotives

The diesel engines on GE's locomotives are capable of burning a range of fuels. The performance of the engines, however, is optimized when burning petroleum-based #2 diesel fuel. Burning of fuels other than the petroleum-based #2 diesel fuel may have a negative impact on engine/locomotive performance, reliability, maintenance, and regulatory compliance.

With ever increasing concern over the cost and availability of diesel fuel, along with increasing questions around the potential environmental effects of burning fossil fuels, the railroad industry has elevated their interest in researching and qualifying alternative fuels for use in locomotives. One such alternative fuel is ***biodiesel***.

Biodiesel is a blend of chemically reacted oils from plant seeds, animal fats and used cooking oils with combustion properties similar to petroleum-based diesel fuel. While ***biodiesel*** can be used in pure form (B100), it typically is blended with #2 diesel fuel to create a more suitable fuel for burning in diesel engines.

Certain US states, Canadian provinces and countries around the world are strongly promoting the use of ***biodiesel*** blends as an alternative fuel. In many cases these various government entities have either adopted, or are considering adopting, legislation that would limit the sale of diesel fuel within their respective jurisdictions to only those fuels that can be classified as ***biodiesel*** fuels. Additionally, some of these government entities are providing significant financial incentives to those that produce, blend and burn ***biodiesel***. In response to this growing opportunity, several railroads that operate or are considering operating GE locomotives have been inquiring about the acceptability of using ***biodiesel*** in GE's family of locomotives. In assessing the acceptability of using ***biodiesel*** fuel in GE's locomotives, the prime considerations are the effects on engine power output, fuel efficiency, reliability, service requirements and regulated emissions compliance.

GE has conducted extensive testing of its locomotive engines using diesel fuel specified by the US EPA, as well as other variants, to ensure compliance with the US EPA and EU emissions requirements as well as our customers' fuel efficiency, performance and reliability expectations. Accordingly, GE's representations of regulated emissions compliance; performance and reliability of its engines (and thus its warranties and guarantees) are based on the composition of the actual diesel fuel used during testing.

As GE works toward the approval of alternative fuels or different fuel compositions for application in GE's engines, it is essential that each proposed fuel be tested in locomotive engines under the environment that such engines would actually see in operation. Without such testing, it is impossible for GE to know the performance impact of the fuel on the locomotive and thus how it might impact engine performance, reliability and regulated emissions compliance.

In addition to validating engine performance and reliability, it is necessary to ensure that the regulatory agency with jurisdiction recognizes and authorizes the use of the alternative fuel. An example of this is that under current US federal regulations governing locomotive emissions, US EPA approval is required before a manufacturer can approve its locomotive engines for use with a fuel (or mixed fuel) other than diesel fuel or natural gas fuel [40CFR 1033.101(f) and 40CFR 1033.501(e)].

Some proposed laws encouraging the use of ***biodiesel*** fuels are vague in specifying the composition of these new proposed fuels. The definition of ***biodiesel*** fuel includes a wide range of compositions, some of which have proven to be satisfactory when properly tested, and others that will likely not be satisfactory. To address this significant issue, standards are being developed around the world to accurately define the requirements for the base diesel & biofuel, as well as the final blended ***biodiesel***. GE's analysis and validation efforts have been based on the ASTM standards defined below:

ASTM D975 - 09a	Standard Specification for Diesel Fuel Oils
ASTM D6751 – 09	Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels

In an effort to support our customers and the industry, GE has recently completed an extensive evaluation of the impact from running ***biodiesel*** in GE's family of locomotives powered by FDL and Evolution® engines. The validation process includes three (3) specific phases with a go/no-go decision at the end of each phase.

- The first phase was to determine the impact on regulated emissions, fuel efficiency and performance. This phase has been completed by means of exhaustive testing at GE and third- party test facilities.
- The second phase was to assess the impact on reliability along with any potential changes to the overhaul and running maintenance work scope and interval on specific components on the locomotive that are exposed to the fuel. This phase has also been completed by means of exhaustive testing at GE and third- party test facilities.
- The final phase was to validate that the actual operating environment does not have an impact on the results that were found in the laboratory. This phase was completed through field operation in cooperation with selected North America based customers.

