SCHOOL OF CONSTRUCTION AND THE ENVIRONMENT
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Draft Report
Environmental Impact Assessment
Biomass-to-Energy Project

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1 INTRODUCTION

The British Columbia Institute of Technology (BCIT) is planning to construct a biomass-to-energy facility (the Project) at its campus in Burnaby, BC, to extract energy from the 250,000 kg of wood waste produced annually by its Joinery and Carpentry training programs. This energy will be used to heat water in the Burnaby campus district heat distribution line. The Project is still in the preliminary design phase; details on equipment to be installed and their specifications will be defined during the detailed design phase.

The objective of the Project is to build a biomass-to-energy system, fueled using wood waste from BCIT's Joinery and Carpentry training programs. The Joinery and Carpentry shops on BCIT's Burnaby campus generate a total of approximately 250,000 kilograms of wood waste per year, which is currently being trucked away by a waste management company at a significant cost. By implementing the proposed biomass-to-energy project, BCIT will divert 93% of the wood waste currently being removed from campus, and use it as a carbon neutral fuel for heating water. This will reduce BCIT's fossil fuel consumption by lowering the demand on natural gas fired boilers and reducing truck traffic attributed to waste management.

The Project does not require an environmental assessment under either the *Canadian Environmental Assessment Act* 2012 (CEAA 2012) or the BC *Environmental Assessment Act* (BC EAA). BCIT has undertaken an assessment of the potential environmental effects of the Project, applying the general principles of environmental assessment followed in BC, as part of its internal due-diligence procedures. This environmental impact assessment (EIA) reflects the institute's commitments towards its neighbours at the Burnaby campus, where the Project is to be located. Requirements of BCIT's Environmental Protection Procedure 7100-PR7 were considered in developing this EIA.

2 PROJECT PURPOSE AND JUSTIFICATION

2.1 Strategic Objectives

BCIT's vision is to be a leader in the training and practice of environmental sustainability and the proposed biomass-to-energy project provides excellent opportunities in both of these areas. Demonstrating the capabilities of the school's students, faculty, and applied researchers, with the aim of transforming BCIT's campuses into living laboratories of sustainability, is one of strategic initiatives of BCIT's School of Construction and the Environment (SoCE). SoCE's overarching goal is to achieve a 75% reduction in energy and materials throughput in seven buildings on the Burnaby campus while maintaining existing service levels. This goal is part of a BCIT initiative, known as Factor Four, which aims for a four-fold, or 75%, reduction in energy and materials consumption to achieve ecological sustainability.

The Project is also supported by BCIT's 2014-2019 Strategic Plan, which states, "*Economic growth, productivity, and greater competitiveness will require expanding skill development, creating new knowledge, and solving business and industry problems through applied research. Through our programming and applied research in strategic areas, BCIT will remain at the forefront of technological change and the state of practice to meet the needs of industry partners and maximize the institute's impact on economic development and environmental sustainability".*

2.2 Project Benefits

BCIT's Joinery and Carpentry programs train their students by building a series of practical projects. Whenever possible, projects are constructed that can be used either on or off campus. When this is not possible, materials are re-used until they are either too small or structurally unusable, and then they become waste. The largest volume of BCIT's waste is solid wood, but a percentage of plywood and medium density fiberboard (MDF) is also present.

All of these materials are comprised of woody biomass and are currently being removed from campus by a waste removal company, but could be used as fuel for a biomass boiler. Biomass is a renewable resource that is considered carbon neutral, because the carbon released during combustion is reabsorbed by the growth of new trees, resulting in zero net atmospheric carbon gain. Use of biomass as fuel offers the following key benefits:

- When compared to fossil fuels biomass fuels generate significantly lower levels of atmospheric pollutants such as sulphur dioxide (a major cause of acid rain)

- Modern biomass combustion systems are highly sophisticated, offering combustion efficiencies comparable with the best fossil fuel boilers
- Using waste as fuel diverts materials that would otherwise be consigned to landfill. This eliminates costs for disposal, and reduces the burden on limited landfill resources.

The proposed biomass-to-energy system will be used to heat water in the campus district heat distribution line and eventually in the Factor Four micro thermal grid for education, reduce energy and material throughput, establish best practices and standards, and educate BCIT students and faculty as well as government and industry partners. Energy produced by this biomass system will also partially offset the consumption of natural gas in existing gas-fired boilers (approximately 7% offset of total annual consumption) on campus, and reduce BCIT's carbon emissions by 250 tonnes $CO2_{eq}$/year, which is equivalent to the carbon released by burning 100,000 litres of gasoline.

In addition to the benefits outlined above, the Project offers training and research opportunities for students and faculty from the following Schools:

- Construction and the Environment (Sustainable Energy Management, Environmental Engineering, Sustainable Resource Management, Architectural Science, Piping, Joinery and Carpentry)
- Energy (Power Engineering, Mechanical Systems, Industrial Instrumentation and Controls)
- Health Sciences (Occupational Health and Safety, and Environmental Health)

2.3 Support and External Interest

Staff from Metro Vancouver and the BC Ministry of Environment, regional and provincial government bodies responsible for the air quality management in BC, have expressed an interest in working with SoCE to investigate whether emissions from combustion of construction wood waste can be managed to achieve very low emissions standards (e.g. particulate matter of 2 to 5 mg/m^3) by utilizing best-in-class market-ready technologies.

BCIT received a letter of support dated May 16, 2012 from the British Columbia Ministry of Environment which states, "*Your efforts will help BC become a leader in this energy recovery field, with attendant potential social and economic benefits. We note that you are positioning the project to maximize academic education, public awareness, and industry partnering and we applaud this. This will afford the next generations of construction workers an opportunity to rethink how they build and what constitutes waste in their industry. We look forward to the results of your investigations, and wish you all the best in achieving your goals*."

The Architectural Woodwork Manufacturers Association (AWMAC) of Canada has recently launched its Sustainable Architectural Woodwork (SAW) program. This point-based program rewards manufacturers that produce energy or heat from wood waste, reduce their carbon footprint, and use alternative (renewable) energy. Wood product suppliers are also involved in the SAW program and a long-term goal of this initiative is to explore opportunities to influence the way sheet-good products (plywood, fiber board, etc.) are manufactured, in order to make them better suited as biomass fuel (cradle-to-biomass energy concept). All of these factors are perfectly linked to a biomass-to-energy initiative, and the BC chapter of AWMAC has expressed their interest in, and support for BCIT's goal of implementing a biomass-to-energy facility in a letter to BCIT dated May 26, 2011.

3 PROJECT DESCRIPTION

3.1 Location

Wood waste from the Joinery and Carpentry workshops located in the northeast quadrant of BCIT's Burnaby campus (Buildings NE2 and NE4, **Figure 1**), including wood shavings and fines collected from an existing dust extraction system located on the exterior face of the west wall of Building NE2, will be the primary source of fuel for the proposed biomass-to-energy system. Given this, the southwest corner of the Joinery Department's main workshop was selected as the most appropriate location for the Project.

The proposed facility will be accommodated in a new structure that wraps around the southwest corner of the Joinery workshop (Building NE2, **Figure 1** and **Figure 2**), adjacent to the existing dust collection system.

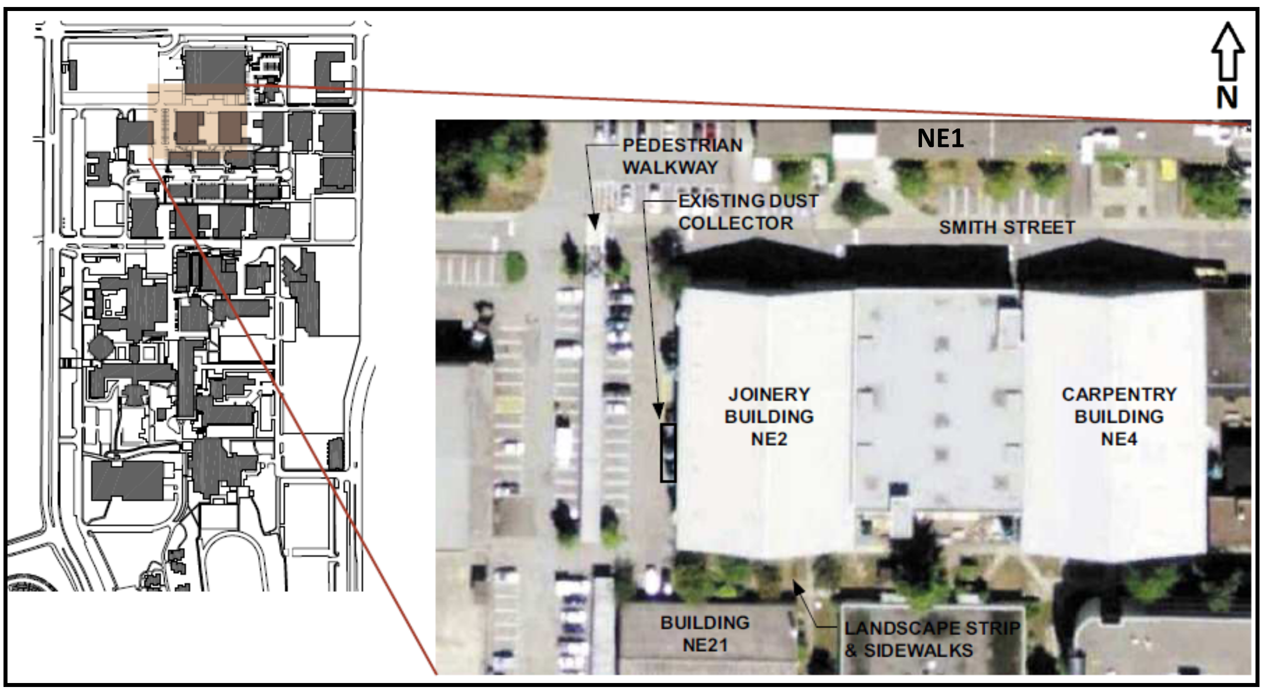

Figure 1 BCIT's Burnaby campus with detail of Joinery building (NE2) and nearby features.

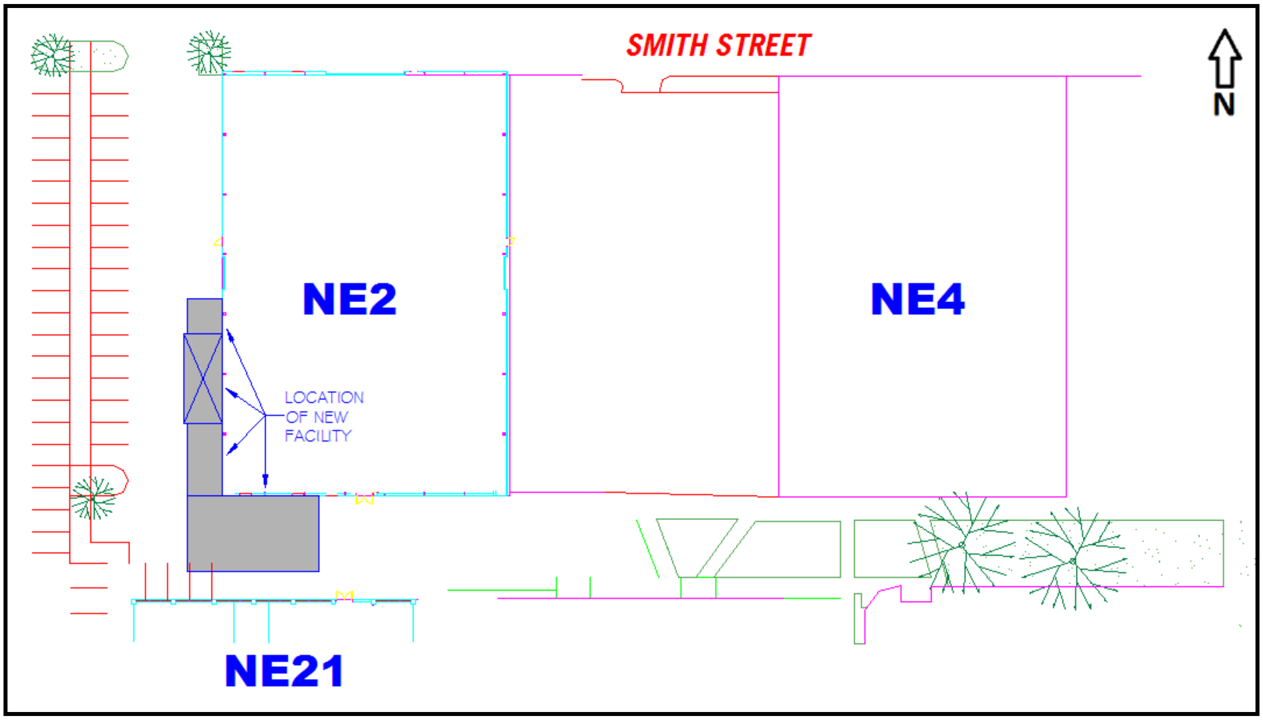

Figure 2 Location of New Biomass Facility

3.1.1 Advantages of the Proposed Project Location

This location offers a number of advantages, some of which serve to mitigate potential adverse effects of the Project:

- Close proximity to the existing dust collector, which results in a shorter transfer distance for the wood shavings and fines.
- Close proximity to the source of BCIT's solid wood waste, so transport to the size reduction equipment and subsequent transport to the fuel storage area will be minimized.
- Close proximity to the district heat distribution line, which runs under the parking lot directly to the west side of the Joinery Building (NE2).
- Close proximity to Joinery and Carpentry departments, which will enable the Project to serve as an excellent demonstration site for students to see how energy can be created from waste wood.
- Lack of interference with traffic flow in the existing parking lot located to the west of the Joinery building
- High visibility from the surrounding pedestrian paths, which enhances the Project's value as a demonstration facility.

3.2 Project Scope

The Project involves the installation and operation of a 200 kW combustion (heat only) biomass boiler housed in a new structure with viewing windows, metering devices that provide real-time data, wood fuel storage, and a covered outdoor interpretative teaching space. The Project will function as a *Living Laboratory* that targets an annual waste reduction of 250,000 kilograms, and greenhouse gas emission reduction of 250 tonnes of $CO_{2eq.}$

3.2.1 Project Components and Technology

The proposed biomass-to-energy system includes the following main components:

1. Material size reduction equipment
2. Fuel storage area
3. Fuel meter
4. Boiler and firebox
5. Particulate filtration system
6. Heating distribution line connection

BCIT has undertaken an analysis of viable options and alternate technologies available for each of the above components, and developed a preferred system design as shown schematically in **Figure 3**. Preliminary details on individual system components as currently proposed is provided in the paragraphs that follow Figure 3. These details will be refined further and specifications will be developed prior to procurement and installation of Project components. A discussion on the various options and alternate technologies that were considered, and the rationale for selecting the preferred options presented here is included in **Appendix A**.

