

**Environment and Natural Resources Trust Fund  
2015 Request for Proposals (RFP)**

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**Project Title:**

**ENRTF ID: 110-E**

Reducing Emissions from Open Burning through Biomass Gasification

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**Category:** E. Air Quality, Climate Change, and Renewable Energy

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**Total Project Budget:** \$ 268,188

**Proposed Project Time Period for the Funding Requested:** 2 years, July 2015 - June 2017

**Summary:**

Open burning of wood waste in Minnesota results in unnecessary harmful emissions. This project will characterize and promote clean and efficient distributed biomass gasification of wood waste for rural energy.

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**Sponsoring Organization:** U of MN

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**Location**

**Region:** Metro, SE

**County Name:** Brown, Hennepin

**City / Township:** Minneapolis and New Ulm

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**Alternate Text for Visual:**

Diagram showing how unnecessary emissions from open burning of wood waste can be avoided through clean and efficient distributed gasification

|                          |                         |                             |                      |
|--------------------------|-------------------------|-----------------------------|----------------------|
| _____ Funding Priorities | _____ Multiple Benefits | _____ Outcomes              | _____ Knowledge Base |
| _____ Extent of Impact   | _____ Innovation        | _____ Scientific/Tech Basis | _____ Urgency        |
| _____ Capacity Readiness | _____ Leverage          | _____ TOTAL                 |                      |



**PROJECT TITLE: Reducing Emissions from Open Burning through Biomass Gasification**

**I. PROJECT STATEMENT**

Minnesota forests produce 2.4 million tons of wood waste per year. A significant fraction of that biomass is burned in open piles resulting in harmful pollution, generating unnecessary carbon dioxide emissions and wasting energy. The Minnesota DNR estimates that 35,000 tons of piled woody biomass was burned in Southwest MN this winter alone emitting approximately 128,000 tons of CO<sub>2</sub>. ***This project proposes distributed gasification for combined heat and power as an alternative to open burning of wood waste in Minnesota.***

Large-scale, high efficiency gasification systems have been demonstrated in regions of MN with high agricultural intensity. However, large-scale gasification is too expensive for wood waste produced over a large geographic area due to collection and transportation costs. Our hypothesis is that small-scale (less than 50 kW) gasification systems can produce energy from wood waste nearer to its source, improving the economics of gasification while reducing emissions of pollutants and reducing reliance on fossil sources of energy like propane that have high price fluctuation. State parks are ideal sites for distributed gasification due to their low energy use and remote location. The three primary goals of our project are:

- 1) Quantify the pollutant emissions reduction potential of a reliable, small-scale, locally operated combined heat and power gasifier system operated on wood chips compared to open burning of the same quantity of biomass. Measured emissions will include oxides of nitrogen (NO<sub>x</sub>), hydrocarbons and particulate matter.
- 2) Estimate the carbon emissions reduction potential of small-scale gasification for distributed heat and power for remote applications like state parks and rural residences. CO<sub>2</sub> emissions will be measured from the gasifier system and equivalent carbon emissions avoided from fossil fuel burning will be calculated.
- 3) Publically promote the use of distributed gasification technology by demonstrating a 10 kW combined heat and power gasification system at a MN DNR facility and posting energy savings on the DNR’s Energy Smart website ([www.dnr.state.mn.us/energysmart/](http://www.dnr.state.mn.us/energysmart/)).

We will measure emissions from a donated gasifier-generator system from All Power Labs at the University of Minnesota (UMN) Engine Research Facility during the first year of the project. The system will then operate on dried wood chips in the DNR’s Regional Office Facility in New Ulm, MN augmenting their newly installed photovoltaic array providing electricity during times of peak energy demand. The system will be returned to UMN at the end of the project. This two year program has the potential to have significant impact in Minnesota by illustrating the benefits of small-scale distributed gasification to avoid open burning of woody biomass while saving energy and reducing emissions.