The results of testing indicates that a blend rate of 5% (B5) will not have a detrimental impact on the ability of the locomotive to produce its rated horsepower and comply with

current US EPA regulatory requirements for emissions. Furthermore, the impact on fuel consumption at this blend level will be minimal.

At this point in the *biodiesel* validation effort, GE is able to approve the use of *biodiesel* in GE's family of locomotives powered by FDL and Evolution® engines at a maximum blend rate of 5% (B5) by volume, providing the *biodiesel* fuel used is fully compliant to **ASTM D975 - 09a** Standard Specification for Diesel Fuel Oils, and the biofuel (B100) used to make the B5 meets **ASTM D6751 – 09** Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels.

GE will continue with our validation process for other biodiesel fuel blends, and will carry on with a clear focus to ensure that GE's locomotives will be able to support the needs of the railroads and the railroad industry in the area of alternative fuels. If you have any questions on GE's Biodiesel effort, please contact Pete Lawson, at pete.Lawson@ge.com or at (814) 875 – 6603.

8.2.9 *Shipping Federation of Canada (email)*

The Shipping Federation of Canada would like to acknowledge the work undertaken by Natural Resources Canada as part of the National Renewable Diesel Demonstration Initiative, more specifically with respect to a 2% renewable diesel use in the Canadian marine sector under the Renewable Fuels Regulations. We would like to think that biodiesel offers a promising avenue in reducing air emissions and greenhouse gases from the marine sector, and we are pleased to see that the body of research on this topic is growing.

Unfortunately, the work did not include any experiments on oceangoing vessels, which would have addressed some of the concerns we have with respect to the operations of such vessels. While there have been several studies involving biodiesel on-board ships, none of these experiments are transferable due to the differences in engine sizes and overall operational environments. We have stated in our comments to Environment Canada that the proposed regulations lack specific information as to how the regulations would be applied to the marine sector. More specifically, the proposed regulations do not offer insight as to whether their provisions would be aligned with the ISO *Petroleum products -- Fuels (class F) -- Specifications of marine fuels*, which has been developed to ensure fuel quality.

The newly completed standard, ISO 8217:2010 *Petroleum products -- Fuels (class F) -- Specifications of marine fuels* published on June 15, 2010, specifically excludes biodiesel products. Several factors support this decision, including concerns related to storage and handling (such as poor low temperature flow properties, tendency to oxidation, long term storage issues, affinity to water, risk of microbial growth and FAME material deposition on exposed surfaces including filter elements). Moreover, Working Group 6 under the Technical Committee 28/SC4, which specifically addresses marine fuel standards, recommends that the possibility of including biodiesel in marine fuels be debated at the next revision.

It is of the utmost importance to our industry that fuel purchases are tested for compliance with these specifications, since non-conformity will effectively void the warranty on the ships' engine. As a consequence, no engine damage will be insured, which is a risk that no shipowner will take. Given that biodiesels were excluded from the new ISO 8217 norm for the abovementioned reasons, as well as the fact that there has been no long-term study of biodiesel usage on-board oceangoing vessels, we cannot endorse a 2% renewable diesel use for use in the Canadian marine sector.

8.2.10 Chamber of Shipping of British Columbia (email)

As previously mentioned, the only concern expressed by our members has been one of bio-diesel content potential price differential, however, this does not currently appear to be a factor.

In researching this subject I did come up with the following article on ISO standardization which was a concern well expressed by Mr.Lantz during the recent teleconference.

Quote:
25th September 2009 10:48 GMT

The ISO8217 working group will continue to assess test methods

Changes proposed in the fourth edition of the international marine fuel standard, ISO 8217, represent a "significant advance on previous editions", according Wanda Fabriek. Fabriek is the chair of the working group that oversees the specification's revision process, the ISO TC/28/SC 4/Working Group 6 (WG6).

In an article prepared for Bunkerworld, she said a request by the **International Maritime Organization (IMO)** to ensure the fourth edition was ready by July 2010 has been a "particular driver" behind the development of this latest edition. The draft of the fourth edition of ISO 8217 is currently out for balloting, and the Draft International Standard (DIS) version is available from the **International Organization for Standardization (ISO)** website (www.iso.org) for public comments.