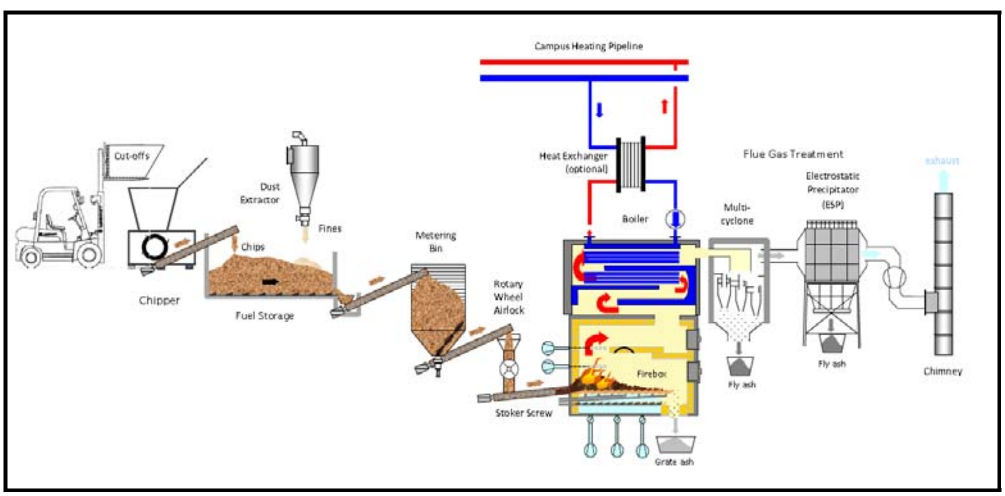

Figure 3 Schematic of Proposed Biomass-to-Energy System

Material Size Reduction Equipment

BCIT's waste stream includes materials that need to be reduced in size prior to being used as fuel in the biomass-to-energy system. This will be achieved by using a chipper equipped with a gravity-fed, top-mounted hopper that produces chips no larger than 25mm (1") in size. Materials that need to be reduced in size will be dumped into the hopper using a forklift. After materials have been dumped into its hopper, the chipper can operate unmanned.

BCIT is reviewing available options to identify the equipment that is best suited to meet the specific needs of the Project. Primary factors that will determine chipper specifications include waste volume, waste type, size materials need to be reduced to, equipment footprint, noise levels, and ease of operation and maintenance.

Chippers are equipped with sharp knives that are mounted on a drum or disk and use a slicing action to reduce material size. Students will be instructed to remove all nails and screws from wood before it enters the hopper; however, a small percentage of metal is expected to enter the chipper. Given this, considerations for chipper selection will include its ability tolerate some metal in the feed-stock, and a system that allows its knives to be easily replaced or sharpened. To prevent metal from entering the biomass boiler, magnets will be mounted on the out-feed side of the chipper. The chipper will operate between two and three hours on a daily basis.

Chippers typically have a noise range between 80 and 90 db. The chipper will be installed in a sound proof enclosure to reduce this noise level to a maximum of 60 db. This enclosure will have a hatch above the chipper's hopper for material entry and a limit-switch on the hatch will prevent the chipper from operating when it is in the open position. This will ensure safe operation and maximize noise reduction. The chipper will only be operated during daytime.

Fuel Storage

Biomass boilers are designed to run 24 hours a day, seven days a week, and are known to perform poorly during start-up and shut-down phases. It is therefore desirable to keep the system running continuously. To accommodate this, BCIT's biomass-to-energy system will require some form of fuel storage, because its wood waste fuel stream is generated by programs that run only seven hours a day, with volumes varying from day to day and week to week. Without some form of storage, the system could not be kept running continuously.

A final decision on wood fuel storage details has not yet been made. To accommodate the fluctuation of fuel availability, the following criteria are being considered in the selection of the fuel storage system(s):

- Best case scenario is to have biomass system operate 24/7, 365 days of the year to minimize storage requirements and start-up and shut-down phases of the system. Multiple start-up and shut-down phases are undesirable because during these phases the air emission quality is low.
- If the biomass system does operate 24/7 the storage facility should still have storage to accommodate fluctuations in fuel availability, and act as a buffer should the chipper or biomass energy system experiences down-time.
- If the biomass system does not operate 365 days of the year excess fuel that will be generated (during the summer months when the main gas fired boilers and distributed heating system are shut down) will either need to be compacted and stored, stored in a non-compacted state, or removed from campus. In the short-term BCIT intends to operate the biomass boiler 10 months of the year to coincide with the operation of main gas fired boilers and the district heating system, which may require waste removal in the summer months.

Based on preliminary considerations around ease of fuel transfer as well as space constraints and visual impacts, a walking floor storage system is being proposed for the Project. This allows for the use of the space under the existing steel structure supporting the dust extractor, and the structure itself can be used as a frame for the storage facility.

BCIT will make provisions for fuel storage of 10 tonnes, or 50 m^3 of fuel, which is equivalent to 10 days of maximum waste production. While larger than common, this size will allow the chipper to operate even if the biomass boiler should be down for an entire week. It will also allow operating the boiler at high fire rate even if the chipper or its operator is not available for an entire week.

Fuel Meter

A fuel metering bin is proposed as part of the Project for the following reasons:

1. Monitoring fuel consumption;
2. Creating a homogenous mixture of sawdust and chips; and
3. Separating the fuel bin from the combustor for fire safety reasons.[1]

Monitoring of fuel consumption will facilitate the research component of the Project. Ensuring a homogenous mix of sawdust and chips will increase boiler efficiency and safety reasons for separating the fuel bin from the combustor are self-evident.

[1] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013

An inclined auger will be used to transfer materials from the fuel storage area to a metering bin. It is also worth noting that this auger could also be used to remove excess fuel from the storage area if the boiler is not operational 12 months of the year.

A general schematic of the fuel metering system is shown in **Figure 4.**

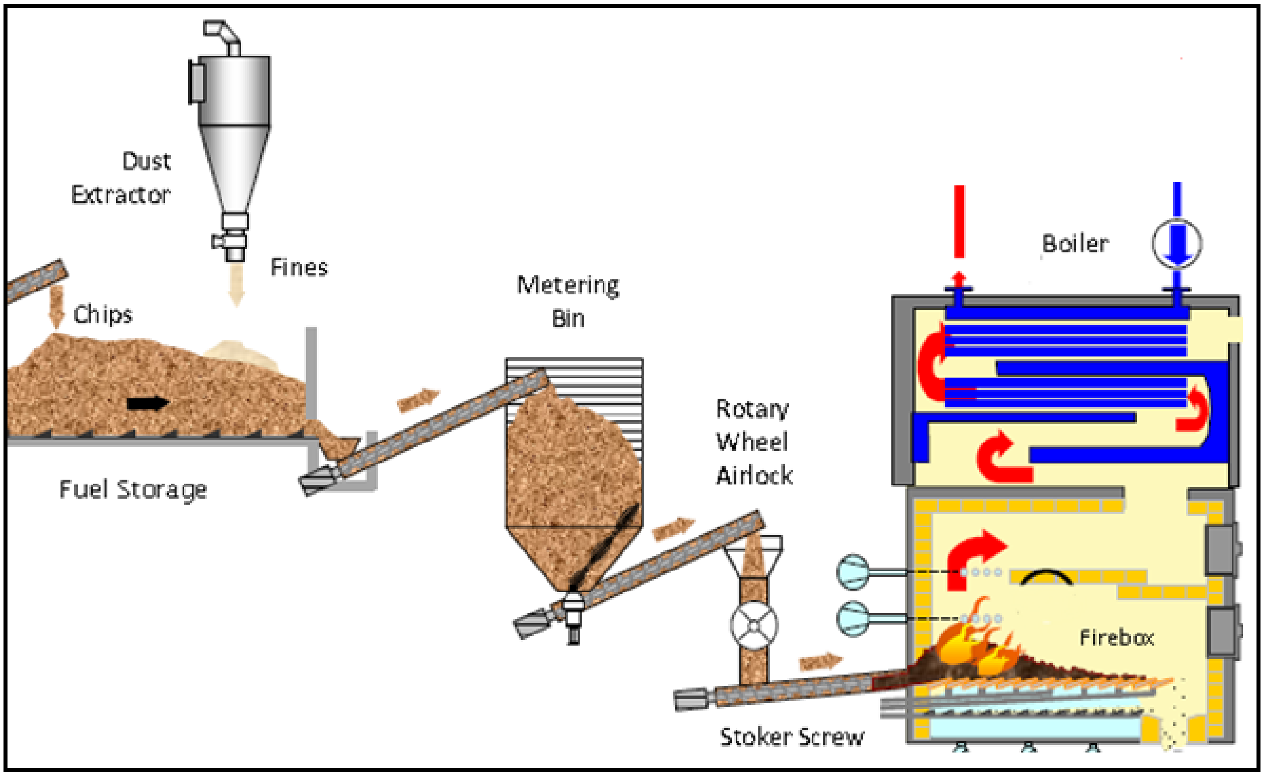

Figure 4 Schematic of Fuel Metering System

Boiler and Firebox

For the size of system required at BCIT, the boiler and firebox are typically sold as a package with the boiler mounted above the firebox as shown schematically in **Figure 5**. Sizing biomass boilers is either based on fuel availability or heat demand. Since the available potential energy contained in BCIT's 250,000 kg of wood waste would only reduce the energy consumption of BCIT's existing natural gas fired boilers by approximately 7%, BCIT's biomass boiler will be sized on fuel availability rather than heat demand. Another key consideration in sizing BCIT's biomass boiler is that its fuel availability has historically varied between nine tonnes and 30 tonnes per month.

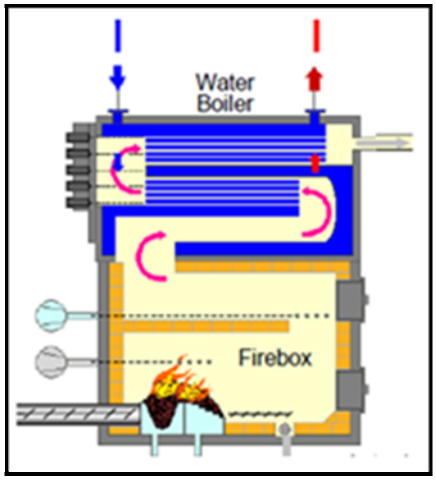

Figure 5 Schematic – Firebox and boiler

BCIT has determined that a firebox boiler with a rated output in the range between 170 and 200 kW, depending on the robustness of the design, is best suited for the fuel available at BCIT [2]. BCIT also intends to employ a *warm water* boiler that operates below 100°C and below 206 kPa (30 PSI). This will simplify the requirements of the BC Safety Authority and reduce equipment costs [3].

One of two preferred firebox designs—a pile burner or a moving grate burner, shown schematically on **Figure 6**—is proposed for the Project.

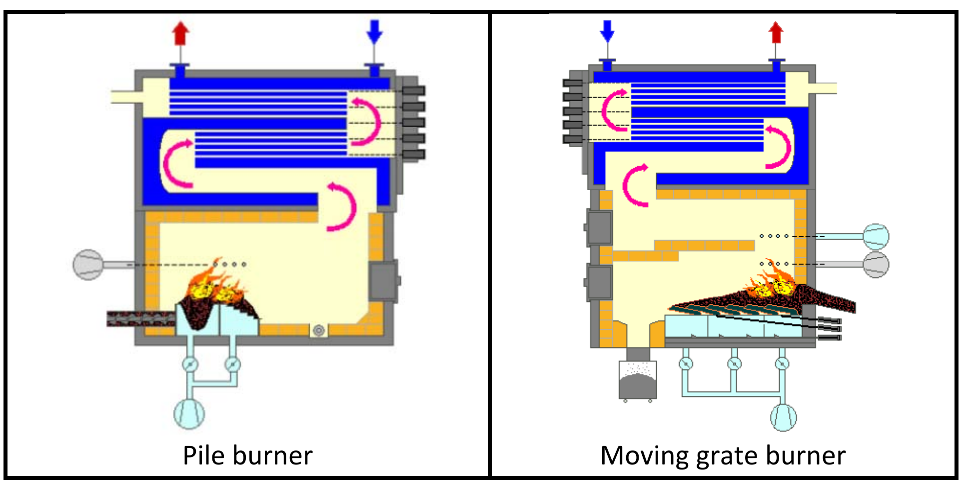

Figure 6 Preferred Firebox Designs for the Project – General Schematic

Pile burners, also called underfeed stokers, stoke fuel from underneath into retort in the combustion chamber rather than from above onto a grate. At low fire only a trough-shaped retort is filled. As

[2] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013
[3] Ibid

demand for heat increases, more fuel is stoked into the retort, piling up in the trough, moving upward and eventually overflowing onto a sloped secondary grate.[4] With no moving parts in the firebox, pile burners can provide a cost-effective solution for the size of boiler required at BCIT.

Moving grate burners burn the fuel on a moving grate. The grate is sloped, stepped, or horizontal. Reciprocating grates move the fire bed forward until the fuel pile is entirely burned out. A laser sensor at the end of the grate makes sure all embers are completely burned out and only grate ash is left. The moving grate design could help avoid buildup of clinker if the fuel is heterogeneous (for example, wood waste that includes plywood or medium density fibreboard (MDF)).[5] Selection of the final firebox design will be based on further consideration of fuel composition and operational cost considerations.

Particulate Filtration System

Particulate filtration is used to remove particulate matter (PM) from the exhaust gas after it leaves the combustion chamber and before it exits the chimney. The preferred filtration technology proposed for the Project includes a cyclone or multi-cyclone filter to separate out PM from exhaust gas, combined with an electrostatic precipitator (ESP) that allows the separated PM to fall into a collector. This combination reduces the risk of fire, is very effective at removing particulate matter while reducing the power consumption of the flue gas fan.

Cyclone and multi-cyclone filters use centrifugal forces to separate PM from exhaust gases, and are often used as the primary stage of filtration and remove approximately 90 per cent of particles that are 10 micrometres or less in diameter (PM10), and less than 10 per cent of particles that are 2.5 micrometres or less in diameter (PM2.5).

Electrostatic Precipitators work on the principle of electrostatic attraction. Charged particles in the exhaust gas are attracted by plates on the side of the ESP that have the opposite charge. These units are often supplied with built-in *hammers* that strike the plates during a cleaning cycle, thereby loosening the particulate matter and allowing it to fall into a collector below. The control efficiency of PM10 and PM2.5 appears to be 99% or better, making this control technology very compelling.[6] Until recently, ESPs were only used on large biomass energy systems (3 MW or larger). New versions are now being made that are suitable for a 200 kW boiler. These systems have a relatively small footprint, low maintenance costs, are safe to use and consume limited energy when they operate.

