
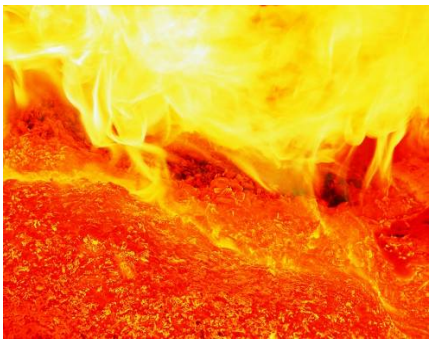


Pre-design Report
Biomass Boiler Plant at BCIT's Burnaby Campus

DRAFT

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This report covers the finding of the **pre-design phase** for a biomass boiler plant at BCIT's Burnaby Campus. The pre-design phase consisted of four days of meetings and site visits at BCIT and subsequent evaluation of information and data collected.

BACKGROUND

The School of Construction plans to install a **biomass boiler that uses wood residue generated mainly by the Carpentry and Joinery Workshop to heat part of the Burnaby campus**. The School has retained Canadian Biomass Energy Research (CBER) Ltd and Ing. Aigner GmbH to develop a workable technical solution for the biomass boiler plant.

All data and numbers provided in this report are preliminary and , based on new information made available, could change during the schematic design phase.

OBJECTIVE OF THIS REPORT

The purpose of this report is to provide sufficient information to move to the next phase, the schematic design phase. BCIT will need to review assumptions made in this report and authorize the authors to proceed. Instructions should be given on all items that will affect the development of the schematic design phase.

PAST STUDIES AND DOCUMENTS RELEVANT TO THE PROJECT

1. John Lavery, Sylvis: *Letter regarding ash management options for wood waste boiler*, January 15, 2013
2. Deacon Tong, Cornelius Suchy, Andrea Linsky, Alexandre Hebert: *BCIT Biomass Waste-to-Energy Report*, May 18th, 2012
3. Cornelius Suchy, CBER Ltd: *Design of a Program Monitoring Emissions from Combustion of Construction and Joinery Residue, Technical Requirements*, March 31, 2012
4. Cornelius Suchy, CBER Ltd: *District Heating BCIT's Sustainability Precinct Area, Prefeasibility Study*, March 31, 2011
5. DA Architects & Planners: *BCIT Biomass Education Facility, Schematic Design and Cost Plan Study*, March 2012
6. Stantec: *Biomass Energy System, A review of MAWERA Boiler Proposal*, no date
7. Prism Engineering Ltd: *Hot Water Distribution System Review, BCIT Burnaby Campus*, January 2008
8. Earthtech (Canada) Inc.: *BCIT Infrastructure Review 2004,* March 2005
9. Prism Engineering Ltd: *BCIT Central Heating Plant Analysis*, March 31, 2004
10. H.H. Angus & Ass. Ltd.: Drawing titled "Central Heating Distribution BCIT", Feb 1973

PURPOSE OF THE BIOMASS BOILER PLANT

The boiler plant has three purposes, listed in their order of importance:

1. Campus heating
2. Education & training (also referred to as 'demonstration')
3. Research

BCIT **facilities department will oversee the system's operation and maintenance**. Students will be able to view equipment through windows and have access to monitoring data, but will not gain access to the boiler or its controls, which will be housed in a secure location.

KEY PARAMETERS & REQUIREMENTS

Waste Volumes:

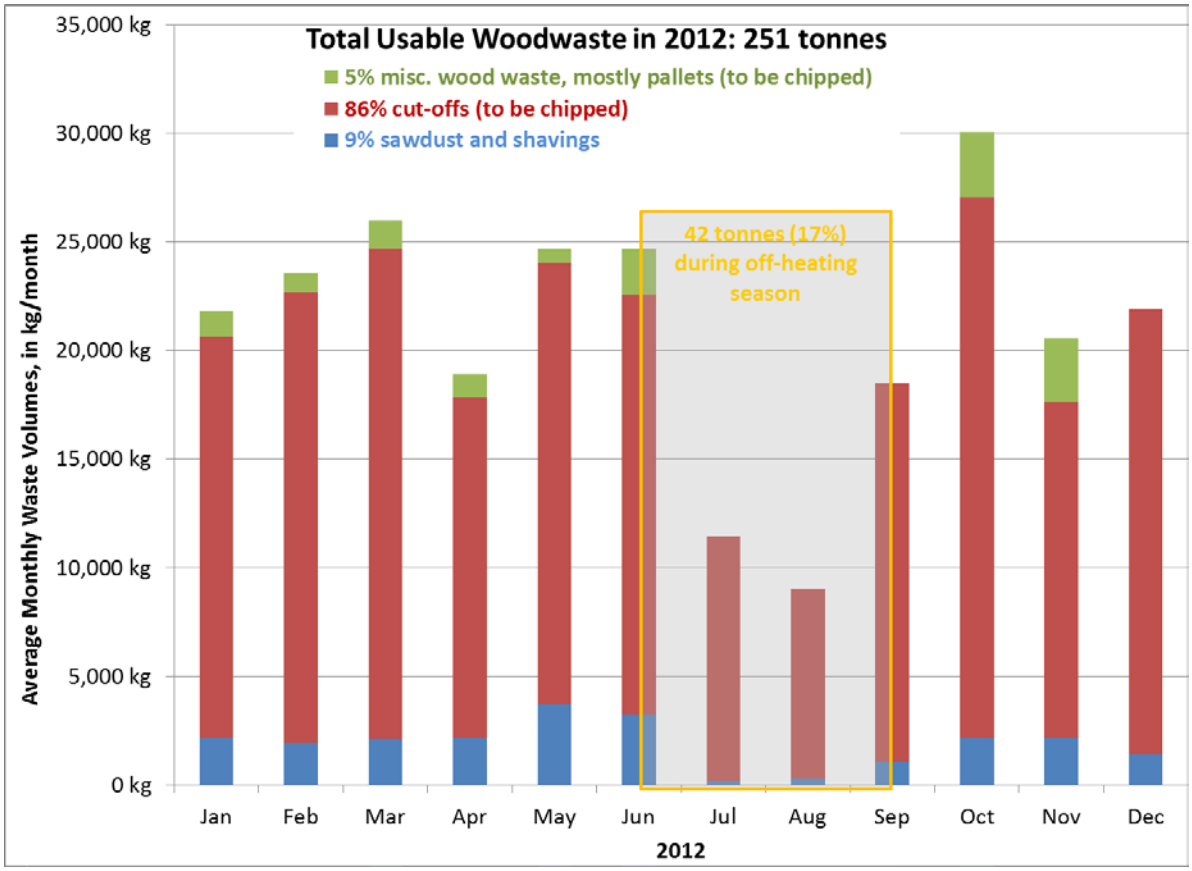
Wood waste type	Waste Details	Annual amount[1] (in 2012)	Percentage[2]	Lower Heating Value (wet basis)
Raw Lumber	Untreated 2X4's, 2X6's studs (SPF)	150 t/yr	60%	15.8 MJ/kg
Plywood	All types of plywood	31 t/yr	12%	16.1 MJ/kg
Wood dust	Planer shavings & sawdust	31 t/yr	12%	16.1 MJ/kg
MDF	Particle board, artificial wood of all types	22 t/yr	9%	17.6 MJ/kg
Pallets	Raw lumber, heat treated, may contain nails	16 t/yr	6%	15.8 MJ/kg
Total		**251 t/yr**	**100%**	**16.0 MJ/kg**

