

**NCERA-101: Committee on Controlled Environment Technology and Use  
2016 Station Report**

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**Impact Nugget**

Research is continuing in the target area of plant growth in controlled environments: focusing on greenhouse heating using wood pellets, creating innovative greenhouse designs for crop production in extreme climates and investigating light emitting diodes on plant growth. We have been working to refine the design of three filed patents: 1) a wood pellet furnace exhaust gas enrichment system for greenhouses 2) soot particle removal system and 3) a design for a tropical greenhouse. Our work with LED lighting systems is ongoing and will be reported next year. We had a change of Dean at our faculty with the new Dean Anja Geitmann, a plant scientist taking over.

**Accomplishment Summaries**

The Macdonald Campus of McGill University is researching means to use biomass for heat and carbon dioxide enrichment in controlled environments with a focus on greenhouses. This greenhouse heating research has resulted 2 patent applications on the removal of particulate matter from flue gas. Test of this system has shown that up to 97% of all soot produced can be removed using this system and when in its default (failure mode) over 70% of the soot can be removed. The system combines an electrostatic chamber and a cyclone section that allow for extended operation of the traditional air filter. This design allows for the soot free exhaust gas to then be treated in the catalytic system and used to heat and provide CO<sub>2</sub> for improved production in the greenhouse. Stability of the system has been very good with up to 7 days of continuous operation possible with longer term testing required. We are continuing this research and are entering into an option agreement with an industry partner to build a commercial unit.

We are continuing our light emitting diode research. This project is to determine the proper wavelengths and ratios of light emitting diodes to maximize production. This research is ongoing, but we have begun to add in amber LEDs to the red and blue mixture with improved production of lettuce plants. We are expanding this research to include Arabidopsis and tomato plants and are hopeful have published results in the coming year.

We have continued to a tropical greenhouse design called the NVAC, with test units build at campus, inside a greenhouse and at Barbados. The data collected from the NVAC in a greenhouse has been used to quantify air movement and temperature control of the system and determine operation ranges. The combined data from these 3 systems are being combined and published results are expected in the next year.

The design of a northern greenhouse is continuing with further testing and improvements required. We have successfully grown a crop of lettuce and had fruit set on tomato plants inside the unit. We have recently submitted a LOI to create a northern food security network and are hopeful on its success to allow the project to move forward.

### **Impact statement**

The biomass heating group at McGill University has identified methods to utilize both the heat and carbon dioxide that result from the combustion process. This research has developed a method to remove the soot from the exhaust gas streams. A patent has been filed that describes a system to remove the soot and allow for a cleaner exhaust gas before conversion and removal of the noxious gases with the catalytic conversion system. Testing of the unit is ongoing and have signed an option agreement with an industry partner.

Light emitting diodes are slowly replacing all supplemental lighting systems in greenhouses, growth chambers and urban agricultural systems. Our research has been to determine the optimum wavelength of light for plant production and we have begun to alter light composition by adding amber wavelengths to the red and blue LEDs with improved production of the lettuce.

### **Published Works**

1. Madadian, E., A.H. Akbarzadeh, M. Lefsrud. 2016. Pelletized Composite Wood Fiber Mixed with Plastic as Advanced Solid Biofuels: Thermo-Chemical Analysis. Waste and Biomass Valorization. WAVE-D-16-00799.
2. Madadian, E., M. Lefsrud, C. Perez Lee, Y. Roy, V. Orsat. 2016. Gasification of Pelletized Woody Biomass Using a Down-Draft Reactor and Impact of Material Bridging. Journal of Energy Engineering 04016001:1-7.