[4] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013
[5] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013
[6] Biomass Energy Resource Center (BERC), Emission Controls for Small Wood-Fired Boilers, May, 2010

Since the filter will have an effect on the operation of the firebox and boiler, BCIT will discuss selection of filtering equipment with the supplier of the biomass boiler.[7] The typical set-up of a biomass system particulate filtration system is shown in **Figure 7**[8]**.**

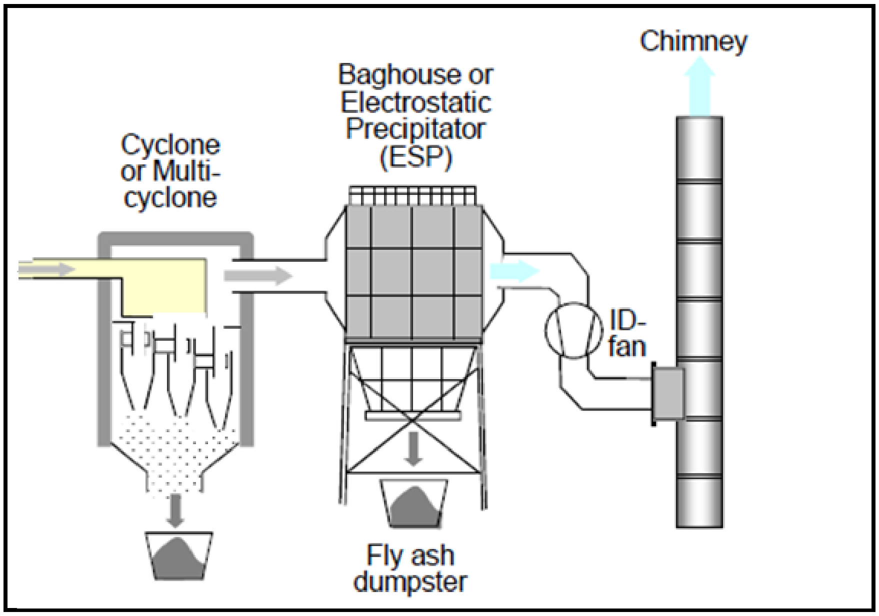

Figure 7 Typical Heat-only Biomass Boiler with Particulate Filter Technology

<u>**Heating Distribution Line Connection**</u>

BCIT's Burnaby campus has an existing heat distribution line that is currently being heated by natural-gas fired boilers. The northern extent of this distribution line is the Inglis Building (NE1, **Figure 1**). The Project will be located just south of NE1 at the southwest corner of the Joinery Shop (NE2, **Figure 1**).

The biomass boiler will feed into the arm supplying building NE1, as shown schematically in **Figure 8**. A heat exchanger will be installed[9] to provide an indirect connection between the campus heating line and the boiler, which will protect the boiler from potential issues related to poor water quality.

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[7] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013
[8] Canadian Biomass Energy Research (CBER), BCIT Biomass to Energy Workshop, May 31, 2012
[9] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013

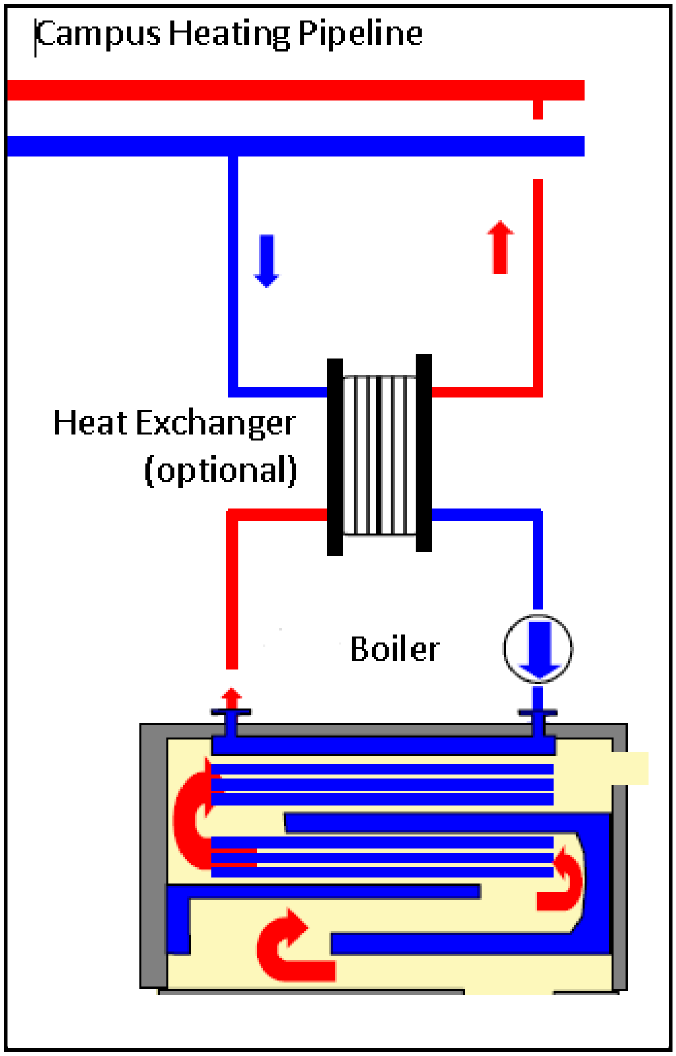

Figure 8 Schematic Drawing: Heating Distribution Line Connection

3.2.2 Project Layout and External Structures

Project components identified in Section 2.2.1 will be accommodated within an L-shaped plant building, with a net floor area of 50 to 70 m^2 (540 to 750 sq ft), that wraps around the southwest corner of the existing Joinery building (Building NE2, **Figure 1**). The proposed layout of Project components within the plant building are shown on **Figure 9**. A detailed list of design requirements for the plant building is included in **Appendix B**. **Figures 10** and 11**0** show the west and south elevations of the proposed plant building respectively, with suggested locations of Project components.

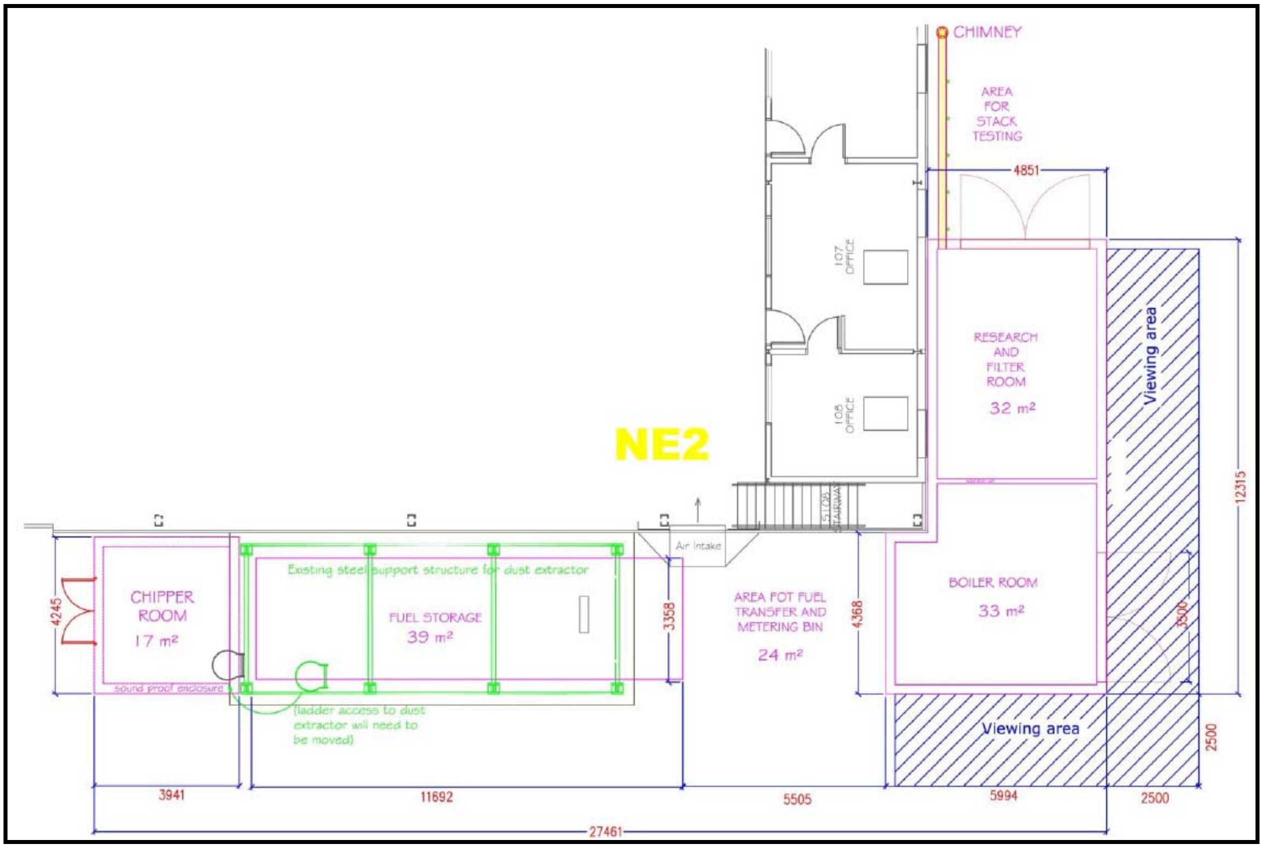

Figure 9 Proposed Project Layout

The chipper enclosure and fuel storage will be located entirely within the parking lot to the west of Building NE2. The boiler house will be built partially on the parking lot, and on a grassy area with trees to the south of Building NE2.

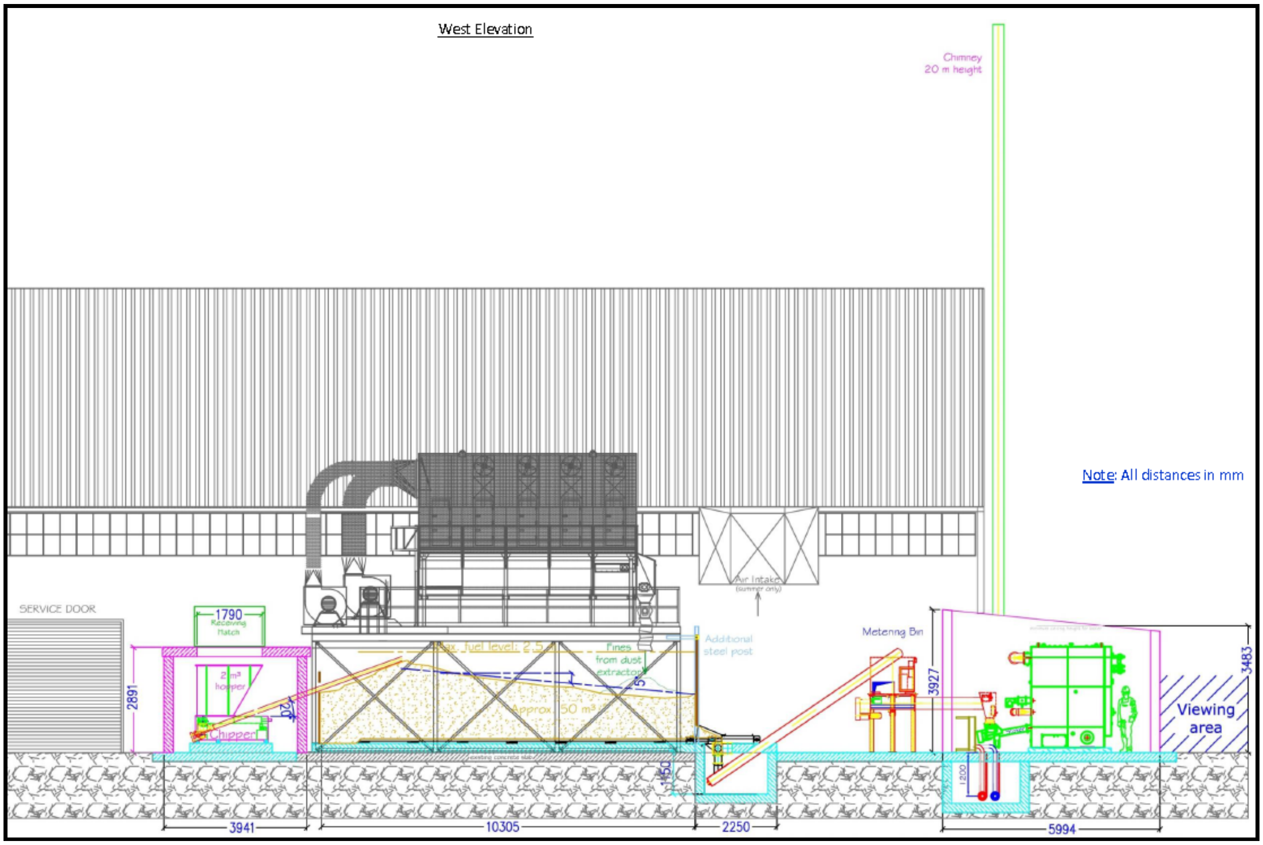

Figure 10 Proposed Plant Building: West Elevation with Project Components

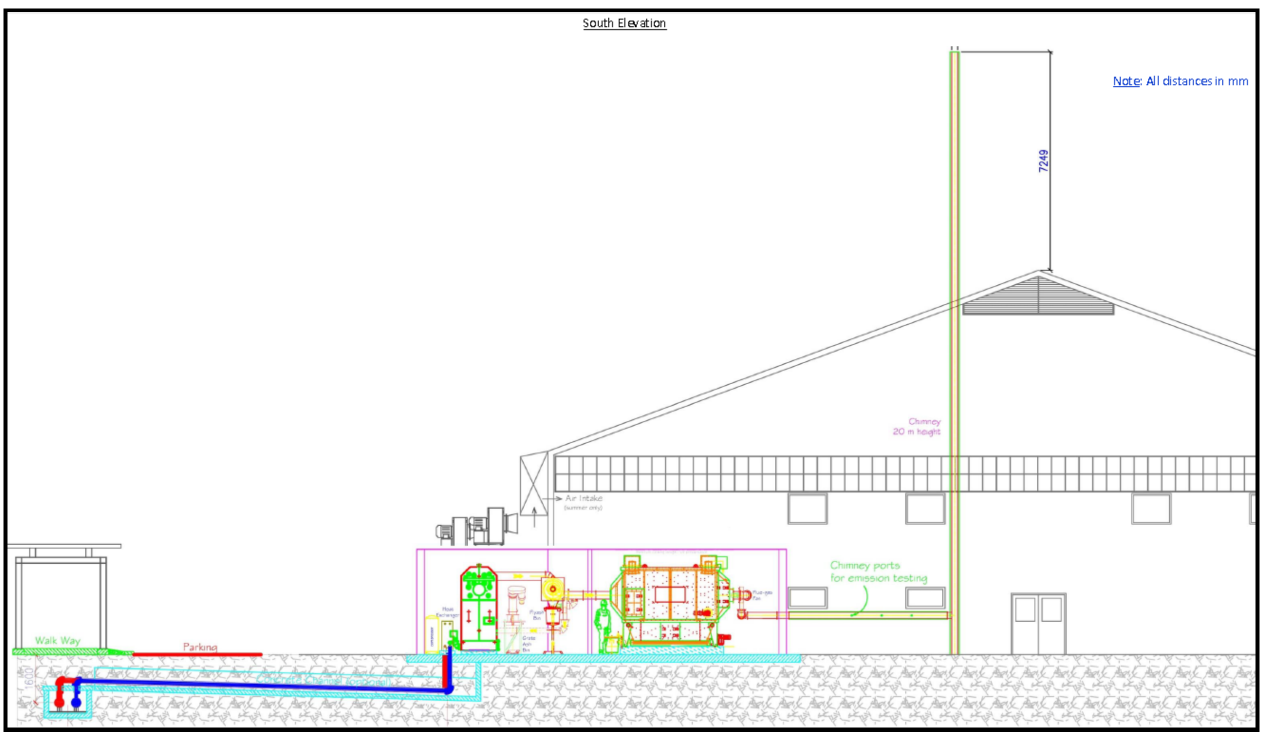

Figure 11 Proposed Plant Building: South Elevation with Project Components

3.2.3 Fuel Source and Composition

Fuel used in the proposed biomass-to-energy system will be limited to wood waste generated on campus by the Joinery and Carpentry training programs. No wood waste will be imported to fuel the system, so truck traffic on or around BCIT's Burnaby campus will not increase as a result of the Project. At present, wood waste generated on campus is collected in a 40 cubic yard wood waste bin that is taken off-site once per week on average, and a four-cubic yard bin that is emptied into the solid waste management service provider's disposal vehicle once per day on average. Once the Project becomes operational, contents of these bins will be used as fuel for the biomass-to-energy system, and both waste removal streams will be discontinued, resulting in a net decrease in truck traffic on and around the campus.

