



Environment and Natural Resources Trust Fund (ENRTF) M.L. 2015 Work Plan

Date of Report: December 22, 2014

Date of Next Status Update Report: January 1, 2016

Date of Work Plan Approval:

Project Completion Date: June 30, 2017

Does this submission include an amendment request? No

PROJECT TITLE: Reducing Emissions from Open Burning through Biomass Gasification

Project Manager: William Northrop

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Location: Minneapolis (Hennepin County), New Ulm (Brown County)

Total ENRTF Project Budget:	ENRTF Appropriation:	\$268,000
	Amount Spent:	\$0
	Balance:	\$268,000

Legal Citation: M.L. 2015, Chp. 76, Sec. 2, Subd. 07b

Appropriation Language:

\$268,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota in cooperation with the Department of Natural Resources to characterize and promote distributed biomass gasification of wood waste as a means for producing renewable and sustainable energy in rural areas through a demonstration at the Department of Natural Resources regional office facility in New Ulm.

I. PROJECT TITLE: Reducing Emissions from Open Burning through Biomass Gasification

II. 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 CO₂. ***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. Large scale waste woody biomass heat and power systems also exist in concentrated metropolitan areas but again depend on transportation infrastructure to maintain low cost. 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 nitrogen oxides (NO_x); particulate matter (PM); light hydrocarbon emissions known as volatile organic compounds (VOCs); and aromatic hydrocarbon emissions including benzene, toluene and ethyl-benzene.
- 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. CO₂ 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/).

We will measure emissions from a donated gasifier-generator system from All Power Labs (APL) 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. These times correspond to winter heating during the day where electricity from the photovoltaic array is insufficient to power geothermal heat pumps. The gasifier-generator system will be returned to UMN at the end of the project for use in future research programs. 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.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of January 1, 2016:

Project Status as of July 1, 2016:

Project Status as of January 1, 2017:

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Characterize Pollutant Emissions from Small-Scale Gasifier System

Description: In this task we will characterize the pollutant emissions from a 20 kW-electric Power Pallet gasifier-generator system donated to UMN by All Power Labs (APL), Berkeley, CA. The most recent generation of the Power Pallet from APL has been successfully installed in remote locations worldwide. The gasifier converts woody biomass to syngas, a gas containing high concentrations of hydrogen, methane and carbon monoxide. Syngas is easily combustible in spark-ignited engines and serves as the only engine fuel. An intermediate filtration system removes tars and other impurities from the syngas before being sent to the engine. However, the filtration system does not completely remove some impurities from the syngas. This activity will fully characterize the engine's ability to reduce regulated and unregulated compounds through combustion and to determine whether engine combustion generates additional pollutant emissions. Increasingly stringent emissions regulations on stationary boilers and generators necessitate understanding of whether biomass gasification systems can operate cleanly and safely in the locations where they are installed.

As part of Activity 1, the Power Pallet gasifier-generator will be initially installed at UMN's new T.E. Murphy Engine Research Laboratory (MERL). The MERL is equipped with an outside test cell ideally suited for testing gasifiers. The laboratory also has a full suite of emissions equipment readily available for the purposes of evaluating the system. Pollutant emissions to be measured includes nitrogen oxides (NOx); particulate matter (PM); light hydrocarbon emissions known as volatile organic compounds (VOCs); and aromatic hydrocarbon emissions including benzene, toluene and ethyl-benzene. Pollutant concentrations will be measured at three locations in the gasifier-engine system; at the outlet of the gasifier reactor, the outlet of the syngas filtration system and the engine exhaust. Results from the testing will help to inform APL on how to optimize their system and will provide data for proving emissions reductions compared to open burning of woody biomass. Additional benefits from this task will be a set of procedures for testing pollutant emissions which can be later applied to other wood burning appliances in future projects or collaborations.

This task will also compile existing data concerning pollutant emissions from open burning of wood waste. Input will be sought by federal and state organizations on the study to determine the amount of woody biomass burned on a yearly basis and measured emissions from such fires. The scientific literature will also be searched for emissions factors per mass burned for open burning of different types of waste biomass. These data will be compared to the experimental results from the gasifier generator to be tested in this project.

