

**Environment and Natural Resources Trust Fund  
2011-2012 Request for Proposals (RFP)**

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**LCCMR ID: 164-F3+4**

**Project Title:** Liquid Biofuel With Economic And Environmental Benefits

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**Category:** F3+4. Renewable Energy

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**Total Project Budget:** \$ \$151,963

**Proposed Project Time Period for the Funding Requested:** 1.4 yrs, July 2011 - Sept 2012

**Other Non-State Funds:** \$ 0

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**Summary:**

The research will demonstrate that dimethyl ether, produced from renewable biomass is a value added, second generation liquid biofuel for home heating and cooking applications.

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**Name:** David Kittelson

**Sponsoring Organization:** U of MN

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Minneapolis MN 55455

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**Web Address:** http://www.me.umn.edu/research/faculty/kittelson.shtml

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**Location**

**Region:** NW, NE

**Ecological Section:** Northern Superior Uplands (212L), No. Minnesota and Ontario Peatlands (212M)

**County Name:** Statewide

**City / Township:**

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<input type="checkbox"/>	Funding Priorities	<input type="checkbox"/>	Multiple Benefits	<input type="checkbox"/>	Outcomes	<input type="checkbox"/>	Knowledge Base				
<input type="checkbox"/>	Extent of Impact	<input type="checkbox"/>	Innovation	<input type="checkbox"/>	Scientific/Tech Basis	<input type="checkbox"/>	Urgency				
<input type="checkbox"/>	Capacity	<input type="checkbox"/>	Readiness	<input type="checkbox"/>	Leverage	<input type="checkbox"/>	Employment	<input type="checkbox"/>	TOTAL	<input type="checkbox"/>	%

# 2011-2012 MAIN PROPOSAL

**PROJECT TITLE:** Liquid Biofuel With Economic And Environmental Benefits

## I. PROJECT STATEMENT

The objective of the research is to demonstrate that dimethyl ether (Bio-DME), produced from the gasification of renewable biomass resources is a value added, second generation liquid biofuel that can be blended with propane for home heating and cooking applications. Production of Bio-DME from biomass, as shown in the illustration, reduces greenhouse gas emissions, does not harm the environment, and will create a new market for Minnesota biomass. Since Bio-DME is a liquid fuel it can be used in combination with propane for heating, as a future transportation fuel in diesel engines, or exported, much like wood chips, but with a much higher monetary value because of its higher energy density and flexibility. Bone dry wood chips sell for about 7 cents per pound of wood chips. Bio-DME would be expected to sell for about 36 cents per pound. Bio-DME combustion produces less black smoke than propane and is produced from a renewable biomass source, thus the net greenhouse gas emissions compared to propane derived from fossil fuel is near 0. Bio-DME also has no impact on the earth's ozone layer, is biodegradable, is virtually non-toxic, and has chemical and physical properties similar to propane.

The most immediate large scale use of Bio-DME in Minnesota would be as a blending agent with propane for use in cooking and home heating. In Minnesota, 193,000 homes use propane for heating (9.3%). Annual sales of propane in Minnesota amount to about 400 million gal/yr at a cost of about \$2.05/gal. Grills and space heaters also use propane, and distribution of the standard 20 lb white propane tank is common throughout the state at stores and gas stations. We intend to demonstrate that Bio-DME blended with propane is a suitable fuel for gas grills, space heaters, cooktops and home furnaces. The overall goal of the project is to demonstrate and publicize the use of Bio-DME to show potential producers of Bio-DME that there is a market for the product in Minnesota.

In Minnesota Bio-DME could be produced using a process developed in Sweden that uses a by-product of pulp manufacturing, black liquor. Normally black liquor is recycled back into the plant to generate additional heat or electricity in a black liquor boiler. In the Swedish process, mills harvest additional forest residue (slash, limbs, leaves, etc) or other biomass (stover, grass, etc.) along with wood for pulp. The residue and/or harvested biomass is processed in a boiler producing additional heat or electricity for the pulp plant, thus allowing some (20%) of the plant's black liquor to be used in a black liquor gasifier to produce Bio-DME. No significant impact on the forest landscape is expected as long as MN Forest Resources Council woody biomass harvest guidelines are followed, and solvents in the black liquor are recycled. The additional black liquor can be gasified at the mill to produce Bio-DME that can be sold locally or exported. We estimate that about 3.6 % of Minnesota's total propane consumption could be met with a modest expansion of the Boise and Sappi mills. The production and sale of Bio-DME would bolster the economies in Cloquet and International Falls.

