Agricultural Campus Biomass Co-Generation District Energy System – Fact Sheet

Owner: Dalhousie University

Mechanical & Electrical Consulting Engineers: FVB Energy

Construction Manager: Dalhousie University

Project Manager: Dalhousie University

Capital Costs: $26.5 million dollars

The 30-year-old biomass boiler and 40 year plus steam system at the Agricultural Campus (AC) provided heating to over 95 per cent of main campus buildings (708,894 square feet) through a district steam system. Both had reached the end of their lives. In 2014, The University applied for and received a Community Feed-In Tariff (COMFIT) approval for small scale biomass co-generation created electricity at a rate of 17.5 cents per kWh. COMFIT projects are required to meet efficiency, air quality standards and biomass fuel specific requirements.

In 2015, the University began a comprehensive renewal project to upgrade the steam distribution system and steam generating thermal plant.

The project helps to:

- address facilities renewal costs of an existing end-of-life system;
- support university and community sustainability goals;
- purchase local biomass supply that meets biomass values statements;
- connect research, teaching and operations; and
- support local economic development.

Through the project, the steam distribution system has been replaced with a district hot water system which is 30% more energy efficient. The old wood biomass steam boiler has been replaced with a biomass fired based thermal oil heater. The thermal oil heat moves a 1 MW turbine used to create electricity. This efficient organic rankine cycle (ORC) system is a first installation of its kind at a University campus in North America. Process thermal energy is used for heating the campus. A new air emissions management system was added along with two fuel storage bays. High efficiency pumps have been integrated to circulate hot water. We have smart meters and controls installed to monitor and optimize plant performance.

Key Features:

Conversion of the steam system to hot-water. This phase of the project included:

- upgrading 16 building energy transfer stations from steam to hot water;
- converting specialized steam-based equipment such as sterilizers and humidifiers to propane or electric;
- replacing steam and condensate lines from buildings to the plant with hot water lines (2.6 km); and
- converting an existing steam boiler to hot water, preserving the remaining life of this asset.

Overall thermal savings projection of roughly 6000 MWht. (21,000 MWht. Steam versus 15,000 MWht. Hot water). Steam is produced at high temperatures. Thermal losses in the distribution system account for the savings.

Fuel supply. The University created a biomass value statement that outlines standards for biomass supply. Biomass supply must meet the conditions of COMFIT rules. These statement and standards provide direction on topics such as fuel type, trucking distance (distance of fuel 175 km or less), and land uses (Appendix A – COMFIT Directive.). The University each year will submit a COMFIT report that outlines where fuel comes from and calculates contributions to silviculture programs though The Registry of Buyers. The majority of biomass (over 85%) is sawmill residue [bark and shavings] from a local mill and smaller amounts of local yard and clean wood waste [residue from the making of lobster traps] and two smaller amounts of research fuels (chips from selective forest harvests for siliviculture through local forestry cooperatives and an agreement for willow). The bioenergy requirements for the plant is projected to be less than 20,000 tonnes per year.

Fuel handling. Two new fuel storage bays have been created. The storage bays have been moved to a flat access point for trucks (roughly 1-2 a day). Floor rakes, leveling screws and a chain conveyor system move the biomass fuel to the thermal oil heater. Having two bins offers flexibility to mix different products, including reserve fuel.

New biomass fuel thermal oil heater. A 5.7 MWth biomass heater (Wellons) has been installed. Fuel is drawn into the thermal oil heater from the fuel handling system. The new thermal oil heater will enable a more consistent and higher heat burn creating less ash and more efficient use of biomass to make heat. Hot gas from the heater fire warms up thermal oil that provides the thermal energy to the ORC system.

Organic Rankine Cycle (ORC) System. The 1 MW Turboden 10 CHP system is projected to produce 7750 MWh annually; roughly 75% of the campus electricity needs. Electricity is exported to the local Nova Scotia Power grid (as per the requirements of any COMFIT agreement). The ORC is more practical than a steam turbine because it can use lower grade heat than a steam turbine for the same purposes, is still efficient at partial loads, and uses an organic fluid in a closed loop rather than chemically treated water to turn the turbine.

The heat contained in the gases from combustion of the biomass fuel is transferred to a closed thermal oil loop through a heat exchanger. This heat is then transferred to the organic fluid where it heats to a point where the fluid vaporizes. The vaporized fluid expands creating energy that turns the turbine which creates electricity. The vapour is condensed and the heat is exchanged to the campus district hot water system. The cooler thermal oil returns in a closed loop to the beginning of the process at a lower temperature.