Additionally, the ISO 8216-1 standard entitled "Petroleum products - Fuels (class F) classification - Part 1: Categories of marine fuels" has also been revised and is similarly out for balloting. The working group (WG6) that Fabriek chairs comprises 33 expert members from 14 countries, drawn from all sides of the marine fuel industry.

Fabriek highlighted three key issues that were also the subject of discussion at the IMO's Marine Environment Protection Committee (MEPC) meeting in July this year."The work of maintaining and developing of marine fuels quality standards will always require some degree of compromise" One is the presence of biodiesel in marine fuels due to supply chain logistics. It has become "almost inevitable" that some marine distillates, and even perhaps marine residual fuels, could contain some biodiesel, Fabriek noted.

Although biodiesel blends are used and encouraged for the automotive industry, within the marine industry there is a lack of generalised experience with biodiesel and biodiesel blends. There are also a number of issues with regards to storage stability and the potential adverse effects on the existing range

of marine engines and other ancillary equipment from biodiesel and biodiesel blends, Fabriek pointed out.

The ISO 8217 working group has therefore recommended that at the current stage of specification development, only a minimal amount of biodiesel can be tolerated in petroleum-based marine fuels. It is "seeking to develop a suitable test method, or methods, to measure biodiesel concentrations in marine distillate and residual fuels in order to be able to quantify this issue," Fabriek wrote.

Interest in biodiesel or biodiesel blends for the marine sector has been heightened due to its potential to reduce emissions targeted by regulations. Fabriek said trials of such fuels should be "in the full knowledge of all parties as to the particular composition of the fuels being used." The ISO has asked the IMO to consider the status of biodiesel fuels and blends with regard to the MARPOL Convention and other statutory instruments, Fabriek stated.

Hydrogen sulphide - H2S - was another contentious issue at the MEPC meeting in July. As concerns have been raised in some quarters of an increased incidence of H2S in bunker fuels, it has been added as a newly proposed specification parameter for the ISO 8217 standard. Although there is a potential for the presence of this toxic compound in bunker fuel there is very limited data on the incidence of H2S in marine fuels. In the absence of reliable historical data on the occurrence and concentration of H2S in marine fuels, a conservative but practical limit has been set at 2 mg/kg in the liquid phase for both residual and distillate fuels. In doing so, ISO faced criticism at the MEPC for its recommended maximum with the MEPC suggesting that the limit should be reduced to zero.

Fabriek explained that the working group acknowledges that H2S should not be present in marine fuels, but said that a zero level was not technically viable due to the lack of reliable data and limitations of the currently available test methods. The 2 mg/kg maximum limit does not condone the inclusion of H2S in marine fuel, but balances the practicalities of H2S management in component streams and the Safety Data Sheet advice for all involved in working with marine fuels to always take precautions against the possible presence of H2S.

Although it is possible to accurately measure H2S in the vapour phase, as per the standard test method (ASTM D5705), this is "more appropriate as an occupational health protection measure, but due to its limitations it cannot be considered as a marine fuel specification test method." it was also suggested at the MEPC meeting in July to remove H2S measurement from the ISO 8217 specification. By including H2S into the standard, it will help establish the facts about the level of H2S in bunkers supplied to ships and promote better awareness of the safety implications, according to the ISO working group. "By removing this parameter from the specification there will be no warning and no further developments to improve on the test methods available," Fabriek commented.

Turning to fuel combustion and ignition delay, Fabriek said it was "hard to describe the enormity of the task at hand" when considering this complex issue. The available test methods, CCAI (Calculated Carbon Aromaticity Index) and the FCA (Fuel Combustion Analyser), both have their own strengths and weaknesses. CCAI fails to assess the complex chemistry of a particular fuel, nor can it address the fuels actual performance in an engine.

Establishing the FCA test method (IP541/06) as a standard parameter at this time, meanwhile, was deemed premature in view of the ongoing research into the practical application of this method within the marine industry. Fabriek explained that the working group decided to include CCAI because it is a simple and readily accessible tool which, despite its limitations, has proven useful over the years as a means to avoid fuels with extremely uncommon density/viscosity relationships.