[1] *Mainly based on invoices in 2012 from waste management company*

[2] *Percentage according to waste management audit conducted in March 2012*

Annual Availability of Wood Residue/Fuel

- ⇨ **max: 30 t/month** (Oct 2012)
- ⇨ **min: 9 t/month** (Apr 2009, Aug 2012)
- ⇨ absolute minimum of 5.7 tonnes (Jul 2009) not considered because (a) the volume is during off-heating period and (b) data is less secure than volumes measured and recorded in 2012; BCIT staff believes 8 to 9 tonnes is a more realistic number for July.
- ⇨ **No provisions for storing three months of fuel** are to be included in this design, because the size of storage facility (silo, bunker) would be prohibitive. Current estimates show approximately 42 tonnes or 17% of the annual waste amount is generated during the off-heating season. This excess storage will also become redundant when the goal of operating the boiler twelve months of the year becomes a reality.
- ⇨ **Storage** is to be designed to hold approximately **1 week of fuel** for the biomass system.
- ⇨ **During the first year of operation little or no plywood and MDF will be burned.**



Usable Wood Waste Production at BCIT's Burnaby Campus

Fuel Specifics:

- Mix of **12% fines & shavings** and 86% chips (P45 and P60) from solid wood
- Species: mostly spruce-pine-fir, some hardwood,
- Contamination: **no paint, but resin from MDF and plywood**; could contain **some nails**
- **Moisture content**: 6% to 12%, **average < 10%** (wet basis)
- Lower Heating Value: **16 MJ/kg**
- Third party fuel maybe tested on a short term

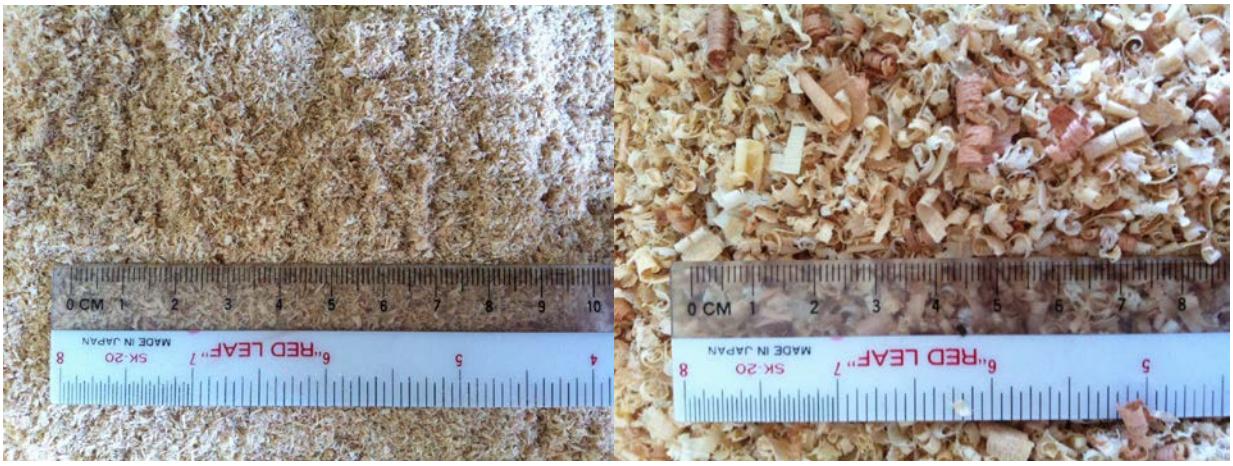


Figure 1: Fines. On a weight basis 50% of the fines are smaller than 2 mm, 50% shavings with a size of 4 to 25 mm

Air Quality Requirements:

Metro Vancouver Bylaw 1190 of 2013, a Bylaw to amend "Greater Vancouver Regional District Boilers and Process Heaters Emission Regulation Bylaw No. 1087" of 2008, defines biomass as

> "(b) uncontaminated wood waste, such as mill ends, wood chips, shavings, sawdust, sander dust, clean construction waste, hog fuel, and clean dimensional lumber from deconstruction;"

that does not include substances that contain:

> "(f) glue, paint or preservative, or foreign substances harmful to humans, animals or plants when combusted;"

According to this definition BCIT's wood waste may be burned if it can be shown that the combustion does not create harmful emissions. For the initial application it is recommended to sort out MDF and plywood cut-offs from the waste stream. This will reduce the amount of available wood residue to 197 tonnes a year. Panel boards containing glue may be added to the waste mix if and when emission monitoring equipment is in place.