Electrostatic precipitator (ESP) is specifically designed for cleaning flue gases from wood-fired energy systems. Wellons proprietary ESP has particulate emission guarantee of 35 mg/normal cubic meters @ 8% O2 per COMFIT or below. The treatment time of emissions is 6.7 seconds. The stack height is 44 feet. The ESP has two electric fields in the Unit. As flue gas goes through the charged area in the ESP, the

particles are attracted to the charged plates. Eventually the particles are shaken off with mechanical movement to the bottom of the unit where it is transported to the ash bin.

Wood Ash Management. In the past, wood ash stayed on the campus farm using campus vehicles to transport the ash in carts during the winter months. With the production of more ash all-year round (estimated at 400 tonnes per year), it is now held in custom designed wood ash bins that is easily transported to a local farm for use as fertilizer. The campus ash is certified as a fertilizer through the Canadian Food and Inspection Agency.

Other energy projects outside this main capital project included upgraded hot water circulating pumps, thermal energy meters at each building, and upgrading controls systems software for better insight and control.

Next Steps:

- In the summer, process heat is used to heat domestic hot water. There is more available heat for use during this period. Our plans are to identify matching funding for a study and solution to capture and utilize this available heat in the summer. This would be the second stage of innovation.
- We will be researching the full-life cycle carbon comparison of the biomass used in this system versus alternatives which would have been oil or compressed natural gas.
- Carbon Neutrality. The campus-based biomass co-generation plant is a positive strategy compared to the alternatives; as a strategy it is not completely carbon neutral. It is part of a broader University plan that pursues many strategies to meet carbon targets including energy efficiency, solar and other renewable energies, and capturing waste heat through process like co-generation. In 2018, the University will be releasing Version 2. of the Climate Change plan that will include the Agricultural campus (version 1 was released in 2010).

Appendix A – COMFIT Directive

SECTION (4.) OF THE COMFIT BIOMASS DIRECTIVE 0002 DATED JULY 26, 2011

4. DIRECTIVE:

The Minister of Energy, in consultation with the Departments of Natural Resources, Agriculture and Environment, has made determinations about the following biomass considerations with respect to eligibility for the COMFIT program:

Primary Forest Biomass

Forest biomass used to generate renewable low-impact electricity will be harvested in a sustainable manner. Proponents must also be registered with the Department of Natural Resources' (DNR) Registry of Buyers and, as such, will be subject to the same legislation, regulations and sustainable forest resource management obligations pertaining to the regular forest industry. Forest biomass used to generate renewable low-impact electricity will be limited to stem wood only of non-merchantable trees. No coarse or fine woody debris from primary forest harvesting will be considered to be sustainable biomass feedstock. Proponents or suppliers shall not harvest or acquire fuel from tree crowns, tops, or stumps from forest management operations. The sole exemption would be for such material generated from land development or urban sites.

Agricultural Energy Crops/Residues

Energy crops are non-food crops grown specifically for their fuel value, including electricity generation. These sources include: short rotation woody crops (e.g. willow), and herbaceous energy crops (e.g. miscanthus). While the EcoLogo Standard CCD-003 provides general guidance on ensuring that crops are produced with low-impact, sound environmental management practices, the NS Environmental Farm Plan (EFP) and Nutrient Management Planning (NMP) are more appropriate references in the Nova Scotia agricultural context.

These crops may provide an economic basis for heating applications, but the business case for use in a combined heat and power situation may not be economic at this time. In addition, potential project using energy crops must demonstrate sustainable agricultural practices.

[3] **28(4)** On approving an application, the Minister must issue the applicant a feed-in tariff approval subject to any terms and conditions that the Minister determines are appropriate.

[4] **2B (2)** The Minister may establish and administer policies, programs, standards, guidelines, objectives, codes of practice, directives and approval processes under this Act.

[5] **43 (1)** The Minister has all the power and authority necessary to implement, administer and enforce these regulations, including the power to issue directions or orders, and must do all of the following: … (b) establish a process for approving and re-approving renewable low-impact electricity generation facilities and renewable low- impact electricity generators;

[6] **43 (2)** In addition to the powers and duties set out in subsection (1), the Minister may do any of the following:…(e) prepare interpretations of these regulations, or policies, standards and guidelines under these regulations.

OTHER

Sawmill and Wood Processing Residues

The wood wastes from the manufacturing of other wood products are always preferred feedstocks over additional harvesting of more primary forest biomass. Proponents should demonstrate that they have secure arrangements or control over this portion of any wood biomass fuels. In addition, proponents must also be registered with the Department of Natural Resources' (DNR) Registry of Buyers.

Farm-based

Farm-based biogas systems that use their own feedstock are eligible for COMFIT.

Those wishing to explore the option of consolidating their feedstocks on a farm and operating a Cooperative/CEDIF COMFIT Combined Heat and Power Biogas facility should contact the Department of Energy's Renewable and Sustainable Energy Branch early in the planning stages. The Department of Energy will work with the Department of Environment to guide proponents in their planning.