Two separate audits have been performed by Waste Audit Canada (May 18th, 2012) on the contents of the 40 yard wood waste bin. The results of these audits are shown in **Figure 11**.

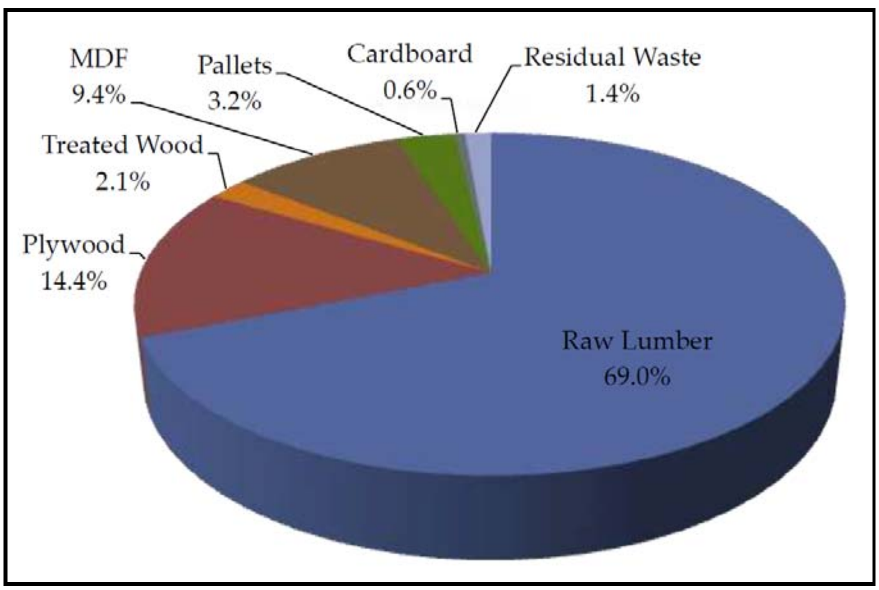

Figure 3 BCIT waste audit results for a 40-yard bin

It is important to note that treated wood is not used in either the carpentry or joinery training programs. It is plausible that the treated wood, residual waste and cardboard present in the audit were placed into the bin after hours by non-BCIT users.

Chemical analyses show that BCIT's combined wood waste is very clean and meets all the standards developed by the European Committee for Standardization for general use pellets (European Pellet Norm (EN 14961-1)).

When the biomass-to-energy system is operational, its fuel source will be located in a controlled and secure location. Solid wood waste and sheet good offcuts will be ground into chips, which will then be blended with shavings and fines (sawdust). This blended mix will be transferred into a specially designed temporary storage area before being fed into the biomass-to-energy system. The secured waste stream associated to the Project will ensure no treated wood can be inserted and combusted.

3.2.4 Residual Ash Management

BCIT retained an environmental consulting firm to review the waste audit findings discussed in Section 3.2.3 and provide advice on options for managing the ash generated by the proposed biomass boiler. Conclusions of this review suggest that BCIT's fuel mix would produce approximately 1.0 – 1.5 tonnes of ash per year composed of separate fly and bottom ash streams that may be combined or left separate for management. This ash will contain mainly carbon and non-volatile minerals (e.g. calcium, potassium, phosphorous), with small quantities of trace elements and trace organic constituents. Several management options, as listed below, are available for wood-derived ash of this type:

- Application to land as a soil amendment
- Use as an amendment within the existing BCIT composting system
- Use as an additive in the manufacture of Portland cement
- Disposal in landfill

The approach chosen for ash management will depend on availability of the options to BCIT and specific properties of the ash generated, which in turn would be determined by the quality and composition of the wood waste used as fuel and combustion conditions.[10]

3.3 Scope of Assessment

Scope of this EIA comprises the following Project phases and components:

- Project Construction
  - Construction of the plant building/boiler room
  - Procurement, delivery, and installation of system components
  - Heating distribution line connection
- Project Operation
  - Biomass-to-energy system operation

[10] Sylvis, Ash management options for wood waste boiler, January 15, 2013

Typically, the scope of an EIA would include decommissioning of the project; however, the Project is expected to be operational for the foreseeable future, and decommissioning is not addressed in this EIA. BCIT is committed to undertaking all activities associated with decommissioning in accordance with applicable regulatory and policy requirements in place at the time of decommissioning.

3.4 Project Schedule

The Project schedule spans April 2014 to March 31 2015. Major elements of the Project schedule are listed below:

Design:	August to November 2014
Construction Document:	November 2014 to January 2015
Construction:	February to May 2015

4 EXISTING ENVIRONMENT

4.1 Biophysical

The Project will be located in an existing parking lot and attached to the southwest corner of the existing main Joinery workshop (Building NE2) in the northeast quadrant of the BCIT's Burnaby campus. A side walk and landscaped strip separates the Joinery workshop from the adjacent Learning Resources building. A portion of the Project footprint will be located within this landscaped area composed of a managed lawn and a few ornamental trees. Wildlife present in the vicinity of the Project area is limited to common and abundant species that are well-adapted to urban settings.

There are no water-courses on or near the Project site. A portion of surface water run-off from the Project area flows into the soil with the landscaped strip, and the rest is captured by storm drains in the adjacent parking lots.

4.2 Socio-Community

4.2.1 Land Use

Land use in the vicinity of the Project area is educational, with majority of the adjacent buildings accommodating workshops for trades, applied science and technology programs such as carpentry, joinery, welding, saw trades and steel trades, and associated class rooms. The nearest residential area is located approximately 800 metres to the east of the Project site, outside the BCIT campus.

4.2.2 Air Quality

In BC, there are approximately 100 continuous and 50 non-continuous ambient air monitoring stations (BC Air Quality 2012). The closest monitoring station to the site is the Burnaby South station (ID # T18) located approximately 5 km southeast of the Project site. The Burnaby South station is a part of the Lower Fraser Valley (LFV) Air Quality Monitoring Network, which includes 26 air quality monitoring stations from Horseshoe Bay to Hope. This station collects both continuous and non-continuous air quality data, and continuous meteorological monitoring for wind, temperature, and precipitation (Metro Vancouver 2010).

Based on a search of iMapBC Air Emissions Inventory, there are no Air Quality Areas of Interest (AOI) near the site. (An AOI is a geographic area defined for a range of possible air quality management related activities (iMap BC 2010)).

Refer to section 3.3 for information regarding Greater Vancouver Regional District Boilers and Process Heaters Emission Regulation Consolidated and Air Quality Management Bylaw No. 1082, 2008.

4.2.3 Ambient Noise

Based on a baseline noise assessment conducted by BCIT in May 2014[11], ambient noise levels in the vicinity of the Project area during morning and lunch break hours have peaks over 70 db on a 30 second average. Some of the measurement points with the loudest sound levels (65 db and higher in the overall average) were observed along the northwest corner of Building NE2. The Average, Maximum, and Minimum noise levels for the study area, obtained by categorizing and averaging noise levels observed at the 42 observation points are summarized in **Table 1** below. *Single Measurements* denote data before averaging the measurements to categories.

Table 1 Ambient Noise Levels in the Project Area

	Average [db]	Maximum [db]	Minimum [db]
Morning	62	70	54
Lunch break	63	74	52
Afternoon	58	65	50
Night	52	64	43
Weekend	53	59	45
Day	62	70	55
Overall	61	70	54
Single measurements	61	77	43

A copy of the report on the baseline noise assessment is included in Appendix c.

4.3 Regulatory and Policy Setting

The following regional bylaws and regulations will apply to the design and operation of the Project:

- *Greater Vancouver Regional District Air Quality Management Bylaw No. 1082, 2008* (Section 26)
- *Greater Vancouver Regional District Boilers and Process Heaters Emission Regulation Consolidated (*as of October 25, 2013*)*

The Project is also being designed to comply with *BCIT Safety Manual for Hazardous Waste Management* (Part 6 Section 95) and *Environmental Reporting* (Part 6 Section 96), and *BCIT Policy 1010 - Economic, Social, and Environmental Sustainability*, and with *Procedure no. 7100-PR7 - Environmental Protection.* These policies include provisions related to the following legislation:

[11] *BCIT Wood Waste-to-Energy Research Facility, Determination of the existing sound levels within the BCIT Factor Four area. Florian Scheit.* June 8, 2014.

- Province of British Columbia: *Environmental Management Act* (and all associated regulations).
- Government of Canada:
  - *Environmental Protection Act* (and all associated regulations)
  - *Hazardous Products Act* (and all associated regulations)
  - *Transportation of Dangerous Goods Act* (and all associated regulations)

5 SCOPE OF EVALUATION

This Environmental Impact Assessment is intended to help BCIT identify potential adverse environmental effects of the Project, and assess the significance of such effects prior to undertaking the proposed works. The EIA considers all activities associated with construction and operation of the Project as discussed under **Section 3.2**.

Changes to the biophysical environment caused by the Project, as well as any resultant effects on the socio-economic environment, are considered in this EIA by identifying and assessing appropriate Valued Components (VCs—*components of the natural and human environment that are considered by the proponent, public, Aboriginal groups, scientists and other technical specialists, and government agencies involved in the assessment process to have scientific, ecological, economic, social, cultural, archaeological, historical, or other importance*[12]).

For the Project, VCs were selected based on the potential for interaction of natural and human environment with the Project, and the relative importance of environmental components that have a potential to interact with the Project. The project interaction matrix included below as **Table 2** was used to identify environmental components that have a potential to interact with the Project during construction and operation of the proposed facility, and develop the list of VCs to be included in the assessment.

Table 2 Potential Project / Environment Interactions Matrix

Project Component or Activity	Environmental Components						
	Soil	Water	Vegetation	Air Quality	Ambient Noise	Land Use	Traffic
Project Construction							
Construction of the plant building/boiler room	o	o	o	o	o		o
Procurement, delivery, and installation of system components					o		o
Heating distribution line connection	o	o			o		
Project Operation							
Biomass-to-energy system operation		o		X	X		o

Note: X = Potential effect of project on environment; o = Minor or negligible interaction; Blank = no interaction

[12] Guideline For The Selection Of Valued Components and Assessment of Potential Effects, BC Environmental Assessment Office, September 9, 2013

Based on potential interactions of the Project with environmental components as identified in **Table 2**, and the relative importance of the components, the following were selected as VCs for assessing potential effects of the Project:

- Air quality
- Ambient noise
- Water quality
- Soil quality
- Vegetation
- Traffic on campus

6 DISCUSSION OF ENVIRONMENTAL EFFECTS, MITIGATION, RESIDUAL EFFECTS AND SIGNIFICANCE

Potential effects of Project interaction with selected VCs were assessed based on information discussed in Sections 3 to 5 (project scope, existing conditions, and scope of evaluation), and professional judgment. Measures to mitigate any identified potential adverse interactions were then identified. Finally, significance of any residual effect (i.e. effect remaining after mitigation) was assessed to reflect such characteristics as the magnitude, geographic extent, duration or frequency, reversibility, and ecological context of the effects identified.

6.1 Potential Environmental Effects, Proposed Mitigation Measures, and Residual Effects

This section provides a discussion of potential adverse environmental effects of the project on VCs identified to interact with the project (**Table 2**, **Section 5**) and appropriate mitigation measures to avoid or minimize such effects.

6.1.1 Air Quality

Description of the Potential Effects: Light and heavy equipment emissions and fugitive dust generated during construction activities, including delivery and installation of Project components, may affect existing air quality in the vicinity of the Project site.

Once the Project becomes operational, emissions from the biomass boiler and fugitive dust released during transfer of wood waste into the fuel storage unit have the potential to affect air quality. These effects, however, are expected to be minimal because modern institutional biomass systems burn cleanly, and have virtually no visible emissions or perceivable odour. These units emit far less particulate matter (PM)[13] and offer better filtration and combustion parameters.

Modern biomass boilers can burn biomass fuel in a controlled fashion that reduces, but not eliminate, emissions. The type and amount of air emissions depend on two key points: what fuel is burned and how it is burned. The following parameters have an impact on the generation of typical air contaminants:

- The fuel's chemical composition, such as sulfur or chlorine content, mineral type and content

[13] Biomass Energy Resource Center, Benefits of Using Biomass Energy

- The fuel's moisture content: dry fuel can be burned cleaner than wet fuel
- The combustion temperature and the control of this temperature
- The oxygen supplied and the way this oxygen mixes with the wood gases
- The time wood gases remain in the combustion chamber
- The geometry of the combustion chamber
- The firebed's size and movement
- The velocity of the air supplied
- The flue-gas temperature in the exhaust and chimney

Since the fuel to be burned at the proposed facility was lab-tested and proven to be clean enough to meet European Class A1 pellet standard, the challenge is reduced to the technology applied and the way the biomass boiler is operated.[14]

Mitigation Measures: BCIT will ensure that appropriate construction best management practices, including minimizing idling and use of well-maintained equipment, and application of water to suppress dust as required, are in place to minimize construction-related effects on air quality. All construction activities will be required to comply with BCIT's *Environmental Protection procedure 7100-PR7* and *Economic, Social, and Environmental Sustainability policy no. 1010* as they pertain to vehicle and other emissions.