### **Oral Presentations**

1. Lefsrud, M. 2017. Urban Agriculture, UBC Chemical Engineering, Vancouver, BC, March 6, 2017.
2. Lefsrud, M. 2017. Will the world run out of food? McGill Alumni. Telus Spark, Calgary, AB, February 28, 2017.
3. Lefsrud, M. 2017. Will the world run out of food? McGill Alumni. UBC Robson Square, Vancouver, BC, February 28, 2017.
4. Lefsrud, M. 2016. Pushing the Limits of Urban Agriculture. ICEC/Auspheno 2016 Conference, Canberra, Australia, September 18-22, 2016.
5. Reddy, S., M.G. Lefsrud. 2016. Effect of LED light wavelength and intensity on accumulation of phytochemicals in lettuce. Paper 162460742. ASABE Annual Meeting Orlando, FL, July 17-20, 2016.
6. Madadian, E, M.G. Lefsrud, C. Crowe, E. Austin. 2016. Thermal behavior of pelletized fiber mix with different ratios of plastic in a downdraft gasifier Paper 162460583. ASABE Annual Meeting Orlando, FL, July 17-20, 2016.
7. McCartney, L., M.G. Lefsrud. 2016. Cubic Farming: An Overview of Intercanopy Lighting and Crop Trials. Paper 162460470. ASABE Annual Meeting Orlando, FL, July 17-20, 2016.

8. Madadian, E., H. Akbarzadeh, M.G. Lefsrud. 2016. Thermal Analysis of Pelletized Composite Fiber-Plastic Biomass Feedstock Paper 162461994. ASABE Annual Meeting Orlando, FL, July 17-20, 2016.
9. Madadian, E., M. Lefsrud, C. Crowe, E. Austin, S. Islam. 2016. Thermal analysis of pelletized composite fiber-plastics material and clinkering characterization during gasification. BioFuelNet ABS, Vancouver, BC, July 7-8, 2016.
10. M. Lefsrud. 2016. Your waste, my fuel. BioFuelNet ABS, Vancouver, BC, July 7-8, 2016.
11. Lefsrud, M. 2016. The Photosynthesis Action Radiation Curve in Lettuce Plants. ICEC/Auspheno 2016 Conference, Camberra, Australia, September 18-22, 2016.
12. McCartney, L., M. Lefsrud. 2016. Natural ventilation augmented cooling (NVAC) greenhouse: analysis of microclimate and plant responses. ICEC/Auspheno 2016 Conference, Camberra, Australia, September 18-22, 2016.
13. McCartney, L., L. Hendry, M. Lefsrud. 2016. Natural ventilation augmented cooling greenhouse. CSA/CSHS 2016 Annual Conference Montreal, Quebec, July 24-26, 2016.
14. Gaudet, P., M. Cool and Mark Lefsrud. Food Security in Northern Canada (Food SINC) Project: Development of Northern Greenhouse and Working Prototype. CSA/CSHS 2016 Annual Conference Montreal, Quebec, July 24-26, 2016.
15. Lefsrud, M. 2016. Biofuel in Agriculture, AALP Class 16 North American Study Tour, Montreal, QC, July 3, 2016
16. Lefsrud, M. 2016. Residue and Waste for Biofuels. CRIBIQ-BioFuelNet Symposium. Orford, QC, March 17-18, 2016.

### **Patents**

1. Lefsrud, M., Y. Roy, J. Ashfield, L. Roy. 2014. Electrocyclonic Particles Collector (EPC). PCT 2015 Provisional 14647-P48167US. US 62/155,615, WO 2016176757 A1
2. Lefsrud, M.G., P. Fateeva, L. McCartney. 2014. Natural Ventilated Augment Cooling Greenhouse. US 14/574,634; AU 2013273819; CA 2,838,296
3. Lefsrud, M.G., Y. Roy, F. Filion, J. Bouchard, Q. Nguyen, L.M. Dion, A. Glover. 2013. Apparatus For Carbon Dioxide Enrichment. WO2015003252. PCT/CA2014/000565; US61/844,976

### **Other relevant accomplishments and activities.**

Dean Anja Geitmann, a plant scientist, has become the Dean of the Faculty of Agricultural and Environmental Sciences at McGill University.