Liquid, solid, and gaseous fuels made from biomass

This category includes the material(s) used in the process to create products such as pyrolysis oil, syngas, pellets, and eligible liquid biofuels. The relevant issue for eligibility is whether the material comes from sustainable sources consistent with the EcoLogo™ definitions. Liquid, solid, and gaseous fuels made from biomass raise issues with respect to source that are similar to those with respect to primary forest biomass and the related fuel procurement plans; therefore, proponents considering the use of non-harvested biomass sources (i.e., waste) should have an early discussion with the Department of Energy about the eligibility of the sustainable source, plans for its collection, and any requirements to demonstrate the source is, and continues to be, sustainable.

Eligible liquid biofuels are liquid fuels that are derived from eligible biomass and that can be shown to provide a net environmental benefit, or that are derived from waste feedstocks, which include, but are not limited to, waste vegetable oils, waste animal fats, substances derived from wastewater and the treatment of wastewater, or grease trap waste.

Air Quality Considerations

In order to be eligible for the biomass CHP COMFIT, all new, refurbished, or replaced biomass boilers must be rated to achieve the air emission performance rate (below, Table 1). To achieve such performance, it is anticipated that boilers will likely require emission control technology. In the application for the COMFIT, proponents must identify the rated particulate matter emission level, the manufacturer's emission testing method, and the type of pollution control equipment.

Table 1: Rated particulate matter emission numbers upon installation required for eligibility of biomass boilers for the COMFIT.

Size Range (MW_{input})	**PM Emission Cap (mg/m^3)***
0.25 to 1	120
1 to 3	50
3 to 10 (upper COMFIT MW)	35

*tested under normal operating conditions at standard conditions of 20 degrees Celsius, 101.3kPA and 8% oxygen

Existing boilers that are not subject to alteration, upgrade, modification, etc. must be rated to meet 120mg/m3*, and pollution control equipment will likely be needed.

Efficiency Considerations

While the Department of Energy has not implemented efficiency standards for biomass CHP projects, it is important to note that the COMFIT rate structure will incent proponents to obtain the highest overall efficiency possible. Proponents must report their annual overall efficiency as part of the Biomass Fuel Procurement and Use Plan annual reporting requirements. During the 2012 review, the Department of Energy may consider whether formal efficiency standards are required for biomass CHP projects. These standards would apply only to new projects applied for after the review is complete.

Further Considerations on Eligibility

Community Based District Heating Projects

Community-based biomass projects are required to be CHP; however, they are permitted to sell excess heat to others.

An industrial "private company" biomass project is not required to be a community-based project; however, they must use the heat themselves on site in an industrial process. If there is an additional surplus, they may sell to others.

For the purposes of COMFIT, eligible biomass projects must:

- Apply only to the electricity produced and sold from a combined heat and power (CHP) plant;
- Produce renewable low-impact electricity, as defined above; and
- Conform to air emission performance standards and/or operating approvals, where applicable.

All biomass project proponents are encouraged to take the following steps in planning their projects:

1. Proponents should seek early guidance on the availability of primary forest biomass within the cap by contacting the COMFIT Administrator at the Department of Energy. The COMFIT Administrator will provide a current assessment of biomass allocated and anticipated.

2. Proponents should then approach the Executive Director of the Renewable Resources Division at Department of Natural Resources to discuss their fuel procurement and use plans. This opportunity will provide proponents with a Preliminary Assessment of their plans and identification of any issues prior to formal submission. A comment by DNR that the plan is in compliance with all DNR requirements can be filed with the application for the COMFIT. In cases where the use of primary forest biomass has been identified, the Department of Natural Resources Preliminary Assessment will include advice to the Minister of Energy to enable the Department of Energy to give a proponent a Preliminary Allocation of a portion of the 350,000 dry metric dry tones biomass cap. This Preliminary Allocation will expire if an application for a COMFIT CHP project is not filed within 12 months.

3. Upon filing the COMFIT application, all proponents must formally submit their multi-year biomass fuel procurement and use plan. The plan must indicate both the current use and the incremental supply required to produce electricity. Proponents must demonstrate how the incremental supply meets the biomass eligibility criteria listed above. The plan must outline anticipated sources for biomass, region of harvest, land tenure type (i.e., private, industrial or Crown land), species (softwood or hardwood species), fuel types (i,e., bark, sawdust, chips, pellets, etc), moisture content, and dry tonnes required for the project.

4. Once a Feed-In Tariff Approval has been issued, a Final Allocation of the primary forest biomass will be given to the project. If there is a scarcity of resource to be allocated, priority will be given to projects in order of their notice from DNR that their fuel procurement plan is in compliance with Departmental requirements. A Final Allocation will be subject to the normal timeline requirements for project in-service.