The following mitigation measures will be in place to minimize or avoid operational effects of the Project on air quality:

- The proposed facility will be designed and operated in strict adherence to Metro Vancouver Air Quality Management Bylaws – specifically Bylaws numbered 1082, 2008 and 1087, 2008 (as amended by Bylaw 1190, 2013) that help manage the major sources of business and industrial emissions and restrict these contaminants. Bylaw provisions that are of specific relevance to the Project are included in Appendix D.
- Wood waste from external sources will not be used as fuel for the proposed biomass boiler.
- The fuel storage area will be kept secured at all times to prevent introduction of waste from external sources being introduced into the system.

[14] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013

- Appropriate procedures will be in place to ensure that only appropriate wood waste is introduced in the fuel stream from the carpentry and joinery workshops. BCIT is finalizing a waste/fuel management plan that will be in place prior to commissioning the biomass-to-energy facility. The plan includes a combination of physical barriers (for example, storage of wood waste in locked areas) and standard operating procedures for staff. This will allow BCIT to fully control the material that ends up in the boiler.
- The fuel storage and transfer areas will be enclosed to minimize dispersion of fugitive dust during fuel transfer.

Residual Effects – With the recommended mitigation measures in place and given negligible magnitude of effects that are intermittent, reversible, and limited geographically to the ecologically disturbed site during construction activities, residual effects on air quality are not expected.

6.1.2 Ambient Noise

Description of the Potential Effects: Operation of construction equipment, and delivery and installation of Project components could result in minor, short-term increases in ambient noise levels. The sound generated during Project construction will be typical to small-scale construction projects, and is not expected to have any significant effect on ambient noise levels.

The noisiest component in the biomass-to-energy system will be the chipper, which will be operational between two and three hours on a daily basis. Chippers typically have a noise range between 80 and 90 db. The chipper will be placed in an enclosure specifically designed for noise reduction. Noise generated by other Project components are expected to be typical of operations associated with an instructional workshop.

The Project site is located in an area of campus where ambient noise levels are relatively high, as discussed in **Section 4.2.3 Ambient Noise**, and the sound emission of the proposed facility is expected to be under the existing average noise level. Studies undertaken in May 2014 indicate that ambient noise levels in the Project area during the morning and the lunch break hours have peaks over 70 db on a 30 second average. So it is expected that the assumed sound emissions of the new biomass facility will not have any significant influence on the sound distribution on the BCIT Burnaby Campus and the surrounding areas.

Mitigation Measures: BCIT will ensure that appropriate construction best management practices, including minimizing idling and use of well-maintained equipment, are in place, to minimize construction-related effects on ambient noise.

The following mitigation measures will be in place to minimize sound generated during Project operation:

- The chipper will be placed in an enclosure specifically designed for noise reduction. This enclosure will have a hatch above the chipper's hopper for material entry and a limit-switch on the hatch will prevent the chipper from operating when it is in the open position. This will ensure safe operation and maximize noise reduction. A target of no more than 60 db from the chipper operations will be given to the chipper enclosure designer.
- The chipper will be operated primarily during the morning hours of the work week to avoid an increase of sound emissions in the evenings and on weekends.
- BCIT intends to measure background noise levels after the biomass-to-energy system is installed to ensure its operation does not contribute to an increase in ambient noise.

Residual Effects – With the recommended mitigation measures in place, residual effects on ambient noise are not expected.

6.1.3 Surface Water

Description of the Effect: Potential effects construction activities associated with the Project include accidental spills of deleterious substances such as fuel from machinery during construction reaching surface water bodies through the storm sewer system.

No liquid effluent will be generated during operation of the proposed facility. The biomass boiler, like any pressurized boiler, will be equipped with pressure relief valves that open and release water in case the pressure inside the boiler exceeds the threshold that the boiler is registered for. There is a potential for the released water to enter the municipal sewer system in such instances. These occurrences, however, are expected to be extremely rare, and the water released will be domestic water with a small amount of anti-corrosion material—potassium hydroxide or sodium hydroxide—added. Given this, potential effect of any incidental release of water from the boiler is expected to be negligible.

Mitigation Measures: Proposed mitigation measures that will be applied to avoid potential effects on surface water include standard construction best management practices to avoid release of sediment and deleterious substances into the storm sewer system. If required, depending on the size of the biomass boiler, a container will be installed to capture water released by pressure relief valves during instances of pressure build-up.

Residual Effects – With the recommended mitigation measures in place and given negligible magnitude effects that are intermittent, reversible, and limited geographically to the ecologically disturbed site during construction and operation activities, residual effects on surface water are not expected.

6.1.4 Soil Quality

Description of the Effect: Construction of the plant building and the excavation associated with the heating distribution line connection, and accidental leaks or spills of fuel and other deleterious substances from construction equipment and vehicles have the potential to have a minor effect on soil quality.

Mitigation Measures: Proposed mitigation measures that will be applied to avoid potential effects on soil quality include standard construction best management practices to avoid or minimize leaks and spills of fuel and other deleterious substances from construction machinery. Landscaped area outside the Project foot print that is disturbed during construction will be revegetated or otherwise covered to prevent erosion of topsoil.

Residual Effects – With the recommended mitigation measures in place and given negligible magnitude effects that are intermittent, reversible, and limited geographically to the ecologically disturbed site during construction and operation activities, residual effects on soil quality are not expected.

6.1.5 Vegetation

Description of the Effect: The only Project-related effect on vegetation is the removal of a small area of managed lawn and a few ornamental trees to accommodate the new plant building.

Mitigation Measures: Given the nature and extent of vegetation loss, no mitigation or compensation measures have been identified; however, BCIT has included a budget for re-doing the landscape around the new facility in the approved, overall budget for the Project.

Residual Effects – The residual effect of the Project is limited to the loss of a very small number of ornamental trees, and is considered negligible.

6.1.6 Traffic on Campus

Description of the Effect: Movement of construction vehicles and equipment during construction may have a minor effect on traffic in the vicinity of the Project site. These effects will include a temporary disruption of the walkway between the joinery and carpentry workshops and classroom/learning resources building to the east. Once the Project becomes operational, the number of truck trips within and adjacent to the campus is expected to decrease because of waste diversion achieved by the biomass boiler.

Mitigation Measures: The following mitigation measures will be in place to avoid or minimize potential Project-related effects on traffic:

- Traffic control best practices will be put in place during periods of high volume construction-related traffic.
- A temporary pathway will be established a safe distance from the construction area, and signage for alternative arrangements will be installed to redirect pedestrian traffic until the corridor is reinstated.

Residual Effects – With the recommended mitigation measures in place and given negligible magnitude effects that are intermittent, reversible, and limited geographically to the immediate vicinity of the Project site during construction and operation activities, residual effects on traffic are expected to be negligible.

6.2 Other Project-related Effects and Considerations

6.2.1 Fire Safety

The proposed facility is classified under the BC Building Code as *low hazard boiler occupancy group F, div 3, < 50 kg/m*^{3}, and the Project design and operation will comply with the requirements of this classification. Key considerations in ensuring fire safety for the proposed facility are back burn prevention, smoke build-up, and dust explosions. The existing dust collection and disposal method will be reassessed in terms of potential for dust explosions.

Unlike oil or gas-fired boilers, solid fuel-fired combustors cannot be easily switched on or off. Even when heat demand ceases, the fuel inside the combustor needs to be completely burned rather than left smoldering. Power outages or a failure of the flue-gas fan can lead to smoke or fire traveling back from the combustion area into the fuel supply chain and—in the worst case—set the fuel storage on fire. This requires the following additional safeguards: [15]

- Continuously monitoring the negative pressure operation in the combustion chamber, which makes the smoke stack the only route flue gases can exit.
- Pre-loaded fuel cut-off gate, which activates if there is a power failure, positive pressure in the combustion chamber or the boiler fire goes out.

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[15] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013

- Fire locks and sluices, which control air and flue gas flow as well as preventing fire travelling back into the fuel supply.
- Deluge system, which is used as a last resort and floods the fuel supply chain with water.

6.2.2 Operations Monitoring

Because the plant will be burning fuel that is classified by GVRD Bylaw 1087 as contaminated, there might be a requirement to test emissions from the flue gases. The design therefore includes stack testing ports located on the horizontal section of the exhaust pipe that are accessible from the ground level. The ground level ports may also be used by students training to become professional stack testers.

BCIT's biomass-to-energy system has been designed for operation as a research facility, particularly regarding air emissions monitoring. As such the system design provides for future retrofit to accommodate monitoring equipment for research purposes, including access to parameters measured by the boiler control system, such as combustion temperature and oxygen content. Monitoring for these parameters is not required from a regulatory or permitting perspective, and is not included in the present scope of the Project

6.2.3 Project-related Commitments

BCIT is committed to the following:

- At a minimum BCIT will meet Metro Vancouver's stringent bylaws related to air emissions
- BCIT will ensure its operation does not contribute to an increase in ambient noise levels, by measuring background noise levels prior to and after the biomass-to-energy system is installed
- BCIT will deal with the ash produced in an environmentally responsible manner
- Prior to considering inclusion of any external sources of fuel, an additional environmental assessment will be completed
- BCIT will design and implement a public communication plan during the detailed design phase of the Project (the plan will include an open house session)

Table 3 Summary of Potential Effects and Mitigation Measures

Valued Component	Potential Effects	Mitigation	Significant Residual Effects?
Air Quality	Light and heavy equipment emissions and fugitive dust generated during construction activities, including delivery and installation of Project components, may affect existing air quality in the vicinity of the Project site.	• The proposed facility will be designed and operated in strict adherence to Metro Vancouver Air Quality Management Bylaws – specifically, Bylaws numbered 1082, 2008 and 1087, 2008 (as amended by Bylaw 1190, 2013). • Wood waste from external sources will not be used as fuel for the proposed biomass boiler. • The fuel storage area will be kept secure at all times to prevent introduction of waste from external sources being introduced into the system. • Appropriate procedures will be in place to ensure that only appropriate wood waste is introduced into the fuel stream from the carpentry and joinery workshops, as part of the waste/fuel management plan. • The fuel storage and transfer areas will be enclosed to minimize dispersion of fugitive dust during fuel transfer.	None expected
Ambient Noise	Operation of construction equipment, and delivery and installation of Project components could result in minor, short-term increases in ambient noise levels.	• The chipper will be placed in an enclosure specifically designed for noise reduction. This will ensure safe operation and maximize noise reduction. A target of no more than 60 db from the chipper operations will be given to the chipper enclosure designer. • The chipper will be operated primarily during the morning hours of the work week to avoid an increase of sound emissions in the evenings and on weekends. • BCIT intends to measure background noise levels after the biomass-to-energy system is installed to ensure its operation does not contribute to an increase in ambient noise.	None expected

Valued Component	Potential Effects	Mitigation	Significant Residual Effects?
Water Quality	Potential effects construction activities associated with the Project include accidental spills of deleterious substances such as fuel from machinery during construction reaching surface water bodies through the storm sewer system.	• Standard construction best management practices to avoid release of sediment and deleterious substances into the storm sewer system. • If required, a container will be installed to capture water released by pressure relief valves during instances of pressure build-up.	None expected
Soil Quality	Construction of the plant building and the excavation associated with the heating distribution line connection, and accidental leaks or spills of fuel and other deleterious substances from construction equipment and vehicles have the potential to have a minor effect on soil quality.	• Proposed mitigation measures that will be applied to avoid potential effects on soil quality include standard construction best management practices to avoid or minimize leaks and spills of fuel and other deleterious substances from construction machinery. Landscaped area outside the Project foot print that is disturbed during construction will be revegetated or otherwise covered to prevent erosion of topsoil.	None expected
Vegetation	Removal of a small area of managed lawn and a few ornamental trees.	• Given the nature and extent of vegetation loss, no mitigation or compensation measures have been identified. • A budget for re-doing the landscape around the new facility has been included in the approved budget for the Project.	Negligible
Traffic	Movement of construction vehicles and equipment during construction may have a minor effect on traffic in the vicinity of the Project site.	• Best practices for traffic control will be put in place during periods of high volume construction-related traffic. • A temporary pathway will be established a safe distance from the construction area, and signage for alternative arrangements will be installed to redirect pedestrian traffic until the corridor is reinstated.	Negligible

6.3 Significance of Residual Effects

The evaluation indicates that potential environmental effects can be substantially mitigated for all Project interaction with VCs. Consequently, the Project is not expected to cause significant adverse residual effects.

7 CONCLUSION AND RECOMMENDATIONS

This environmental impact assessment has identified valued environmental and socio-economic components and their potential interaction with the BCIT Biomass-to-Energy Project. Mitigation measures have been recommended to minimize or avoid potential adverse effects. With mitigation in place, there are no predicted significant adverse effects associated with the Project. No residual effects were identified.

We recommend that a qualified environmental monitor be present during construction activities to ensure that appropriate mitigation measures and best management practices are in place to avoid or minimize potential adverse effects on the environment.

APPENDIX A

REVIEW OF OPTIONS: ALTERNATE BIOMASS-TO-ENERGY TECHNOLOGIES & SYSTEM COMPONENTS

Alternate Technologies

BCIT determined a combustion (heat only) biomass boiler is the best choice based on our waste make-up and volume, maturity of this heat-only technology (used extensively in Europe and BC's greenhouse industry, though at a much larger scale), available footprint, and cost. Other technologies that were considered include:

Combined heat and power (CHP)

Combined heat and power (CHP) systems generate electricity as their primary function and then utilize the residual energy from this primary function for other purposes, such as heating water. The 250,000 kg of wood waste BCIT generates on an annual basis is sufficient for operating:

- A 200 kW_{th} heat-only boiler
- A 20 – 30 kW_{el} power generator[1] also producing 100 to 120 kW_{th} heat

Combined heat and power systems convert biomass to energy either through combustion or gasification. Their compatibility with alternative and renewable energy sources has become increasingly significant as the price of conventional fuels rises, and also in light of concerns such as peak oil and climate change.

Combustion driven combined heat and power

Heat from the combustion of biomass converts water into high-pressure steam, which in turn rotates an output shaft, which is connected to a generator for producing electrical power. When steam passes through a turbine it expands losing a portion of its thermal energy, so when it exits the turbine it still has a relatively high thermal energy. Rather than venting this heat to the atmosphere through a cooling tower, the way conventional thermal power plants do, CHP systems focus on capturing this heat and using it for productive purposes,[2] such as supplying heat exchangers in district heat distribution networks. It is worth noting that these units will require Special Safety Authority approval.