Summary Budget Information for Activity 1:

ENRTF Budget: \$ 124,925
Amount Spent: \$ 0
Balance: \$ 124,925

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

Activity Status as of January 1, 2016:

Activity Status as of July 1, 2016:

Activity Status as of January 1, 2017:

Final Report Summary:

ACTIVITY 2: Quantify Carbon Emissions Reduction Potential from Biomass Gasification

Description: This task will quantify CO₂ emissions from the Power Pallet gasifier-generator system and use that data to estimate the savings possible when using the system as a replacement for propane and other fossil fuels. Biomass burning is renewable to the extent that additional fossil energy is not used in its harvesting, transport or processing. Wood waste generally is from forest thinning and logging activities and thus can be considered a

byproduct of other operations. Burning wood in open piles emits CO₂ but does not use the heating value of the material to do useful work.

During this task, a complete energy balance of the Power Pallet will be completed taking into account both heat and electricity generated by the system. This information, in combination with the measured CO₂ emissions will be used to compare with both the CO₂ generated by open burning as well as the CO₂ emitted from other stationary generator fuels used in rural applications like propane or diesel fuel. From this collected information, a good estimation of carbon savings for biomass gasification compared to fossil power will be made and published in the open literature.

Summary Budget Information for Activity 2:

ENRTF Budget: \$ 42,575
Amount Spent: \$ 0
Balance: \$ 42,575

Outcome	Completion Date
1. Measured CO₂ emissions from gasifier-generator system and energy balance	12/31/2015
2. Estimation of achievable carbon reductions based on fossil fuel savings	6/1/2016

Activity Status as of January 1, 2016:

Activity Status as of July 1, 2016:

Activity Status as of January 1, 2017:

Final Report Summary:

ACTIVITY 3: Demonstrate and Promote Distributed Gasification for Rural Applications

Description: In this activity, we will transport the Power Pallet gasifier-generator at the MN-DNR’s Regional Office Facility in New Ulm and install the unit in an outbuilding to protect it from weather. A contractor will be hired to install the unit and perform the necessary electrical and plumbing connections to the DNR facility. The Power Pallet unit will be placed adjacent to a facilities maintenance garage and staff from the shop will run the unit during the winter of 2016/2017. Electrical energy will be used to power geothermal heat pumps during the day, supplementing the installed photovoltaic array at the facility. Heat will be provided to an adjacent building and electricity will be connected to the facility power.

The main purpose of this phase of the project is to demonstrate the feasibility of small-scale gasification systems in rural applications like state parks. A key outcome will be to understand the staffing needs for the unit in terms of refueling and maintenance required for such a system. DNR staff will operate the system and The UMN project team will monitor the unit both on-site and remotely using a data acquisition system to collect additional performance and emissions data.

Once the system is operational, the DNR will allow public access to the facility and publish energy generation data on their Energy Smart website. These outreach activities are a crucial part of the program to educate the public and government decision makers about the benefits of distributed gasification for combined heat and power.

Summary Budget Information for Activity 3:

ENRTF Budget: \$ 100,500
Amount Spent: \$ 0
Balance: \$ 100,500

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

Activity Status as of January 1, 2016:

Activity Status as of July 1, 2016:

Activity Status as of January 1, 2017:

Final Report Summary:

V. DISSEMINATION:

Description:

Results regarding emissions and CO₂ from the gasifier generator system will be disseminated through journal papers in scientific publications and through presentations at conferences. The Program Manager will also work with DNR to schedule tours and activities once the gasifier system is operational in New Ulm. Instantaneous energy production from the system will be published on the DNR's Energy Smart website: (<http://www.dnr.state.mn.us/energysmart/>).

Status as of January 1, 2016:

Status as of July 1, 2016:

Status as of January 1, 2017:

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	\$ Amount	Overview Explanation
Personnel:	\$ 204,500	1 project manager at 8% FTE; 1 laboratory director at 2% FTE; 1 research scientist at 25% FTE; 1 undergraduate student researcher at 50% FTE; and 1 graduate research assistant at 50% FTE
Professional/Technical/Service Contracts:	\$ 30,000	Construction serviced firm TBD; installing outbuilding and electrical service at DNR New Ulm facility.
Equipment/Tools/Supplies:	\$ 15,000	Consumables, wiring, plumbing and maintaining emissions and performance instruments for gasifier emissions testing. Also includes communications hardware for sending data back to UMN from New Ulm installation.
Capital Expenditures over \$5,000:	\$ 15,000	All Power Labs Power Pallet 20 kW gasifier generator system
Travel Expenses in MN:	\$ 3,500	Mileage and travel expenses for field site visits and meetings at New Ulm. Lodging and expenses for a 3 month student visit for gasifier installation and commissioning in second year of project.
TOTAL ENRTF BUDGET:	\$ 268,000	