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1: Characterize Pollutant Emissions from Small-Scale Gasifier System** **Budget: \$92,541**

In this task we will characterize a 10 kW gasifier-generator system given to the project by All Power Labs, Berkeley, CA at UMN’s new T.E. Murphy Engine Research Laboratory. A full suite of emissions equipment is readily available for the purposes of evaluating the system.

| <b>Outcome</b>   | <b>Completion Date</b> |
|--|------------------------|
| <i>1. Measured NOx, volatile hydrocarbon, and particulate matter emissions from system</i> | <i>12/31/2015</i>      |
| <i>2. Efficiency of gasifier-generator system with combined heat and power unit</i>        | <i>12/31/2015</i>      |
| <i>3. Comparison of emissions generated by gasifier-generator to open burning</i>          | <i>6/1/2016</i>        |

**Activity 2: Quantify Carbon Emissions Reduction Potential from Biomass Gasification** **Budget: \$38,386**

This task will measure CO<sub>2</sub> emissions from the gasifier-generator system and use that to estimate the savings possible when using the system as a replacement for propane and other fossil fuels. A complete energy balance will be completed taking into account both heat and electricity generated by the system.

| <b>Outcome</b>  | <b>Completion Date</b> |
|---|------------------------|
| <i>1. Measured CO<sub>2</sub> emissions from gasifier-generator system and energy balance</i> | <i>12/31/2015</i>      |
| <i>2. Estimation of achievable carbon reductions based on fossil fuel savings</i>             | <i>6/1/2016</i>        |



**Activity 3: Demonstrate and Promote Distributed Gasification for Rural Applications Budget: \$137,261**

In this activity, we will transport the gasifier-generator system to the DNR facility in New Ulm, MN and install the unit in an outbuilding constructed to contain it. Heat will be provided to an adjacent building and electricity will be connected to the facility power. Once the system is operational, the DNR will allow public access to the facility and publish energy generation data on their Energy Smart website.

| Outcome  | Completion Date |
|--|-----------------|
| 1. Installed gasifier-generator system and hookup at DNR                               | 9/1/2016        |
| 2. Data from operating system updated on DNR Energy Smart Website                      | 12/31/2016      |
| 3. Multiple tours and exhibits of installed gasifier-generator system conducted at DNR | 6/1/2017        |

**III. PROJECT STRATEGY**

**A. Project Team/Partners**

Will Northrop is an Assistant Professor at the UMN in the Department of Mechanical Engineering. He is the project’s principal investigator and UMN is the recipient of all funding. Prof. Northrop is partnering with Mark Lindquist, Biofuels Program Manager for the Department of Natural Resources to conduct the project. The DNR will host the gasifier system at its New Ulm office during the second year of the project. DNR will supply woody biomass collected from nearby Flandrau State Park or use woody biomass slated for open burning. Woody biomass will be stored and dried at the New Ulm facility in the first year of the project in preparation for the installation. Energy from the gasifier system will be used from 7 to 11 AM in the winter and 2 to 5 pm in the summer for peak shaving and heating as required. Excess energy will be returned to the grid or stored in batteries for later use. The gasifier system will provide data for DNR to evaluate small-scale distributed gasification to complement and expand its already comprehensive renewable energy program. The system will be returned to UMN at the end of the two-year project. A graduate and undergraduate student will characterize and modify the gasifier system as previously described during year 1 and will assist in the installation and performance evaluation in year 2. DNR staff will be responsible for maintaining the system during the demonstration phase and for posting data to the Energy Smart web site.

**B. Project Impact and Long-Term Strategy**

This project expands a project Prof. Northrop began in 2011 with funding from the UMN College of Science and Engineering. A similar gasifier-generator system, procured on a DOE grant, was set up and operated on UMN’s St. Paul Campus to evaluate pollutant emissions. In the project, it was determined that the gasifier’s packed bed filter and the combustion of the producer gas in the spark-ignited engine substantially reduced emissions with the greatest impact on particulate matter and aromatic compounds like benzene, toluene, and tar. The current project extends our previous findings by measuring a greater number of pollutants over a larger testing campaign.

It is our long-term vision that this project will demonstrate the environmental and economic benefits of small-scale gasifier systems that utilize local biomass for distributed energy generation using wood waste that would be otherwise be disposed of through open burning. For example, we estimate that operating a small-scale gasifier-generator at 10 kW for 5 hours per day can save \$2,636 per year in energy costs, displacing propane used as the heating fuel and electricity from the grid.

**C. Timeline Requirements**

The three activities of this project are scheduled to be completed within 24 months. Characterization of the small-scale gasifier-generator system will occur in the first year of the project. The system will be installed at the New Ulm facility starting in the second year. It is estimated that it will be operational and incorporated into the facility heat and power by September of 2016, in time for the heating season. During the demonstration activity, DNR will operate the system and post-results on the Energy Smart web site. In later phases of the project, Prof. Northrop and co-workers will publish the results and seek federal funding for a larger project to further demonstrate the benefits of utilization of waste wood for distributed energy generation.