One option for combustion-driven CHP systems is utilizing the biomass energy to generate steam, which then drives a turbine, a reciprocating piston or rotary screw:

- In a steam-driven turbine system, steam rotates a turbine to create electricity. These turbine systems require fuel volumes much larger than available at BCIT (smallest units are 500 kW_{el}).

[1] Canadian Biomass Energy Research (CBER), BCIT Biomass to Energy Workshop, May 2012
[2] Biomass Innovation Center, Fueling growth through clean technology

- In a similar fashion, steam can also be used to drive reciprocating pistons to create electricity. This is a proven technology and commercial units are available that match BCIT's wood waste quantities, but may require constant supervision by a steam engineer and are noisy and vibrate when operating.
- A screw-type system is a form of rotary displacement engine, where steam is expanded in a closed working chamber. Screw-type engines are suitable for biomass CHP plants in the range of 200 to 2,500 kW_{el}[3], have some technical challenges and may require constant supervision by a steam engineer.

A second option for combustion-driven CHP systems utilizes the Organic Rankine Cycle (ORC). The Rankine cycle is the fundamental operating cycle of all thermal power plants where an operating fluid is continuously evaporated and condensed. The selection of operating fluid depends mainly on the available temperature range.[4] The term "Organic" is used when the working fluid is an organic fluid (usually silicon oil), which has a much lower boiling point than water. Using the silicon oil instead of water, decreases the system's efficiency, but eliminates the need for continuous supervision. Thermal fluids such as silicon oil reduce the corrosive characteristics associated with water and steam, but introduce a poisonous and flammable material into the system. These are larger systems (minimum 200 kW_{el}), with high capital costs and require a large footprint. Not a viable option for BCIT's needs.

Another option for combustion-driven CHP systems is the hot gas (Sterling) engine. Stirling engines are external combustion engines, based on a closed cycle, where the working gas is alternately compressed in a cold cylinder and expanded in a hot cylinder. The advantage of the Stirling engine in comparison to internal combustion engines is that the heat is not supplied to the cycle by combustion of the fuel inside the cylinder, but transferred from the outside through a heat exchanger in the same way as in a steam boiler. Combustion related problems or problems related to dirty fuel are confined to the engines outside, rather than the inside as occurs in an internal combustion engine. Consequently, the combustion system for a Stirling engine can be based on proven furnace technology, yet keeping the heat exchanger clean on a continuous basis has been the Achilles heel of this technology. The heat input from fuel combustion is transferred to the working gas through a hot heat exchanger at high temperatures. The heat that is not converted into work on the shaft is rejected to the cooling water in a cold heat exchanger.

The Stirling engine is noted for its simplicity compared to steam engines, quiet operation, and the ease with which it can use almost any heat source. This engine is currently exciting interest as the core component of micro combined heat and power (CHP) units, in which it is more efficient and safer than a comparable steam engine. In the biomass sector, the Sterling engine is not yet commercially available and concerns regarding the heat exchanger have been raised.

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[3] Bioenergiesysteme GmbH, Description of the screw-type steam engine cycle in biomass-fired CHP plants

[4] Thermopedia, Rankine Cycle

Gasification combined heat and power

Combustion of any solid fuel requires a phase change from solid to gas. Once the fuel is 'devolatized' or 'gasified' it is mixed with air, thereby oxidizing the gases. While the combustion of a solid fuel always includes a stage of gasification, advanced combustors physically separate these two processes by employing a primary (gasification) and a secondary (oxidation) chamber, both with separately controlled air supply. The concept is generally referred to as staged combustion, though a number of North American companies have coined the term 'gasification'.

The main difference to conventional combustors is the clear separation between the two combustion stages. Heat gasifiers achieve this by heating and devolatizing fuel in an oxygen deprived environment. This produces a flammable wood gas (sometimes called 'syngas') ready to combust, however with a much lower heating value than natural gas (10-20%). The process works at high temperatures (800-1,400°C) and therefore uses part of the energy in the feedstock for the gasification step.[5]

Gasification of wood is of interest for combined heat and power generation as the syngas may be used inside an internal combustion engine, resulting in overall higher efficiencies than any other biomass CHP technology. The advantage of gasification is that using the syngas is potentially more efficient than direct combustion of the original fuel, because it can be combusted at higher temperatures.[6] Syngas may be burned directly in gas engines, turbines or fuel cells. Gasification technology is not an option for BCIT because the technology does not allow for any contamination of the fuel, such as resins used in MDF and plywood. The smallest units are in the 30 - 45 kW_{el} range.

Pyrolysis

An alternate option for our wood waste is to convert it into a higher quality fuel, which could be used at a later date and/or in an alternate location. In order to create highly efficient transportable biomass-to-energy fuel, pyrolysis of biomass in combination with densification (pelletisation or briquetting) is a promising step to make it easier to transport and store.

Pyrolysis is the thermal decomposition of biomass occurring in the absence of oxygen. It is the fundamental chemical reaction that is the precursor of both the combustion and gasification processes and occurs naturally in the first two seconds. The products of biomass pyrolysis include biochar, bio-oil and gases including methane, hydrogen, carbon monoxide, and carbon dioxide. Depending on the thermal environment and the final temperature, pyrolysis will yield mainly biochar at low temperatures, less than 450^{o} C, when the heating rate is quite slow, and mainly gases at high temperatures, greater than 800^{o} C, with rapid heating rates. At an intermediate temperature and under relatively high heating rates, the main product is bio-oil.

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[5] Cornelius Suchy, Disposal and Utilization of Bovine SRM Waste, Feb 25, 2010

[6] Wikipedia, Gasification

Pyrolysis can be performed at relatively small scale and at remote locations which enhance energy density of the biomass resource and reduce transport and handling costs. Heat transfer is a critical area in pyrolysis as the pyrolysis process is endothermic and sufficient heat transfer surface has to be provided to meet process heat needs. Pyrolysis offers a flexible and attractive way of converting solid biomass into an easily stored and transported liquid, which can be successfully used for the production of heat, power and chemicals.

This option is not attractive to BCIT, because the fuel is to be utilized on site and the need for storage is not in the school's long-term plan. Pyrolysis and its associated cost would therefore be an unnecessary step.

Composting

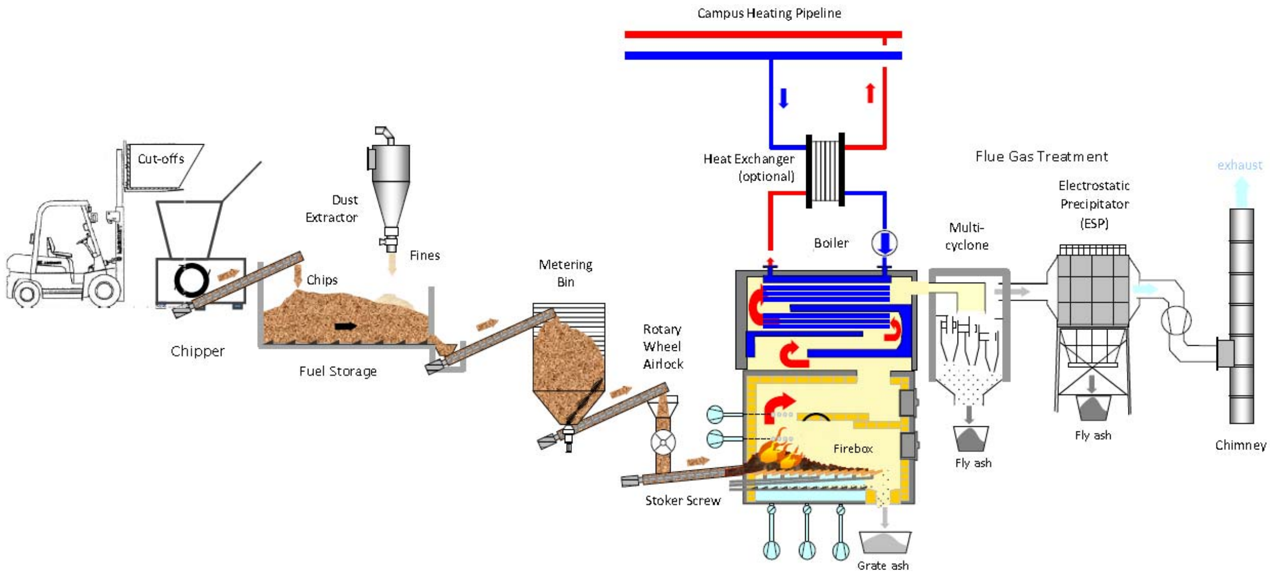
At the time of writing this report, composting wood waste for heat generation is an unproven technology. Literature reviews and expert interviews have taken place. Examples of composting installations that utilize similar volumes and composition of wood waste to heat water have not been identified.

Composting of pure wood has proven to be a rather slow process as evidenced by heritage wood chip or hog fuel piles. The reason for this is mainly seen in the lignin content of wood. A mix of wood and other non-ligneous biomass is known to accelerate the degradation process.

The technology is not suitable for BCIT at as it would require importing non-woody biomass. There are also odour issues associated with composting that might not gel with the work and study environment that BCIT wishes to offer.

Preferred Technology and System Components

The following schematic shows the technology that will be used in the biomass-to-energy system proposed at BCIT's Burnaby campus. Technology available for each component and its viable options are described in the sub-sections that follow.



Material Size Reduction Technology

BCIT's waste stream includes materials that need to be reduced in size prior to being used as fuel in the biomass energy system. The selection of this equipment is based on our: waste volume, waste type, size materials need to be reduced to, equipment footprint, noise levels, ease of operation and maintenance.

Wood chipper

The two main classifications of size reduction equipment are:

- Chippers
- Grinders

Chippers reduce material size using a slicing action with sharp knives, which are either mounted on a drum or on a disk. These knives produce homogenous chips of consistent size with clean cut edges and operate in a quieter fashion when compared with grinders. This consistent chip geometry increases the biomass boiler's combustion efficiency. Final chip size is determined by equipment set up and typically ranges between 3 and 31mm (1/8" to 1 ¼").

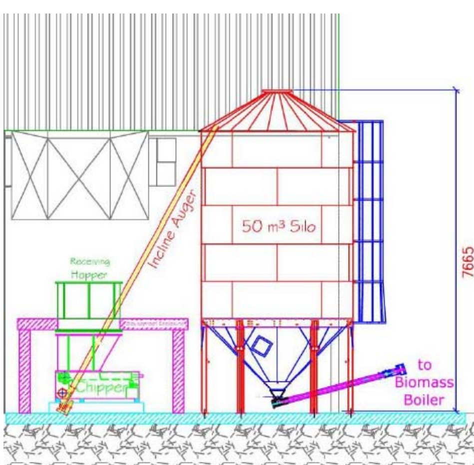
Grinders (hammerhogs and hammermills) reduce material size by hammering the material with blunt tools and the grinds they produce (often referred to a "Hog Fuel") are damaged by compression, have irregular shapes and inconsistent sizes. Grinders are useful when fuel source has high contamination levels (gravel, dirt, etc.) or when the fuel needs to be reduced to very small dimension 2mm (1/16") or less, but they have a greater risk of blockage. Disadvantages of using hog fuel in a biomass boiler include reduced efficiency (due to inconsistent fuel size) and higher potential for bridging in the fuel storage system. Grinders are also much noisier to operate, which would be problematic on BCIT's Burnaby campus.

At BCIT, materials that need to be reduced in size will initially be dumped into a hopper using a forklift. One option for transferring materials from the hopper into the size reduction equipment is using a side-feed conveyor belt, but this method is expensive and designed for volumes much larger than available at BCIT. A gravity-fed system, with the hopper above the size reduction equipment, is more cost effective and requires a smaller footprint.

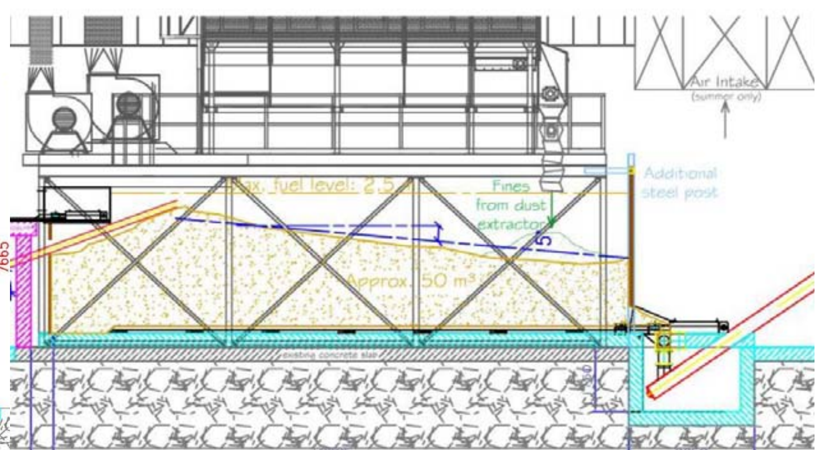
BCIT will be using a chipper equipped with a gravity fed top-mounted hopper, which produces chips no larger than 25mm (1"). Students will be instructed to remove all nails and screws from wood before it enters the hopper, but realistically a small percentage of metal will enter the chipper. Criteria for chipper selection will include its ability tolerate some metal in the feed-stock and a system that allows its knives to be easily replaced or sharpened. To prevent metal from entering the biomass boiler, magnets will be mounted on the out-feed side of the chipper. After materials have been dumped into its hopper, the chipper can operate unmanned. The chipper will operate between two and three hours on a daily basis. Chippers typically have a noise range between 80 and 90 db. BCIT will place its chipper in a sound proof enclosure to reduce this noise level to a maximum of 60 db. This enclosure will have a hatch above the chipper's hopper for material entry and a limit-switch on the hatch will prevent the chipper from operating when it is in the open position. This will ensure safe operation and maximize noise reduction

Storage Technology

Biomass boilers are designed to run 24 hours a day seven days a week and perform poorly during start-up and shut-down phases. BCIT's biomass-to-energy system will require some form of fuel storage because its wood waste fuel stream is produced from programs that run seven hours per day and the load produced varies from day-to-day and week-to-week. Without some form of storage, the system would be unable to run on a constant basis.



Storage silo



Storage bunker using existing steel structure

To accommodate the fluctuation of fuel availability, fuel storage will be based on the following criteria:

- Best case scenario is to have biomass system operate 24/7, 365 days of the year to minimize storage requirements and start-up and shut-down phases of the system. Multiple start-up and shut-down phases are undesirable because during these phases the air emission quality is low.
- If the biomass system does operate 24/7 the storage facility should still have storage to accommodate fluctuations in fuel availability, and act as a buffer should the chipper or biomass energy system experiences down-time.
- If the biomass system does not operate 365 days of the year excess fuel that will be generated (during the summer months when the main gas fired boilers and distributed heating system are shut down) will either need to be compacted and stored, stored in a non-compacted state, or removed from campus.
- Storage options include a silo, an above ground bunker or a below ground bunker.