Emission thresholds of **Bylaw 1190** are as follows:

- ⇨ Total particulate matter **< 18 mg/sm³** * => Plan is to install electrostatic precipitator
- ⇨ Carbonmonoxide < 250 ppm
- ⇨ Total Volatile Organic Compounds < 20 mg/m³ *

(* at 8% O_2 content in stack gas corrected to dry conditions at 20° C and a pressure of 101.325 kPa)

According to **Bylaw 1087** an **emission test for filterable particulate matter** has to be conducted and submitted to the authorities within three months of commencing operation of the biomass boiler. The Bylaw also calls for an **emission dispersion model** to be submitted with the application. This dispersion model has meanwhile been prepared (July 2014).

Noise Thresholds/Requirements:

- ⇨ Max. noise level of **60 db desirable during daytime** hours of 7:00 am to 7:00 pm, **50 db during the rest of the day** (Thresholds established and used by UBC)
- ⇨ No (noisy) chipper in the vicinity of classes (under the canopy) (Yves, 12-Feb-2013)
- ⇨ Chipper will need sound proof enclosure
- ⇨ Meeting noise threshold is part of the architectural design, not this design phase.

FIREBOX BOILER CAPACITY

In order to consume all combustible waste generated at BCIT the biomass boiler would have to have the ability to consume between 12 and 42 kg of fuel per hour, resulting in a boiler output between 46 kW and 166 kW, see the table below. With a turndown ratio of 1:4 a firebox boiler with a rated output of 200 kW should be able to operate between 50 kW and 200 kW. On average the firebox boiler will likely only have to burn 25 kg of fuel an hour during the heating period, delivering approximately 100 kW heat output.

	Minimum (Apr 2009 , Aug 2012)	Maximum (Oct 2012)	Short-term maximum [3]
Waste production[1]	9.0 t/month [2]	30.0 t/month	
Average fuel consumption required	12 kg/hour	42 kg/hour	53 kg/hour
Lower Heating Value (LHV) of fuel	15.9 MJ/kg	15.9 MJ/kg	15.9 MJ/kg
Fuel input	200 MJ/hour	660 MJ/hour	850 MJ/hour
Fuel input	55 kW	184 kW	235 kW
Firebox boiler efficiency	85%	90%	90%
Boiler output required to burn fuel	46 kW	166 kW	200 kW
Turndown ratio of firebox boiler	25% (1:4)	25% (1:4)	25% (1:4)
Max. boiler rating	186 kW		
Min. boiler output		41 kW	50 kW

[1] See graph above
[2] Minimum of 5.7 tonnes (Jul 2009) not considered because (a) during off-heating period and (b) data less secure than in 2012
[3] Several hours only

Capacity Requirements of a Biomass Boiler designed to combust BCIT's Wood Residues

A **biomass with 250 kW of capacity** will be able to use more of the available wood waste. During periods of low waste wood availability the boiler could be simply turned off. This should happen twice a year or less.

Operation of the Firebox Boiler:

- ⇨ The unit will initially operate during the heating season only (mid-Sep to mid-June, depending on weather), i.e. nine month a year. Year around operation is planned for the future.

- ⇨ During most of the year the biomass boiler will be fuel driven, not heat driven. The control system has to allow for turning down the output manually.
- ⇨ Scheduled annual maintenance should be done during the summer months, when fuel supply is typically low.

HEAT USAGE

Several options for using the heat generated by the biomass boiler have been considered:

1. **Connecting to the existing campus heating pipeline** supplying the J. W. Inglis Building, NE01. The pipeline passes the potential future location on the west side of NE02, the Joinery Department, within 15 meters, in a concrete duct 1.6 m below grade.
2. **Supplying NE01 directly**: This would require additional 2 x 200 m of pipe paralleling existing pipes. An initial cost estimate is $200,000 ($1,000 per m of trench). The authors of this report consider this an unnecessary expenditure.
3. **Supplying other buildings in sustainability precinct**: This requires (a) new district heating pipeline and (b) retrofit of heating system inside these buildings. The design of the biomass boiler plant should leave this option open for future implementation.