The working group will continue to assess test methods with regards to fuel ignition and combustion performance with a view to inclusion in future revisions of the ISO 8217 standard. Preparing the fourth edition of ISO 8217 to address air quality, ship safety, engine performance and crew health has undoubtedly provided the ISO working group with a number of challenges. "The work of maintaining and developing of marine fuels quality standards will always require some degree of compromise with the industry's various stakeholders demanding from each other the best engine performance, the best fuel quality together with widespread availability," Fabriek observed.

Fabriek concluded that the draft currently out for balloting "represents a significant advance on previous editions and fairly reflects the realities of the current petroleum and marine worlds."

Unquote

I also came across this article which details a study currently underway by Lloyds Register's Strategic Research Group and funded by the Government of the Netherlands in cooperation with Maersk Line.

http://www.lr.org/news_and_events/press-releases/181528-maersk-and-lloyds-register-team-up-for-marine-engine-biofuel-tests.aspx

Other than this we have nothing further to add to the discussion at this time, however, thank you for the opportunity to comment

sincerely
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8.2.11 Canadian Construction Association

I am writing on behalf of the Canadian Construction Association at the suggestion of Ms. Nancy Johns o Natural Resources Canada. She urged me to share with the views of the association with regard to Environment Canada's intention to regulate B2 biodiesel use across Canada by 2011.

This past weekend in Regina, our Environment and Research and Innovation Committees were treated to a presentation by Mr. Cameron Rittich of FPInnovations on their study: *Demonstration of the Potential Use of Biodiesel for Off-Road Machinery in Canadian Highway Construction and Forest Operations*. The study focused on biodiesel use in off-road operations and found no technical issues exist with regard to widespread substitution of B2 for conventional diesel fuel. While the use of higher content biodiesel presented some performance issues (such as poor engine performance due to the solvent properties of biodiesel and the circulation of dislodged build-up throughout the fuel system), these performance issues were overcome with thorough fuel tank cleanings prior to biodiesel use. Long-term storage of higher content biodiesels in remote areas were also raised as a potential concern however, given that most remote construction occurs on a seasonal basis (spring to fall), any storage challenges (even in remote areas) can be overcome by a change in fuel procurement policies. Therefore, CCA's concerns with regard to the mandated use of B2 are not technical in nature.

While CCA members support the greater use of biodiesel in construction vehicles and equipment, they are opposed to mandated-use policies and believe markets work best when consumer decisions drive innovation, not government policies. Since the FPInnovations study demonstrated B2 fuel will have a negligible impact on tailpipe emissions and that appreciable declines are only registered when formulations of B20 or higher are utilized, there appears to be little environmental justification to proceed with this regulation at this time. Furthermore, mandating B2 across Canada will put further pressure on already tight biodiesel feedstock, thereby likely increasing industry fuel costs without any significant improvement in overall environmental performance.

CCA members find the increased use of biodiesel a laudable goal and one that, over time, has the potential to yield substantial environmental benefits. They remain, however, opposed to a mandated B2 fuel policy and recommend that B2 and other high content bio-oil formulations be introduced into the Canadian economy on a voluntary basis and only expanded gradually as more adequate supplies of biodiesel feedstock become available.

At your convenience, I would be pleased to discuss this matter further with you. In this regard, please do not hesitate to contact me directly at 613 236-9455 ext. 432.
Sincerely,

Bill Ferreira
Director of Government Relations and Public Affairs | Directeur des relations gouvernementales et des affaires publiques

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8.2.12 Canadian Petroleum Products Institute

Appendix C: CPPI comments on the RIAS for 2%

CPPI and its members have participated to a series of programs under the National Renewable Diesel Demonstration Initiative, led by Natural Resources Canada. During the course of the programs, valuable insight has been gained, on the impact of various biodiesel types and renewable diesel blends, under Canadian conditions. In some cases, the gap between experimentation and practical application remains substantial and must be adequately addressed in the final decision-making to ensure a seamless introduction of biodiesel blends into the market place.

Those findings need to be taken under consideration by the Standards setting organizations, such as CGSB, to develop and adopt the required standards that will ensure consumers that the new products are fit for intended purpose, when introduced into the market. CPPI does not support the introduction in the market place, of a new fuel products, without the appropriate standard.