## II. DESCRIPTION OF PROJECT ACTIVITIES

**Activity 1:** Evaluate Bio-DME/propane blends for performance and emissions and compare to 100 % propane. **Budget:** \$ 131,963

Outcome	Completion Date
1. Purchase a gas grill, space heater, cooktop and small home furnace and build a test stand for their evaluation in the laboratory	8/15/2011

2. Measure performance and emissions (particulate matter, carbon monoxide, carbon dioxide, oxides of nitrogen, hydrocarbons and selected hazardous air pollutants) using 100 % propane.	1/13/2012
3. Measure performance and emissions using Bio-DME/propane blends of 10%, 20% and 50%.	6/30/3012
4. Make recommendations for the blend ratio of Bio-DME/propane that optimizes performance and emissions without necessitating a change in hardware design, and if necessary make recommendations on changes in hardware design to allow more efficient use of Bio-DME/propane blends.	9/30/2012

**Activity 2:** Evaluate biomass availability and biomass harvest impacts on the forest environment. **Budget:** \$ 20,000

Outcome	Completion Date
1. Estimate the amount of harvest residue needed for Bio-DME production	10/15/2011
2. Estimate potential availability of woody biomass for Bio-DME production from timber harvest residue within the purchase areas (~ 50 mi) for the two MN pulp mills.	2/15/2012
3. Evaluate the potential impact of the forest residue harvest on the forest environment, and make recommendations for implementing a Bio-DME forest biomass strategy.	6/15/3012

**Activity 2:** Publication and presentation of results. **Budget:** \$ 0

Outcome	Completion Date
1. The results of the project will be shared to ensure the widest possible public distribution. Distribution through the MN Forest Resources Council, the Institute on the Environment, and the scientific literature will ensure broad distribution.	9/30/2012

### III. PROJECT STRATEGY

**A. Project Team/Partners** Funding will be provided to Prof. David Kittelson, principal investigator and Director of the Power and Propulsion Laboratory, and his research team at UMN. The team includes Dr. Winthrop Watts, graduate and undergraduate students and Dr. David Zumeta, Executive Director of the MN Forest Resources Council, and his staff.

**B. Timeline Requirements** We anticipate 15 months will be required to complete this project. This timeline optimizes the amount of time available to our students to conduct lab work during the summer without the requirement to attend class.

**C. Long-Term Strategy and Future Funding Needs** This project is a first step to introduce Bio-DME to MN. MN has had no any previous experience with DME research, thus we envision that it will be necessary to partner with other organizations to encourage Bio-DME production in MN. This project will demonstrate our capabilities and the potential of Bio-DME as a propane additive for use in home heating and cooking applications. We will continue to seek funding from other organizations such as the Department of Energy's National Renewable Energy Laboratory and we will use this project as a platform to highlight the potential of Bio-DME to the MN pulp producers. It will also enhance our capability to educate future engineers about the benefits of biomass-based renewable fuels for the future.