## 2015 Detailed Project Budget

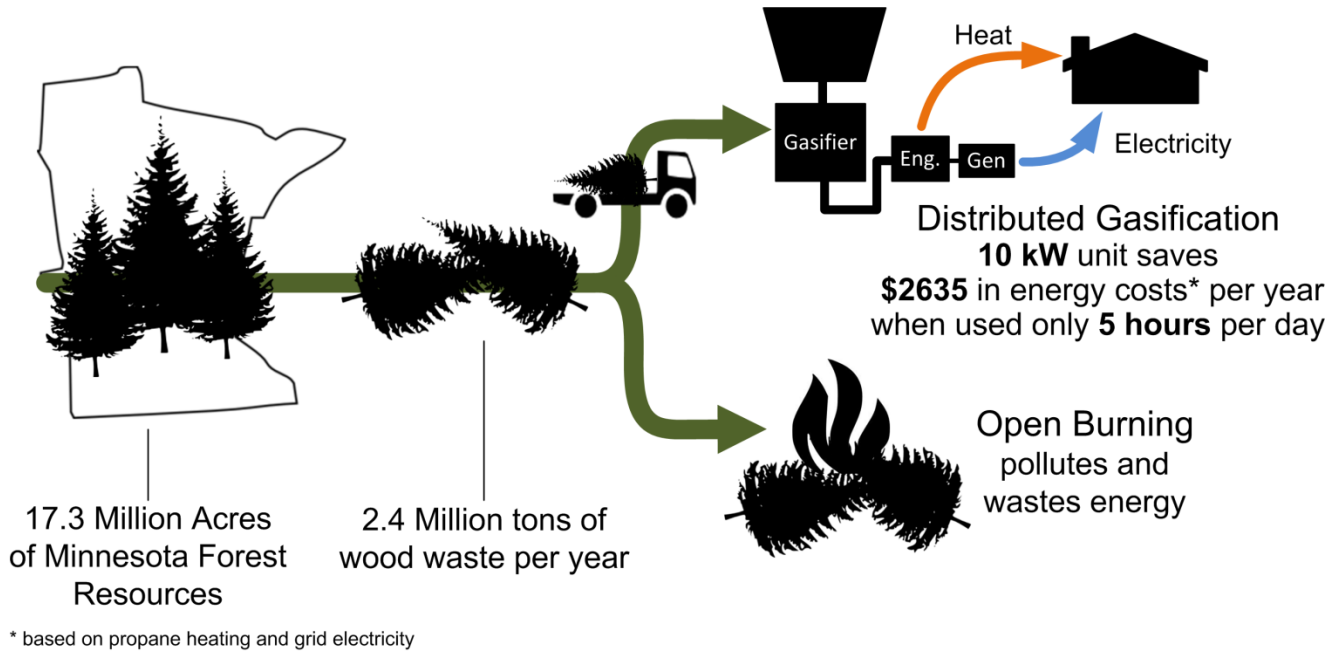
**Project Title:** Reducing Emissions from Open Burning through Biomass Gasification

### IV. TOTAL ENRTF REQUEST BUDGET 2 years

| <u>BUDGET ITEM</u>   | <u>AMOUNT</u>     |
|--|-------------------|
| <b>Personnel:</b>  |                   |
| Prof. Will Northrop, Project Manager (75% salary, 25% benefits); 4% FTE for 2 years        | \$ 13,477         |
| Prof. David Kittelson, Lab Director (75% salary, 25% benefits); 2% FTE for 2 years         | \$ 11,931         |
| Darrick Zarling, Research Scientist (75% salary, 25% benefits); 20% FTE for 2 years        | \$ 39,756         |
| Dr. Win Watts, Research Scientist (75% salary, 25% benefits); 10% FTE for 2 years          | \$ 26,950         |
| 1 Undergraduate Research Assistant (100% salary); 50% FTE for 2 years                      | \$ 24,279         |
| 1 Graduate Research Assistant (60% salary, 40% benefits); 50% FTE for 2 years              | \$ 88,294         |
| <b>Contracts:</b>  |                   |
| Construction services firm TBD; installing outbuilding and electrical at DNR               | \$ 30,000         |
| <b>Equipment/Tools/Supplies:</b>   |                   |
| Consumables, wiring, plumbing and maintaining emissions and performance instruments        | \$ 30,000         |
| <b>Acquisition (Fee Title or Permanent Easements): N/A</b>                                 |                   |
| <b>Travel:</b>   |                   |
| Mileage and travel expenses for field site visits  | \$ 1,000          |
| Lodging and expenses for 3 month student visit for gasifier installation and commissioning | \$ 2,500          |
| <b>Additional Budget Items: N/A</b>  |                   |
| <b>TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST =</b>                     | <b>\$ 268,188</b> |