The introduction of Renewable diesel and Biodiesel blends requires extensive and careful planning, as it impacts on many segments of the supply chain, from Refinery to storage, blending and distribution. Sufficient time must be available, from regulatory certainty, to allow proper infrastructure design, construction and commissioning. For example, the initiatives provided direction on blending components (ULSK & HDRD) requirements and biodiesel attributes (SMG) of concern that require addressing, in order to mitigate the risks to customers of using biodiesel blends under severe Canadian winter operating conditions. We remain concerned that , many of the initiatives understated the logistical challenges in sourcing/transporting the required blending components. The NRDDI NRCan Biodiesel Distribution Infrastructure Analysis is expected to provide additional insight on these important aspects. CPPI members have provided detailed information on the specific requirements and associated timelines and therefore shall be considered a key element in assessing the technical readiness.

In closing, CPPI stresses that these three aspects must be taken into consideration; that is:

- understanding the conditions and limitations,
- having appropriate standards in place, and
- providing sufficient time to implement the necessary infrastructure.

Only when those three aspects are present, one can consider the supply chain is technically ready for a seamless transition to the end consumer.

DRAFT

8.2.13 Canadian Renewable Fuels Association

Canadian Renewable Fuels Association
National Renewable Diesel Demonstration Initiative (NRDDI) Summary Statement

The CRFA believes that all of the NRDDI projects have successfully demonstrated the full operability of renewable diesel fuels under Canadian conditions in a variety of applications that are representative of the renewable diesel fuels are likely to be used in Canada.

Global renewable diesel (RD) consumption in 2010 is projected to be 100 million barrels, distributed across the Americas, Europe and Asia. Biodiesel is the primary commercially available RD, accounting for over 98% of RD. Low level biodiesel blends have been proven in virtually every sector, excepting aviation, for over a decade. Biodiesel is now pipelined and stored in petroleum product terminals around the world. Every major engine manufacturer has approved its use. Mandated markets in several Canadian provinces have been implemented without incident at blend levels exceeding the federal Renewable Fuel Standard.

Natural Resources Canada's **National Renewable Diesel Demonstration Initiative (NRDDI)** program was created to confirm the full operability of renewable diesel fuels under Canadian conditions in advance of the proposed renewable fuels regulation that would require an average annual 2% renewable content in diesel fuel by 2011 or earlier. The NRDDI studies covered all of the key sectors for biodiesel use. Prior to the NRDDI program, the ARDDI (Alberta Renewable Diesel Demonstration Initiative) demonstrated successful use of low level biodiesel blends in on-road applications in extreme Canadian conditions. There were no truck filter plugging issues and no dispenser filter plugging issues in the ARDDI.

The NRDDI projects studied different applications including rail, forestry, agriculture and others. Some of the projects covered some aspects of long term storage. The most exhaustive of these was the Manitoba Hydro Fleet LTS (Long Term Storage) project.

CP Locomotive NRDDI Study
The primary focus of the CP (Canadian Pacific) Locomotive demonstration was to investigate the feasibility of using up to a maximum of five percent biodiesel blend (B5) in freight locomotives operating in cold weather service. The diesel engines on General Electric (GE) locomotives are capable of burning a range of fuels. The scope of this study included operating four GE AC4400 diesel locomotives with a FDL-16 engine in captive service between Calgary and Edmonton on CP's mainline from November 2009 to March 2010.

AC4400s represent approximately 75% of CP's active locomotive fleet. In this demonstration, the assessment was focused on locomotive performance, condition, maintenance and replacement frequency of engine components and fuel efficiency. Regarding the principal objective of assessing operability, no "loss of service events" were noted. There was no indication of significant differences in engine components, lubrication or combustion. Overall, this demonstration showed successful use of B5 blends in rail application in Canadian climate.