In the short-term, BCIT intends to operate the biomass boiler 10 months of the year to coincide with the operation of main gas fired boilers and the district heating system, which may require waste removal in the summer months. To store chipped wood waste produced during the district heating system's down-time (July and August) would require three silos 3.7 metres (12') in diameter and 7.3 metres (24') tall. Space constraints and the visual impact of this option make it undesirable. BCIT is also exploring other avenues for utilizing the biomass energy during July and August. Possible options include heating domestic hot water in the Factor IV area, storing the heat in our geoexchange system, operating an absorption chiller in a large Factor IV building (NE1) or converting the materials into mulch for on campus use. Once a solution for utilizing the biomass energy in the summer months has been implemented, the investment in these temporary storage silos would be redundant.

Two concepts for storing wood fuel exist: cylindrical silos and box-shaped walking floor systems. Silos are usually less expensive but have constraints: to avoid bridging effects inside the silo, the effective wall height should not exceed two times the diameter.

A silo with a diameter of 3.7m (12') would have to have a wall height of 4.7 m to hold 50m3 (the volume we intend to store). Due to the design of commercially designed silos, the overall height would be at least 7.7 m (25'), slightly higher the west wall of the Joinery workshop. The silo would extend past the south face of NE02. Filling the silo will require a rather steep incline auger that could get damaged during loading the hopper of the chipper. Dust from the dust extraction system would have to be funneled or conveyed to this incline auger or to the hopper of the chipper itself.[7]

BCIT will make provisions for fuel storage of 10 tonnes or 50 m3 of fuel storage, equivalent to 10 days of maximum waste production. While larger than common, this size will allow operating the chipper even if the biomass boiler should be down for an entire week. Likewise it will allow operating the boiler at high fire even if the chipper or its operator is not available for an entire week. Instead of a silo storage system, common in the wood remanufacturing industry, a walking floor storage system is recommended. This allows making use of the space under the existing steel structure supporting the dust extractor. The structure itself can be used itself as a frame for the storage.[8]

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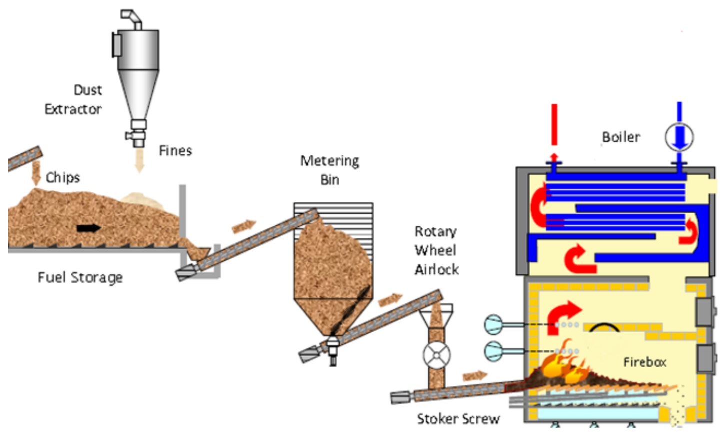
[7] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013

[8] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013

Fuel Metering Technology

An inclined auger will be used to transfer materials from the fuel storage area to a metering bin. A fuel metering bin is recommended for the following reasons:

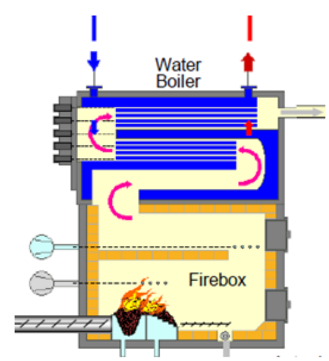
1. Monitoring fuel consumption
2. Creating a homogenous mixture of sawdust and chips
3. Separating the fuel bin from the combustor for fire safety reasons[9]



Monitoring fuel consumption will facilitate the research component of this project. Ensuring a homogenous mix of sawdust and chips will increase boiler efficiency and safety reasons for separating the fuel bin from the combustor are self-evident. It is also worth noting that the inclined auger used to feed the metering bin could also be used to remove excess fuel from the storage area if the boiler is not operational 12 months of the year.

Boiler and Firebox Technology

For the size of system required at BCIT, the boiler and firebox are typically sold as a package with the boiler mounted above the firebox. Sizing biomass boilers is either based on fuel availability or heat demand. Since the available potential energy contained in our 250,000 kg of wood waste would only reduce the energy consumption of our existing natural gas fired boilers by 6%, BCIT's biomass boiler will be sized on fuel availability rather than heat demand. An additional challenge for sizing our biomass boiler is that our fuel availability historically has varied between 9 tonnes and 30 tonnes per month.



Other factors that influence biomass boiler sizing include:

- Avoiding On/Off cycling (improves the quality of air emissions).
- Having a maximum turn-down ratio of 1:4 (improves boiler efficiency).
- Operating biomass boilers for extended time periods at 100% of their rated capacity (decreases boiler life expectancy).

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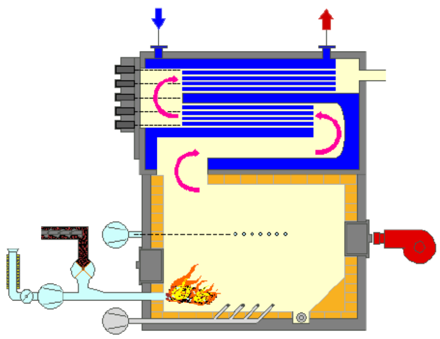
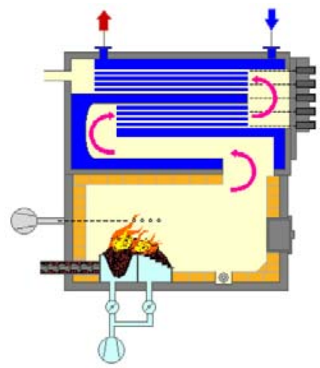
[9] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013

In conclusion it can be said that a firebox boiler with a rated output in the range between 170 and 200 kW (depending on the robustness of the design) is best suited for the fuel available at BCIT.[10]
BCIT also intends to employ a "warm water" boiler that operates below 100°C and below 206 kPa (30 PSI). This will simplify the requirements of the BC Safety Authority and reduce equipment costs.[11]

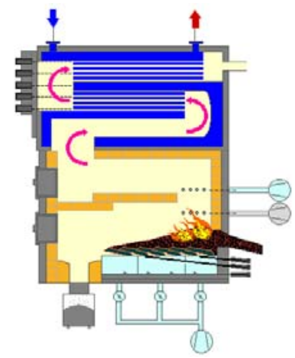
Three distinctly different firebox designs can be used for the capacity and fuel considered by BCIT.[12]



Suspension burners



Pile burners



Moving grate burners

Suspension burners operate by blowing fuel into the heated firebox, which ignites the fuel while it is airborne (suspended). The main advantage of this design is that there are few moving parts. This option has been ruled out because average fuel size needs 2mm (1/16"). Reducing our fuel to this dimension would require the use of a hammermill and as previously discussed, the operational noise levels of this equipment would be unacceptable at BCIT.

Pile burners, also called underfeed stokers, stoke fuel from underneath into retort in the combustion chamber rather than from above onto a grate. At low fire only a trough-shaped retort is filled. As demand for heat increases, more fuel is stoked into the retort, piling up in the trough, moving upward and eventually overflowing onto a sloped secondary grate.13 With no moving parts in the firebox, pile burners are a cost-effective solution for the size of boiler required at BCIT.

Moving grate burners burn the fuel on a moving grate. The grate is sloped, stepped, or horizontal. Reciprocating grates move the fire bed forward until the fuel pile is entirely burned out. A laser sensor at the end of the grate makes sure all embers are completely burned out and only grate ash is left. Suppliers contacted suggested that, because the fuel at BCIT contains MDF and plywood, a moving grate design be used to avoid build-up of clinker.14

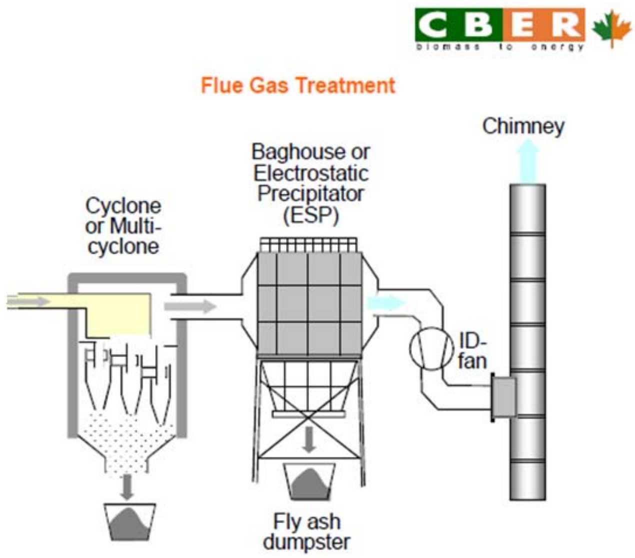
[10] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013
[11] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013
[12] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013
[13] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013
[14] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013

Particulate Filtration Technology

Particulate filtration technology is used to remove particulate matter (PM) from the exhaust gas after it leaves the combustion chamber and before it exits the chimney. Particulate matter is generally divided into categories:

- PM10 which refers to particles that are 10 micrometers or less in diameter
- PM2.5 which refers to particles that are 2.5 micrometers or less in diameter (these smaller particles are more likely to cause adverse health effects).

The following diagram shows a typical set-up of a biomass system's particulate filtration technology.



Typical heat-only biomass boiler with particulate filter technology[15]

There are a variety of available particulate filtration technologies:

- Cyclones and multicyclones – This technology uses centrifugal forces to separate particulate matter (PM) from exhaust gases. They are often used as the primary stage of filtration and remove approximately 90% of PM10 and less than 10% of PM2.5[16]
- Bag house – use fabric filters with small pores to remove particulate matter. Their filtering properties increase as particulate gathers on the filter's surface, but this also increases the pressure drop across the filter as well as its energy consumption. This excess dust "cake" needs to be periodically removed, usually by a soot blower.[17] Bag houses are very effective at removing particulate (99%+ of filterable PM2.5 emissions)[18]. The fabric filters require a high level of maintenance, are prone to clogging and may catch fire. Although it is possible to control or manage this risk, it is less practical in small boilers. This is because small wood-boilers are

[15] Canadian Biomass Energy Research (CBER), BCIT Biomass to Energy Workshop, May 31, 2012
[16] Biomass Energy Resource Center (BERC), Emission Controls for Small Wood-Fired Boilers, May, 2010
[17] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013
[18] Biomass Energy Resource Center (BERC), Emission Controls for Small Wood-Fired Boilers, May, 2010

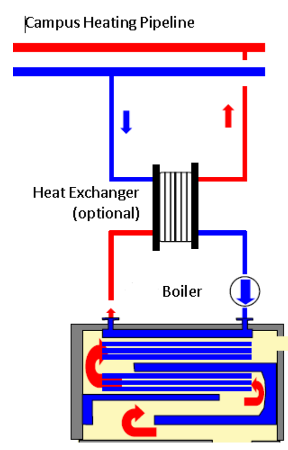
used in small institutions such as schools and hospitals without full time boiler staff. In such situations the fire risk is unacceptable.[19]

- Stainless steel and ceramic filters – utilize technology similar to a bag house, but rather than using fabric, stainless steel or ceramic is used as the filtration medium. These fire-resistant mediums reduce but do not eliminate the risk of fire, because unburned carbon can form a cake on their surface and subsequently catch fire.
- Wet scrubbers – use fluids to dissolve toxic gasses. The gas flowing through the smokestack is mixed with water vapor. The gas dissolves in the vapor, which condenses and flows into a filter. Wet scrubbers are problematic in the small size ranges (<3 MW) because many applications are likely to be in small institutional or commercial buildings where it would be difficult to handle the waste water in an environmentally sound manner.[20]
- Electrostatic Precipitator (ESP) – work on the principle of electrostatic attraction. Charged particles in the exhaust gas are attracted by plates on the side of the ESP that have the opposite charge. These units are often supplied with built-in "hammers" that strike the plates during a cleaning cycle, thereby loosening the particulate matter and allowing it to fall into a collector below. The control efficiency of PM10 and PM2.5 appears to be 99% or better, making this control technology very compelling.[21] Until recently, ESPs were only used on large biomass energy systems (3 MW or larger). New versions are now being made that are suitable for a 250 kW boiler. These systems have a relatively small footprint, low maintenance costs, are safe to use and consume limited energy when they operate.

BCIT's preferred particulate filtration technology will include a cyclone or multicyclone combined with and electrostatic precipitator (ESP). This combination reduces the risk of fire, is very effective at removing particulate matter and reduces the power consumption of the flue gas fan. Since the filter will have an effect on the operation of the firebox boiler, it is recommended to discuss the selection of filtering equipment with the supplier of the biomass boiler.[22]

Heating Distribution Line Connection Technology

BCIT's Burnaby campus has an existing heat distribution line that is currently being heated by natural-gas fired boilers, which are centrally located in Building SE8. The northern extent of this distribution line is the Inglis Building (NE1) and the proposed biomass boiler will be located just south of NE1 at the south-west corner of the Joinery Shop (NE2).



The boiler will feed into the arm supplying the building J.W. Inglis building (NE01), heating up water returned from NE01 and re-injecting it to the supply line of the same arm. To protect the boiler from poor water quality an indirect connection with a heat exchanger would be beneficial.