**Project Budget**

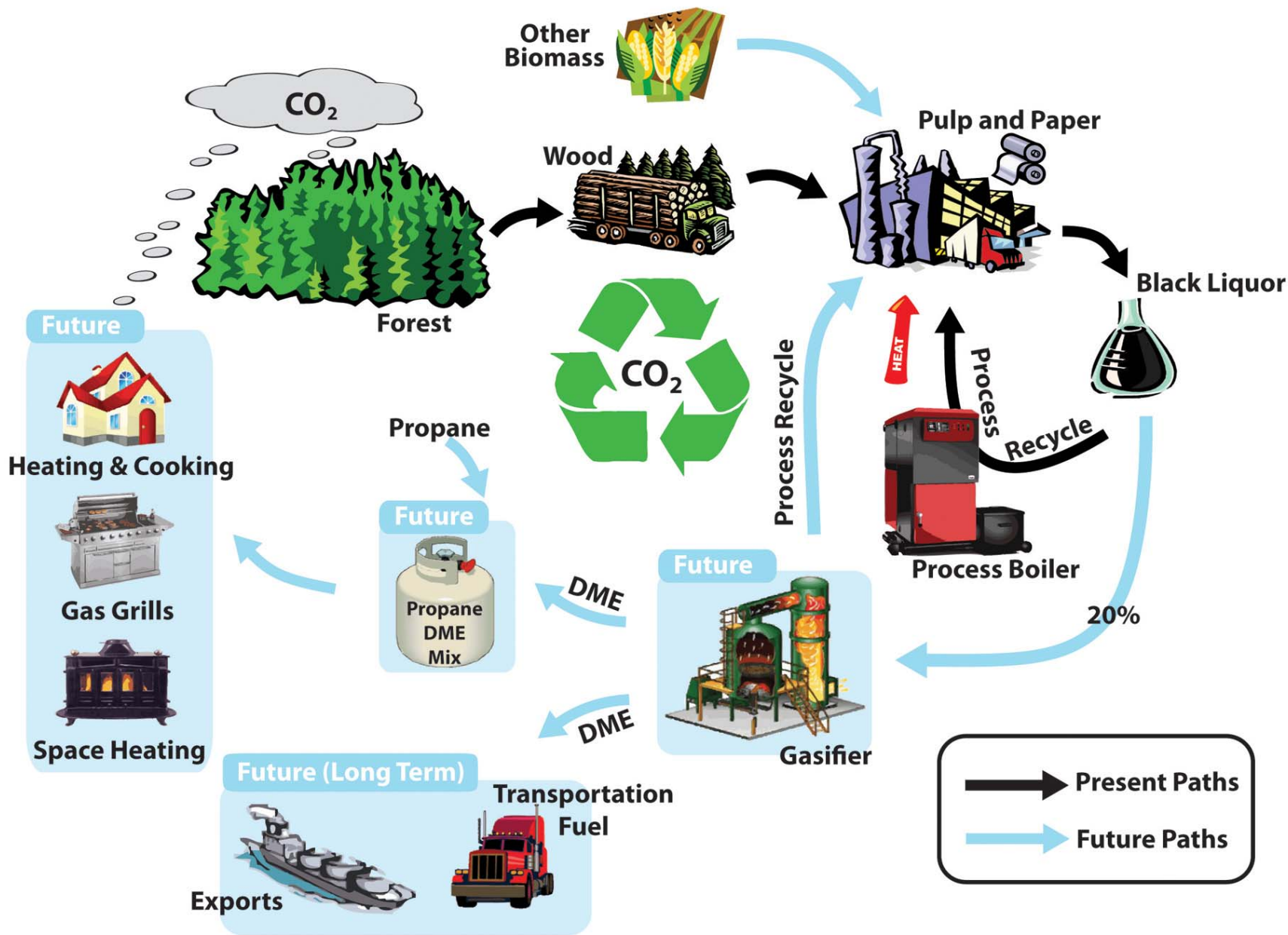
**IV. TOTAL PROJECT REQUEST BUDGET (15 month project)**