Demonstration of the Potential Use of Biodiesel for Off-Road Machinery in Canadian Highway Construction and Forest Operations NRDDI study
The NRDDI forestry study provides evidence that biodiesel blends in the B2 to B10 blend ratio can be used with little to no preparation on the part of the end-user of the highway construction and forest operation sectors. Biodiesel blends all met the blend specifications, and all blends such as B10 in this study's case, were used with ease. In all, 47 machines participated in running biodiesel blends. Monthly machine hours at the sawmill ranged as high as 350 hours for one machine to a low of 8 hours for machines that sit idle and are used on a backup basis. The machinery was monitored to ensure productivity was not compromised and machine operators interviewed to gauge their acceptance and perception on any negative impacts to the machines' operability. The responses from the users were all positive and there was no downtime encountered. Over 280,000 litres of biodiesel blends were consumed and over 7,000 hours of problem free machine time were positive indicators of success.

PAMI Ag Biodiesel Study – Effects of Long Term Storage on Biodiesel Quality
In 2008, PAMI (Prairie Agricultural Machinery Institute) participated in a biodiesel demonstration that included ten farms where biodiesel was used in their harvest equipment. Upon project completion, the biodiesel blend was left in the fuel tanks of the combines. Nine months later, the biodiesel blend samples were sampled and analyzed. In addition, PAMI also collected B5, B10 and B20 samples that had been stored for two years in outdoor storage tanks. The results of the testing demonstrated that long term storage of biodiesel blends up to B20 for periods of up to two years does not adversely affect the quality of the biodiesel blend.

SRC (Saskatchewan Research Council) Agricultural Biodiesel Study - Off Road Biodiesel Demonstration Agricultural Sector
This demonstration provided the Canadian agricultural diesel fuel consumer group with a real-world, closely monitored, biodiesel experience to determine performance characteristics, blending and storage requirements. This NRDDI study demonstrated that adoption of low level biodiesel blends into the agriculture sector does not require changes on the part of producers in relation to on-farm bulk fuel storage practices. This demonstration did not make any modifications to producer bulk tank storage systems such as the incorporation of filters or water separators, or conversion to compatible materials, and throughout the monitoring period, from August 2009 to April 2010, fuel quality was demonstrated to have been maintained.

Project participants indicated that no equipment operational problems were experienced in the demonstration, and no changes as compared to operating on diesel were noted. There were no issues found related to water and/or sediment build-up in equipment stored during the winter period and in unused bulk tanks. None of the tractors or tanks tested indicated excessive water and/or sediment levels. Overall, this demonstration has shown successful use of biodiesel blends in agricultural applications.

Imperial Oil – Furnace Oil Study
In this NRDDI study, a test program was carried out by Imperial Oil to evaluate the long term performance of late-model furnaces using bio-furnace fuel. The test facility was equipped with three furnaces and each test consisted of three cycles (40 days each) to simulate spring/fall, moderate severity and winter cold snap operations using furnace fuel blended with Canola Methyl Ester (CME), Soybean Methyl Ester (SME) and Tallow Methyl Ester (TME). Furnace operating parameters were monitored weekly during the test. Inspection of systems (filters, burners, pumps, burner nozzles, and heat exchangers) was performed after each test. The results from the test program showed that there was negligible impact on furnace operation and performance with furnace fuel up to B10. The results from this NRDDI study were in part used as supporting documentation for the CGSB Heating Oil specification to include B5, which recently passed ballot.

Imperial Truck Study - Low Temperature Operability Test Phase 2: Impact of Saturated Monoglycerides on HDD Truck Operation

This NRDDI study was a laboratory study that employed a technique of spiking a CME (Canola Methyl Ester) with high levels of SMG (Saturated Monoglycerides). The study showed that the performance of the fuel delivery systems associated with the heavy duty diesel trucks tested was negatively impacted when such techniques were used to artificially spike SMG at high levels. The preliminary findings of this study were due to the high melting point of individual SMG components. However, the additional work done in the Manitoba Hydro Fleet study would indicate that spiking high levels of SMG in a lab experiment may yield erroneous results. Based in part on the work of this NRDDI study, the CSFBT test and limit has been included in the proposed CGSB B100 specification.