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[19] Envirochem Services Inc., Emissions from Wood-Fired Combustion Equipment, June 30, 2008

[20] Envirochem Services Inc., Emissions from Wood-Fired Combustion Equipment, June 30, 2008

[21] Biomass Energy Resource Center (BERC), Emission Controls for Small Wood-Fired Boilers, May, 2010

[22] Canadian Biomass Energy Research (CBER) & Ing.Aigner, Schematic Design Report, July 27, 2013

APPENDIX B

DESIGN REQUIREMENTS: BCIT BIOMASS-TO-ENERGY PLANT BUILDING

The following requirements will be taken into account in designing the proposed biomass-to-energy plant building:

- The chipper will need to have a sound-proof enclosure to allow operating it without disturbing classes. The footprint of this enclosure will be approximately 4 x 4 m or 17 m² (170 sft), including a 200 mm (10”) wall. A foundation and a pedestal will have to be poured. The ceiling should allow for a tall person to stand upright, 2 m (6 ½ “) minimum.
- The fuel storage will be mostly underneath the existing dust extraction system. Hydraulic cylinders driving the walking floor will be located just south of this area, anchored into a new concrete foundation to be poured on top of the existing foundation. The fuel storage should have a cover to protect the fuel from the elements and from arson.
- The metering bin can be under a roof as long as this does not obstruct access for third-party fuel. Due to fire protection rules laid down in the BC Building Code the metering bin cannot be in the same room as the boiler.
- As requested by BCIT’s planning department the boiler house has an L-shaped footprint with a net floor area of 56 m² (600 sft). Outside dimensions are roughly or 6 m x 12 m (20’ x 40’), including a wall allowance of 200 mm (10”).
- The boiler needs a foundation that can withhold approximately 4 tonnes (8,800 lb) on an area of 2.5 m x 1.2 m (8’ x 4’). The filter’s foundation would be rated for a maximum of 1 tonne (2,200 lb) with a foot print of 3.5 x 1.5 m (11’ x 5’).
- The boiler room will need a large door, at least 3.0 m high and 1.2 m wide, for introducing the boiler to the building. This door will need to be opened for boiler cleaning.
- The boiler will be connected to the existing underground campus heating pipeline. This will require an opening in the concrete floor and foundation of the boiler house.
- The boiler should be accessible by maintenance staff only; a wall separating the boiler from the filter would allow instructors, and possibly students, access to the research and filter area. Glass wall(s) would make the boiler visible for demonstration and training purposes. The glass walls might have to have a fire rating of ½ hour.
- The boiler room should be designed with 0.6 m (2’) wide escape corridors accessible from every point of the plant.
- The minimum ceiling height above the boiler and above the filter is 3.5 m.
- The boiler house will cover one of the office windows. The walkway corridor between NE02 and NE21 will be partly blocked.

APPENDIX C

DETERMINATION OF THE EXISTING SOUND LEVELS WITHIN THE BCIT FACTOR FOUR AREA

BRITISH COLUMBIA
INSTITUTE OF TECHNOLOGY

Wood Waste-to-Energy Research Facility

Determination of the existing sound levels within the BCIT Factor Four area

Prepared by: Florian Scheit, University of Applied Science Biberach, Germany (exchange student at BCIT

Instructors: Maureen Connelly, PhD, MAIBC Faculty, British Columbia Institute of Technology

Rob Sawatzky, Alexandre Hebert and Vanesa Alzate Restrepo, BCIT Factor Four Team leaders

08. June 2014

Contents

Objective

The of the study is to evaluate of the noise impact of the planned Factor Four wood-waste-to-energy facility on the BCIT Campus. For this purpose an experiment was executed to determine the existing noise levels and compare the sound levels before and after the implementation of the biomass boiler.

Measurement Locations

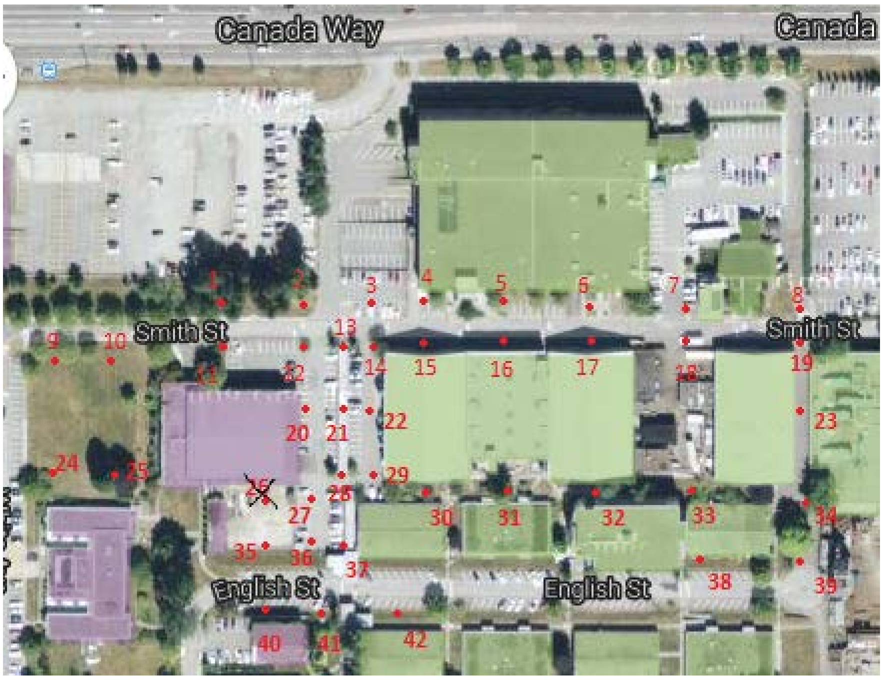
The new biomass heating facility will be installed on the South-East corner of the Joinery building (NE2, near points 22, 29 and 30 on the map below). A detailed Auto-Cad map of the measurement locations and the recognized noise sources is attached.

For the measurement 42 points around the area were selected. Point 26 is within a fenced teaching space. So it was not possible to take measurements at this location.

The characteristic of the North part of the Burnaby Campus is a workspace for trades trainings. So there are several noise sources all over the area. The main ones are:

- Joinery building with dust extraction system (NE2)
- Canopy (between NE2 and NE4)
- Carpentry building (NE4), Carpentry training space (Between NW1 and NW3)
- Welding building (NE8)
- Cooling systems (NE8 and NW3)
- Traffic on the Campus (cars, motorcycles and heavy supply trucks)
- Outside roads with heavy traffic (Willingdon Avenue and Canada Way)
- Construction at the East end of English Street (On the East site of point 34 and 39. This is an additional noise source influencing the results.)

0-1: Construction at English Street



0-2: Measurement Points on the BCIT North Campus

Measurement equipment

For the sound study a sound meter from Larson Davis (Model 831) was used. The reading software was Slm Utility-G3. The sound meter was calibrated before and after each measurement set.

0-1: Larson Davis, Sound level meter, Model 831

Weather

The values for the weather conditions are taken from the site http://www.theweathernetwork.com/weather/canada/british-columbia/burnaby right before the start of the measurement set and are recorded in the attached Excel file "Sound Measurements".

Parameters taken:

- Temperature
- Wind speed
- Wind direction
- Humility
- Atmospheric Pressure

Stakeholders

The biggest cause of noise for the planned wood waste-to-energy facility is the chipper. Noise levels of chippers are typically 80-90 db. BCIT management would like the noise generated to be less than 60 db to avoid disturbing classes in the adjacent Joinery workshops. So the chipper will be installed in an enclosure to reduce the noise level.

The location of the new biomass facility will be in the middle of the BCIT Campus, thus there is no influence to neighbors across the high traffic street surrounding BCIT.

The limiting factor for the noise emission are the nearby classrooms. The closest classrooms from the planned wood waste-to energy facility are located in the joinery workshop in NE21 with a distance of 5 meters to the new biomass facility. But the surrounding area is mainly used for industrial and trades trainings. So there are already several noise sources in the area.

Time and Methodology of the measurement

The measurements were taken in 11 Sets. The necessary time for one set was between 50 min and 60 min. The order of the single measurement points was picked randomly but with the focus of avoiding successive measurements on a close area. (The summary of all measurements with weather conditions, sound level, calibration history of the sound meter, measurement times and the calculation of the averages is in the attached Excel File "Sound measurements". The original measurements files are also attached.)

The sets are aligned with on characteristic operation schedules of the BCIT Burnaby Campus.

	Timeframe	Measurement sets	Amount of sets
Morning	8:30 AM -11 AM	4,7,10	3
Lunch break*	11 AM - 1:30 PM	1,5,8	3
Afternoon	15:30 PM - 8 PM	2,6,9	3
Night	8 PM-8:30 AM	3	1
Weekend	Saturday/Sunday	11	1

* There is no universal lunch break on the North Campus. The lunch break times vary between 11 am and 1:30 pm and there is always noise production in the observed area.

Following types of sound maps are prepared and attached. If there are more than one measurement set in the map the average is calculated for each measurement point.

	Measurement sets	Amount of sets
Morning	4,7,10	3
Lunch break	1,5,8	3
Afternoon	2,6,9	3
Night	3	1
Weekend	11	1
Day	1,2,4,5,6,7,8,9,10	9
Overall	1-11	11

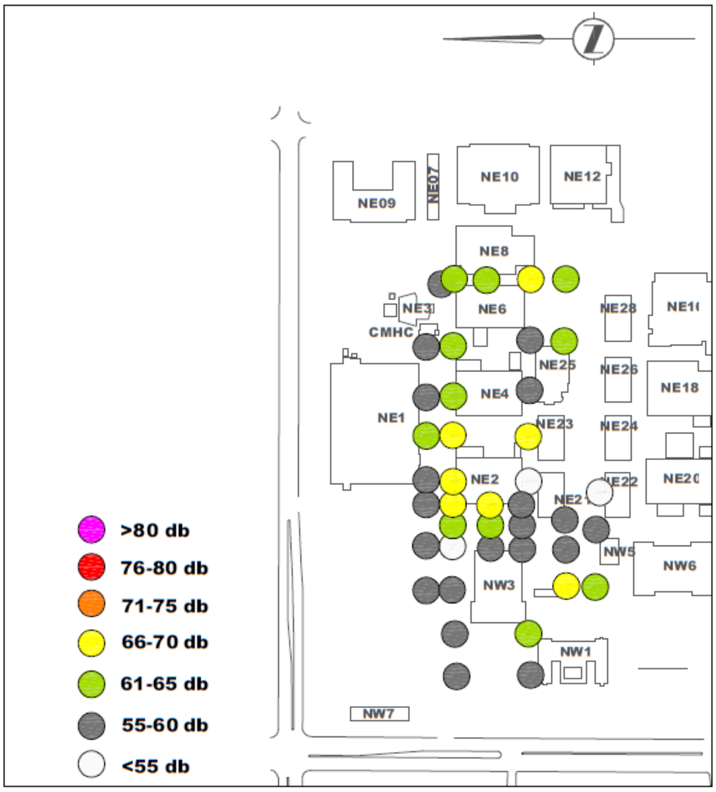
Results

For the creation of the sound maps the energy average over 30 Seconds t Equivalent Continues Level (LAeq) is used. The LAeq of each measurement is listed in the Excel-File "Sound Measurement". All other recorded values are available in the also attached single measurement files.

The table below shows the Average, the Maximum and the Minimum of the combined categories. The Single measurements is using the data before averaging the measurements to categories.

	Average [db]	Maximum [db]	Minimum [db]
Morning	62	70	54
Lunch break	63	74	52
Afternoon	58	65	50
Night	52	64	43
Weekend	53	59	45
Day	62	70	55
Overall	61	70	54
Single measurements	61	77	43

The measurement points with the loudest sound levels (65 db and higher in the overall average) are 13, 14,16, 34 and 35. The highest noise level of 77 db was measured on point 35 during a lunch break measurement.



0-1: Average Sound levels for the morning measurements

Analysis and Recommendation

The sound emission of the planned facility will be under the existing average noise level. The peak of all measurement sets in the morning and the lunch break have peaks over 70 db on a 30 second average. So it is expected that the assumed sound emissions of the new biomass facility has no influence on the sound distribution on the BCIT Burnaby Campus and the surrounding areas.

It is recommended to run the chipper (loudest component of the facility) mainly in the morning hours during the week to avoid an increase of sound emissions in the evening and on weekends. Also a similar sound analysis of single measurements for the before and after comparison after the commissioning of the new facility is recommended.

Attachments

Excel File:

- 02_Sound measurements

Auto-CAD-Drawing:

- 03_Burnabysite with Sound maps

Maps (PDF-Files):

- 01_Measurement Points
- 02_Noise Sources
- 03_Sound map morning
- 04_Sound map lunch break
- 05_Sound map afternoon
- 06_Sound map night
- 07_Sound map weekend
- 08_Sound map day
- 08_Sound map day

Measurement Files

- Measurement Files Excel
- Measurement Files Slm Utility G3- Files

APPENDIX D

RELEVANT EXCERPTS: GVRD BOILERS AND PROCESS HEATERS EMISSION REGULATION CONSOLIDATED BYLAW 1087

The following excerpts from Metro Vancouver's Air Quality By-law 1087 as amended by Bylaw 1190 (2013) are relevant to BCIT's proposed biomass-to-energy project.

Emission testing requirements for boilers or process heaters fuelled by biomass

31 (1) An operator of a boiler or process heater fuelled by biomass must conduct emission testing to determine concentrations of filterable particulate matter, carbon monoxide, nitrogen oxides, and total volatile organic compounds as provided in this section.

(2) Operators of new or modified boilers or process heaters fuelled by biomass must conduct emission testing required in subsection (1) within three months of commencing operation of the new or modified boiler or process heater, or as otherwise authorized by the district director, and at the intervals specified in subsection (4).

(3) Operators of existing boilers or process heaters fuelled by biomass must conduct emission testing required in subsection (1) within six months of the effective date of this Emission Regulation, and at the intervals specified in subsection (4).

(4) Operators of boilers or process heaters fuelled by biomass must conduct emission testing required in subsection (1) as follows:

(a) Once every calendar year with a minimum of 300 days and a maximum of 430 days between each emission test where facility capacity exceeds 1 MW.

(b) As may be required by the district director where facility capacity does not exceed 1 MW.

(5) The district director may vary the frequency of emission testing and the air contaminants to be tested for any operator.

(6) A minimum of three working days advance notice must be given prior to any emission testing. Notification must be given to Metro Vancouver at 604-436-6777.

Continuous Emission Monitoring Requirements for boilers or process heaters fuelled by biomass

38(1) An operator of a boiler or process heater fuelled by biomass where facility capacity exceeds 1 MW, must install and operate a Continuous Emission Monitoring System ("CEMS") at an appropriate location on any biomass boiler exhaust.

(2) The CEMS shall be installed, certified and operated in accordance with a Quality Assurance/Quality Control (QA/QC) plan approved by the district director.

(3) An operator of a boiler or process heater fuelled by biomass with a facility capacity that does not exceed 3 MW shall measure emissions of carbon monoxide and oxygen using the CEMS as required in this section.

(4) An operator of a boiler or process heater fuelled by biomass with a facility capacity exceeding 3 MW shall measure carbon monoxide, oxygen and opacity using the CEMS as required in this section.

39 (1) An operator of a boiler or process heater fuelled by biomass where facility capacity does not exceed 1 MW, must install and operate a CEMS at an appropriate location on any biomass boiler exhaust.

Tune-ups for boilers or process heaters fuelled by biomass

40 (1) An operator of a boiler or process heater fuelled by biomass must conduct a biennial performance tune-up according to procedures recommended by the boiler manufacturer and approved by the district director.

(2) Each biennial performance tune-up must be conducted no more than 26 months after the previous tune- up.