All of these options involve indirect connections, i.e. via a heat exchanger.

Based on the physical location of the biomass boiler plant the favoured short-term option is Option (1), feeding into the arm supplying the building NE01 on the west side of NE02, downstream of the branch to SE02. In August 2014 this arm of the district heating network was decommissioned. This option is no longer viable.

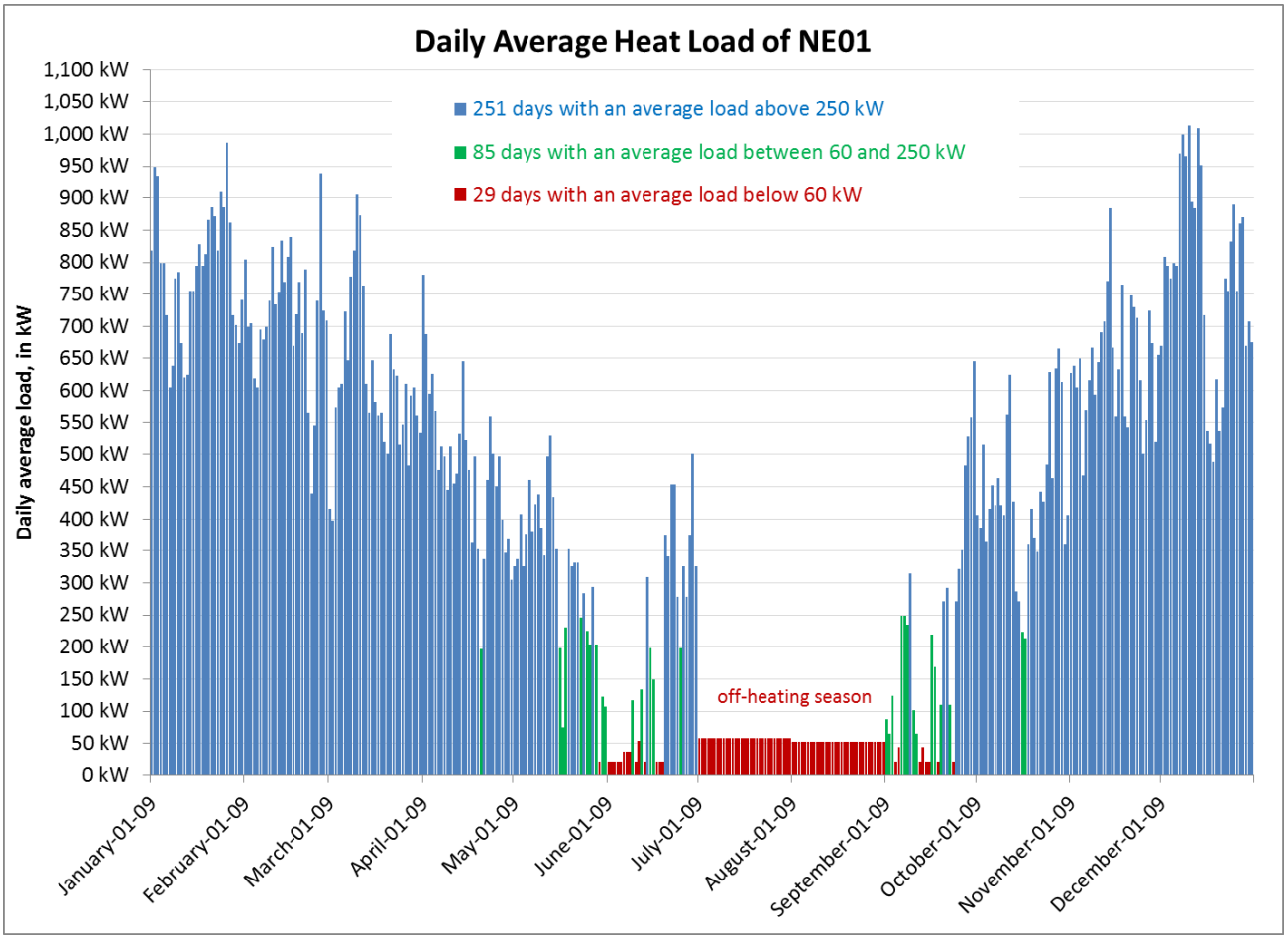
Instead Option (2) is recommended. A new pipeline will be installed connecting the biomass boiler with the mechanical room of the J.W. Inglis Building.