Imperial Oil - Low Temperature Storage Test Phase II - Identification of Problem Species

To gain a better understanding of the saturated mono-glyceride issue, the low temperature storage stability of fifty seven bio-diesel fuels comprising essentially B5 and B20 made with CME (Canola Methyl Ester), SME (Soy Methyl Ester), TME (Tallow Methyl Ester) were tested. The deposits from selected B20 blends after cold soaking were analyzed. Based in part on the work of this NRDDI study, the CSFBT test and limit has been included in the proposed CGSB B100 specification.

Demonstration of the Use of Biodiesel in Electric Generators in Remote Canadian Locations and Long Term Storage in Gensets

The purpose of this NRDDI study was twofold. One purpose was to assess long term storage of biodiesel in remote locations. The other purpose was to demonstrate the use of biodiesel blends to northern Canadian regions for use in gensets for power generation. This project successfully demonstrated storage and use of B5 blends in gensets in remote Canadian locations in extreme conditions.

The genset maintenance records demonstrated that no additional maintenance was required with the use of the B5 blends in the demonstration. There were no issues or additional maintenance required during the course of this project. The Genset Demonstration and LTS (Long Term Storage) Study sought to understand whether the reported dispenser filter issues are related to long term storage, biodiesel blending and handling, biodiesel B100 quality or minor impurities. This study mirrored the efforts of the Manitoba Hydro Fleet LTS NRDDI study in that regard. The testing involved both tank aged and laboratory aged samples. This NRDDI study showed that in cooling the samples to zero degrees over 15 successive days showed no signs of solids formation. The data for samples cooled 3 °C above the cloud point for 15 days showed no signs of solids formation. The D4625 data for the B5 blend demonstrate stable long term storage of up to one year. There were no issues with sediment formation or any fuel related issues of using a B5 blend in a harsh Canadian environment over the course of this demonstration project.

Long Term Storage and Use of Biodiesel in Fleets Summary

The purpose of the testing and monitoring of long term storage of biodiesel blends for the Manitoba Hydro fleets was to study long term storage and distribution of biodiesel blends for trucking use. In the last few years, there have been a few incidents of dispenser filter plugging in biodiesel blends in the USA. The LTS Fleet Study sought to understand whether this issue is related to long term storage, biodiesel blending and handling or biodiesel B100 quality. This NRDDI study provided a greater understanding of the likely root cause of these prior incidents and the implications on long term storage requirements. There were operational or dispenser plugging issues as a result of biodiesel use in Manitoba Hydro fleets in this demonstration. This observation applies to both the period of the project from August 2009 to April 2010 as well as to the prior two years of biodiesel use in Manitoba Hydro Fleets. The Manitoba Hydro Fleet LTS Study sought to understand whether the dispenser filter issues reported in other jurisdictions have been related to long term storage, biodiesel blending and handling, biodiesel B100 quality or minor impurities. This differs from other NRDDI studies in the fact that this study includes both lab data and field data and only used commercially available B100 samples.

The Manitoba Hydro Fleet LTS study also sought to better understand the preliminary findings of the Imperial Oil Low Temperature Storage Test Phase 2 - Identification of Problem Species.

In the Manitoba Hydro study, the fuels were observed upon removal after incubating at 3 °C above cloud point and any visible solid formed went back into solution within one hour with no agitation. Blends up to B15 were evaluated and pictures of the samples taken over the fifteen day test show no signs of solids formation after incubation at 0 °C for 15 days. The D4625 data for the B5 and B8 blends demonstrate stable long term storage of up to one year.

The Fleet Long Term Storage Demonstration thus provided confirmation of successful blending, handling, long term storage and use of these biodiesel blends in extreme Canadian conditions, with no dispenser filter plugging or truck filter plugging issues.

Conclusion

The CRFA believes that all of the NRDDI projects have successfully demonstrated the full operability of renewable diesel fuels under Canadian conditions in a variety of applications that are representative of the renewable diesel fuels are likely to be used in Canada. In many cases these projects were designed to test the fuels in operating conditions far more severe than most users will experience and yet no significant issues were identified in the programs.

The CRFA supports the use of renewable fuels that are commercially proven, produced under industry best practices, and distributed under established fuel specification standards. All of these criteria have been well documented for biodiesel use in Canada and there are no reasons not to proceed with the 2% renewable requirement in the Canadian distillate pool.