<b>BUDGET ITEM</b>	<b>AMOUNT</b>
<b>Personnel:</b>	
Prof. Kittelson, PI, 7.7% time, 75.6% salary, 24.4% fringe	\$ 29,680
9-month academic appointment	
Dr. Watts, Res Assoc., 13.5% time, 75.6% salary, 24.4% fringer	\$ 23,059
Dr. Watts is paid entirely from research funds	
Mr. Zarling, Mechanical Engineer, 6.3% time, 73.0% salary, 27.0% fringe	\$ 7,774
Mr. Zarling is paid entirely from research funds	
Graduate Research Assistant (GRA) 50% time, 57.4% salary, 42.6% fringe	\$ 54,949
GRA Fringe benefit 16.84 % of salary, Tuition benefit \$14.32 * hrs	
<b>Contracts:</b>	N/A
<b>Equipment/Tools/Supplies:</b>	
Dimethy ether fuel @~\$400 per bottle of DME	\$ 4,000
Fuel storage and delivery system	\$ 15,000
Test stand development and modification	\$ 12,500
Calibration gases (NO, CO, NOx)	\$ 400
Factory calibration of flow meters, particle analyzers	\$ 2,500
Swagelock fittings, tubing, miscellaneous parts	\$ 1,500
<b>Acquisition (Fee Title or Permanent Easements):</b>	
<b>Travel:</b>	
Presentation and publication of results at biofuels meetins in MN	\$ 600
<b>Additional Budget Items:</b>	NA
<b>TOTAL PROJECT BUDGET REQUEST TO LCCMR</b>	<b>\$ 151,963</b>

**V. OTHER FUNDS**

N/A

# Pulp Mill Biorefinery



## **DAVID B. KITTELSON**

Frank B. Rowley Distinguished Professor of Mechanical Engineering and Director, Center for Diesel Research and Power and Propulsion Laboratory, University of Minnesota

### **Education**

B.S. and M.S. in Mechanical Engineering, University of Minnesota, 1964 and 1966, Ph.D. in Chemical Engineering, University of Cambridge, England, 1972

### **Work Experience**

1970-76, Assistant Professor, 1976-80, Associate Professor, 1980-present, Professor, Department of Mechanical Engineering, University of Minnesota; 1996-present, Director, Center for Diesel Research, University of Minnesota

### **Other Related Experience**

Visiting Scientist, IRCA Centre de Recherche, Vert le Petit, France (spring 1977) Visiting Professor, University of Vienna, Institute of Applied Physics (spring 1981); Overseas Fellow, Engineering Department, Cambridge University, Cambridge, UK (1985-86 and 2003-04 academic years); Instructor, Short Course (3-4 lectures), "Diesel Particulate and NO<sub>x</sub> Emissions," Leeds University, Leeds, UK, (April 1988-annually); Consultant, European Commission "Particulates" program (2000-03); Health Effects Institute (2005- ); Army Aberdeen Proving Grounds (2005-06); California Air Resources Board (2006- ).

### **Selected Awards**

Overseas Fellowship Churchill College, Cambridge University, 2003-04, Frank B. Rowley Endowed Professorship in Mechanical Engineering (December 2002 - ), Center for Transportation Studies 2000 Braun Distinguished Service Award; SAE 1998 Arch T. Colwell Outstanding Paper Merit Award: Graskow, B.R., D.B. Kittelson, I.S. Abdul-Khalek , M.R. Ahmadi, and J.E. Morris, "Characterization of Exhaust Particulate Emissions from a Spark Ignition Engine," SAE Paper No. 980528; SAE 1995 Arch T. Colwell Outstanding Paper Merit Award: Simons, G.R. and D.B. Kittelson, "Reducing Utility Engine Exhaust Emissions with a Thermal Reactor," SAE Paper No. 951762; Fellow, Society of Automotive Engineers, 1992

### **Research Interests**

Sampling and characterization of exhaust emissions from diesel and gasoline fueled engines; development of advanced engine exhaust aftertreatment systems, production and use of second generation renewable biofuels including biodiesel, butanol, DME, and ethanol; use of hydrogen produced on-board to modify conventional and low temperature combustion in engines; reduction of greenhouse gas emissions from transportation sources, and development of fast response sensors for engine control.

## **ORGANIZATION**

The Center for Diesel Research and the Power and Propulsion Laboratory are in the Department of Mechanical Engineering at the University of Minnesota. These laboratories conduct teaching and research activities aimed at developing and evaluating emission control technology, and second and third generation biofuels. The laboratories are fully equipped to make particulate matter and gaseous measurements and can evaluate emissions and performance from a diverse array of engines. A complete description of the laboratories is found at <http://www.me.umn.edu/labs/pp/index.shtml>.