It is expected that the pipeline operates at a **supply temperature of 75°C**, the temperature required by the heating system of the building. [1]

The biomass boiler will provide between 60 to 250 kW of heat, depending on fuel availability. During 251 days of the year NE01 is expected to have a daily average load of more than 250 kW, during 28 days less than 60 kW. During the latter period the boiler may be shut down.

The graph below illustrating this situation is based on calculations, not measurements. A heat meter monitoring the heat consumption of NE01 has been installed in the secondary arm of the heat supply in the mechanical room in March 2013.

[1] Kenneth McEwen and Marvin Rogers during a site visit of the mechanical room of NE01 on February 14th, 2013

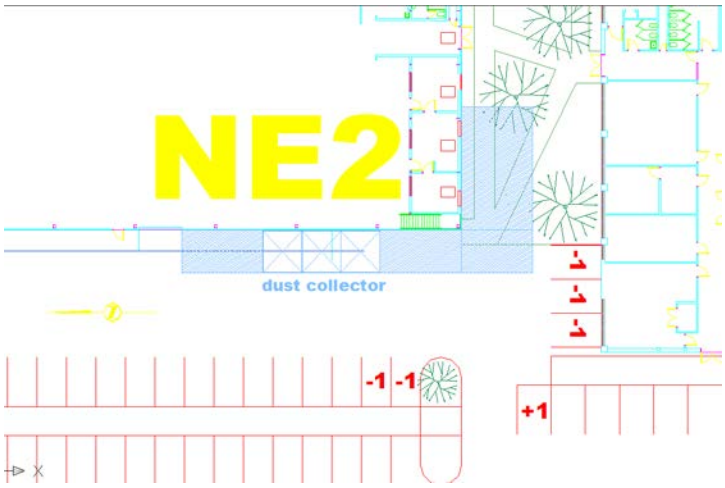


Estimated daily heat load of the J.W. Inglis Building (NE01)

GENERAL LAYOUT / LOCATION OF EQUIPMENT

- ⇨ The area around **South-West corner of Joinery Workshop** (NE02) is the preferred location, see the drawing below.
- ⇨ The boiler house should be **adjoining the South wall of NE02** (Craig, 12-Feb 2013); (based on schematic design of the boiler house conducted by DA Architects in Mar 2012); this design would cover windows of offices on the South wall of NE02.
- ⇨ The **area under steel structure of dust extraction system should be used**
- ⇨ The preferred **chipper** location is **adjacent to dust extractor** (North or South); the South-West corner under canopy connecting NE02 with NE04 is also available, but is close to where classes are held and is not preferred. Noise and forklift traffic could disturb classes. The forklift would have to bring bins to the South around NE02, not across the class area under the canopy.