Explanation of Capital Expenditures Greater Than \$5,000: A 20 kW Power Pallet gasifier generator system manufactured by All Power Labs (APL), Berkeley, CA will be purchased using project funds. Due to the close and longstanding relationship between UMN and APL, the purchase price has been reduced from \$40,000 to \$15,000 with the promise that UMN will provide operating data to APL and help them with improving their product. The outreach component of the proposed project is also valuable to APL in marketing its gasifier technology to customers in the US. The system has a useful life of approximately 15 years and will be used primarily for research and demonstration purposes. Upon completion of the project, the system will be returned to the TE Engine Research Laboratory at UMN for continued research, education and outreach.

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 1.35

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 1.5

B. Other Funds:

Source of Funds	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
State			
	\$ 10,680	\$ 0	150 hours DNR staff time to coordinate installation, procure wood fuel, and operate the gasifier equipment. Wood chips will also be produced by DNR assuming 6 tons at \$30 per ton
TOTAL OTHER FUNDS:	\$ 50,680	\$ 0	

VII. PROJECT STRATEGY:

A. Project Partners:

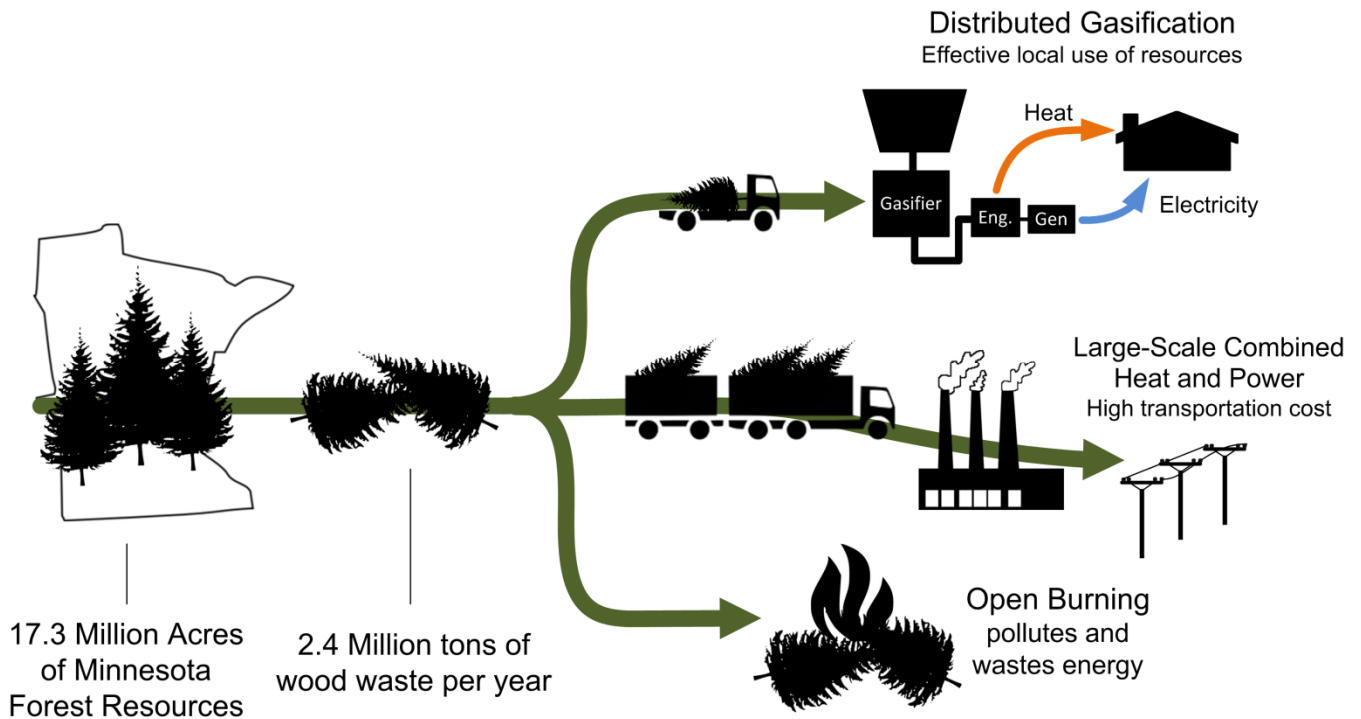
The UMN will work with the MN-DNR on this project. The Power Pallet will be installed at the MN-DNR’s Regional Office Facility in New Ulm in the second year of the project. Mark Lindquist is the main technical contact at DNR responsible for interfacing with UMN to complete this project. Mark will work closely with the UMN team throughout the project. No DNR salary will be paid from this grant. The DNR has committed 150 hours of in-kind staff time to coordinate installation of the gasifier, procure wood fuel, and operate the equipment. DNR staff will also contribute time in putting gasifier energy production on the Energy Smart website.