### V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

| <u>SOURCE OF FUNDS</u>   | <u>AMOUNT</u> | <u>Status</u>  |
|--|---------------|----------------|
| <b>Other Non-State \$ To Be Applied To Project During Project Period:</b> Gasifier to be provided by All Power Labs for emissions characterization and demonstration at Minnesota DNR facility   | \$ 40,000     | <i>Pending</i> |
| <b>Other State \$ To Be Applied To Project During Project Period:</b> N/A  | \$ -          |                |
| <b>In-kind Services To Be Applied To Project During Project Period:</b> 150 hours DNR staff time to coordinate installation, procure wood fuel, and operate the equipment. Wood chips will also be produced by DNR assuming 6 tons at a value of \$30 per ton. | \$ 10,680     | <i>Secured</i> |
| <b>Funding History:</b> N/A  | \$ -          |                |
| <b>Remaining \$ From Current ENRTF Appropriation:</b> N/A  | \$ -          |                |





**PROJECT TITLE: Reducing Emissions from Open Burning through Biomass Gasification**

**I. PROJECT MANAGER QUALIFICATIONS**

Will Northrop, Assistant Professor, University of Minnesota, Department of Mechanical Engineering will be the project manager of the proposed work. Prof. Northrop received his M.S. and Ph.D. in mechanical engineering from University of Michigan-Ann Arbor in 2003 and 2009 respectively. Prior to coming to University of Minnesota (UMN), he worked as a Senior Researcher at General Motors Research and Development as a member of the Propulsion Systems Research Laboratory. At UMN he is a principal investigator on projects in the areas of advanced combustion, alternative fuels, emissions control for internal combustion engines, and hydrogen/syngas production and utilization. Prof. Northrop is currently advising six graduate students and four undergraduate research assistants working on funded research projects. He has published over twenty peer reviewed articles and three US patents. For the past two years, Prof. Northrop has led a research project on small-scale biomass gasification using a system similar to the one to be used in the proposed project. In this work, sponsored by the UMN College of Science and Engineering, emissions and efficiency data were collected from a small-scale gasifier-generator operating on wood chips. The project found that the spark-ignited engine was effective at combusting pollutants found in producer gas, the fuel produced by the wood gasification process. The current project builds on this previous work and is well within the scope of research projects managed by Prof. Northrop.

**II. ORGANIZATIONAL DESCRIPTION**

University of Minnesota Mechanical Engineering Department: The Department of Mechanical Engineering, part of the College of Science and Engineering at the University of Minnesota Twin Cities Campus, serves the state and nation as a leading center of education, research, and innovation. The Department has 44 active faculty, 30 staff members, 300 graduate students, 50 postdoctoral associates, research associates and visitors, and about 550 undergraduate students. In 2013, the Department invested over \$5M into a new laboratory facility for engines fuels and emissions research. Recently named the T.E. Murphy Engines Research Laboratory, the facility is ideally equipped for the proposed research project as it contains an external test cell for generator and gasifier testing as well as all the necessary instrumentation for characterizing the performance and emissions of combustion-powered devices.

Minnesota Department of Natural Resources: The mission of the Minnesota Department of Natural Resources (DNR) is to work with citizens to conserve and manage the state's natural resources, to provide outdoor recreation opportunities, and to provide for commercial uses of natural resources in a way that creates a sustainable quality of life. The Minnesota DNR has worked to support State GHG and energy management strategies through a variety of approaches. DNR is a leader within state agencies in the tracking and reduction of operational GHG emissions reduction and deployment of renewable energy technologies. DNR is also engaged in a range of activities seeking to support the development of sustainable biomass markets and supply chains. In addition, DNR is responsible for wildfire prevention and suppression in the state, and finding alternatives to open burning is an important wildlife mitigation strategy. The New Ulm Regional Office is particularly well suited to piloting the small scale biomass gasifier. The Regional office hosts administrative and specialized technical operations. These include the regional shop, with two full time mechanics experienced in automotive and small engine work, regional fleet and facilities program staff and uniquely the state- wide Biomass Program Manager. The New Ulm Regional Office has both the technical capacity to successfully pilot a biomass project as well as the capacity to support further deployment of successful project experience to other DNR facilities.