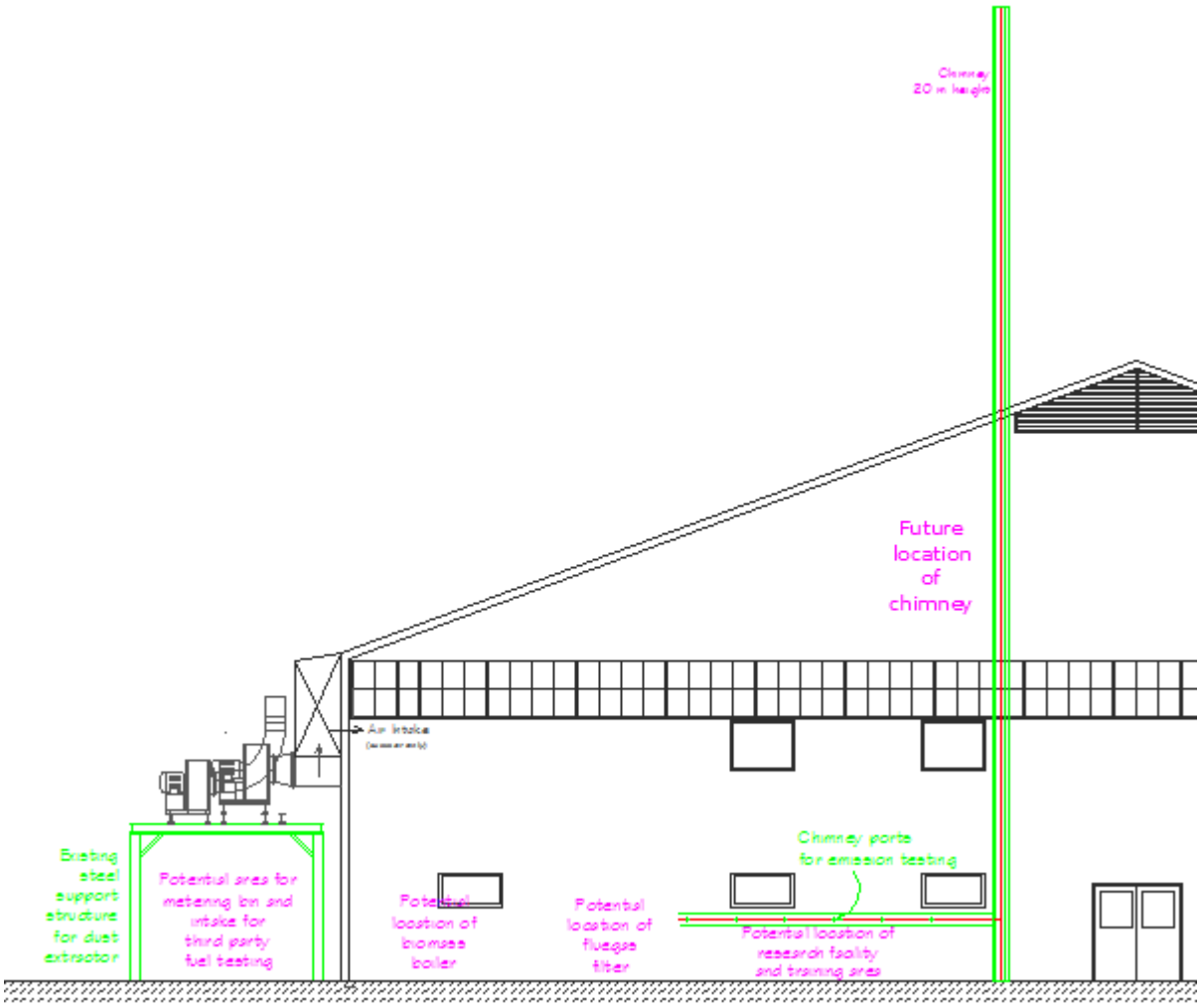
- ⇨ The **boiler** and equipment containing hot and pressurized water should be **accessible by facilities staff only**. One or several glass walls should make the equipment visible for demonstration and training purposes.
- ⇨ Only a technical solution should be developed in this project. The next phase should involve an architect in cooperation with designing engineer(s).
- ⇨ The following area has been agreed on as available for the biomass boiler plant (blue shaded area):



Plan view of the area for the biomass heating plant

Chimney:

- ⇨ The chimney should be located along the South wall of NE02, exiting at or close to the building eve, at least 1 m above eve (BC Building Code);
- ⇨ The minimum stack height must be **20 metres above ground level** unless otherwise specified by the district director (Bylaw 1087, this part is likely to be applied to this project)
- ⇨ The chimney needs to have **ports for official stack tests and for training purposes**. A six meter long horizontal section of the duct could be used for these purposes. The pipe would be at eye level and accessible without any platforms.
- ⇨ An enquiry at Ecco Supply Inc. a local supplier of insulated chimneys expects the dynamic pressure loss to be 36 Pa.



View of the South face of the Joinery department (NE02) indicating the potential location of components of the biomass heating plant and chimney heigh