B. Project Impact and Long-term Strategy:

The main goal of this project is to prove that distributed gasification is a clean, renewable and cost-effective option for reclaiming energy that is otherwise lost when open burning waste woody biomass. The disseminated results from the project will provide information about how small-gasifiers might be installed more widely in rural Minnesota as an alternative to small propane or diesel-fueled generator systems. One immediate result of a successful demonstration of the technology with the DNR could be the installation of more small gasification systems in state parks to meet their goals in renewable energy and environmental stewardship.

Long term, the UMN team hopes to leverage this project to secure new funding to develop new gasifier technologies and perhaps foster the manufacture of such systems in the State of Minnesota.

IX. VISUAL COMPONENT or MAP(S):



XI. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted no later than January 1 2016, July 1 2016, and January 1 2017. A final report and associated products will be submitted between June 30 and August 15, 2017.

Environment and Natural Resources Trust Fund
M.L. 2015 Project Budget



Project Title: Reducing Emissions from Open Burning through Biomass Gasification

Legal Citation:

Project Manager: Will Northrop

Organization: University of Minnesota

M.L. 2015 ENRTF Appropriation: \$ 268,000

Project Length and Completion Date: June 30, 2017

Date of Report: December 22, 2015

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	<i>Characterize Pollutant Emissions from Small-Scale Gasifier System</i>			<i>Quantify Carbon Emissions Reduction Potential from Biomass Gasification</i>			<i>Demonstrate and Promote Distributed Gasification for Rural Applications</i>				
Personnel (Wages and Benefits) Overall	\$102,250	\$0	\$102,250	\$40,900	\$0	\$40,900	\$61,350	\$0	\$61,350	\$204,500	\$204,500
Prof. Will Northrop, Project Manager (75% salary, 25% benefits); 8% FTE for 2 years (\$26,955)											
Prof. David Kittelson, Lab Director (75% salary, 25% benefits); 2% FTE for 2 years (\$11,931)											
Darrick Zarling, Research Scientist (75% salary, 25% benefits); 25% FTE for 2 years (\$65,181)											
1 Undergraduate Research Assistant (100% salary); 50% FTE for 2 years (\$12,139)											
1 Graduate Research Assistant (60% salary, 40% benefits); 50% FTE for 2 years (\$88,294)											
Professional/Technical/Service Contracts											
Construction serviced firm TBD; installing outbuilding and electrical service at DNR New Ulm facility.							\$30,000	\$0	\$30,000	\$30,000	\$30,000
Equipment/Tools/Supplies											
Consumables, wiring, plumbing and maintaining emissions and performance instruments for gasifier emissions testing. Also includes communications hardware for sending data back to UofM from New Ulm installation.	\$7,500	\$0	\$7,500	\$1,500	\$0	\$1,500	\$6,000	\$0	\$6,000	\$15,000	\$15,000
Capital Expenditures Over \$5,000											
All Power Labs Gasifier Generator System	\$15,000	\$0	\$15,000							\$15,000	\$15,000
Travel expenses in Minnesota											
Mileage and travel expenses for field site visits and meetings at New Ulm. Lodging and expenses for a 3 month student visit for gasifier installation and commissioning in second year of project.	\$175	\$0	\$175	\$175	\$0	\$175	\$3,150	\$0	\$3,150	\$3,500	\$3,500
COLUMN TOTAL	\$124,925	\$0	\$124,925	\$42,575	\$0	\$42,575	\$100,500	\$0	\$100,500	\$268,000	\$268,000