Technical Memorandum

To: *Norm Connolly*

From: *Anthony Dickinson*

Date: *March 31, 2014*

Subject: *Technical Memorandum – City of New Westminster Air Quality Impact Study*

1.0 Background

One of the results of the Envision 2032 Sustainability Framework developed by the City of New Westminster (CoNW) is a commitment to reducing greenhouse gas (GHG) emissions through the use of “clean”, low carbon/low emission renewable energy systems for heating and cooling buildings. This is further reinforced in the Official Community Plan (OCP) which set a GHG emissions reduction target of 15% from 2007 levels by 2032. In November 2013, CoNW commissioned a feasibility study to identify potential technologies for providing community heat systems. Two “low carbon” community heat technologies were selected for detailed consideration: biomass boilers and sewer heat extraction. Both alternatives represent “proven” technologies that are currently being deployed at other sites in British Columbia.

Levelton Consultants Ltd. (Levelton) was contracted by CoNW to provide an overview of the potential impact of the business as usual, biomass boiler and sewer heat extraction scenarios on New Westminster’s air quality. CoNW has completed a series of analytical studies during the past 18 months on the proposed Sapperton District Energy System (DES). These studies assume an initial 30-year lifecycle for the overall system, from 2015 to 2045. For the purposes of this air quality study, two levels of heat demand were considered, namely:

“**Start Up**”**stage:** (year 2020 when the renewable energy plant comes online) - assumes 50% of total system capacity being delivered (in terms of annual heat load) and

“Build Out” stage: (2036 forecast). – assumes the maximum annual heat load capacity of the system is achieved by 2036.

The overview is split into four tasks which are summarized in this Technical Memorandum:

Task 1: Biomass and heat extraction projects in the Pacific Northwest

Task 2: Background Ambient Air Quality and Ambient Air Quality Objectives

Task 3: Potential Project Emissions

Task 4: Emission Controls to meet Metro Vancouver By-Law 1087 requirements

Task 5: Technical Memorandum summarizing Tasks 1 – 4

When evaluating the emissions the following options were considered:

Option 0 – Business As Usual – forecast heat demand met using natural gas boilers

Option 1a – Biomass (wood chip) boiler at Start Up (year 2020, 50% of forecast heat demand)

Option 1b – Biomass (wood chip) boiler at Maximum Capacity (forecast build out by 2036)

Option 2a – Sewage Heat Recovery at Start Up

Option 2b – Sewage Heat Recovery at Maximum Capacity

2.0 Task 1 - Literature Review

A literature was review was conducted to identify the location, size, type, and age of biomass projects in BC, Washington, Oregon and Idaho (Pacific Northwest). The review is summarized in Table 7. Twenty community/district heat projects are currently operating in BC. The oldest of these is the Williams Lake 60 MW biomass burning facility installed in 1988. Okanagan College built the first community heat system in BC, utilizing wastewater heat, in 2004. Biomass combustion to produce community heat and/or electricity is more common in BC than heat recovery from wastewater (12 biomass vs 5 wastewater heat recovery projects used for community/district heat projects in BC). District energy systems are far more common in BC than in the rest of the Pacific Northwest jurisdictions reviewed. With only two district energy systems identified in Washington State, two in Oregon and none in Idaho.

In BC all the biomass burners with over 1 MW capacity providing heat to a district energy system use electrostatic precipitators (ESP) for emission control. Some smaller systems use multiclones and fabric filters (“bag houses”). The Seattle Steam company uses a fluidized bed boiler with a bag house filter instead of an ESP whereas the Kettle Falls facility has a travelling grate boiler with an ESP. In Oregon the Seneca Sustainable Energy LLC rotating grate biomass boiler has multiclones and an ESP.

In Table 1 below boiler types were grouped as fixed grate boilers, moving/ vibrating/ rotating/ travelling grate boilers, fluidized/bubbling fluidized bed boilers or updraft gasifiers. By far the most common emission control method for grate type boilers were multiclones followed by either a bag house or ESP. Most updraft gasifiers in the BC area use an ESP while most fluidized bed boilers use bag houses. Of the 50 biomass boilers reviewed in the Pacific Northwest with pollution control and boiler type information 24 (48%) use an ESP.

Table 1: Biomass Emission Control Technology*[1]

Biomass Burner Type	BC (18 boilers)						Pacific Northwest (50 boilers)											
	None	WESP	ESP	MC + ESP	MC + Bag	Cyclone	None	WESP	ESP	MC + ESP	MC + Bag	MC + Scr	MC	Bag	Bag + Cyc	Bag + Scr	Cyclone	Scrubber
Hog Boiler / Fixed Grate Boiler		1	1	3	5	2		1	4	12	6	2	3	2	1	2	2	
Grate (moving, travelling, rotating)				1					2	2		1						
Gasifiers	1		4				1		4									
Fluidized Bed														3	1			1

Notes: 1. Brief explanations of each technology are included in the Glossary of Terms (Section 6.0)
2. WESP = Wet Electrostatic Precipitator; ESP = Electrostatic Precipitator; MC = Multiclone; Scr = Scrubber; Bag = bag house

3.0 Task 2 - Air Quality Impact Comparisons

Between 2009 and 2010 Metro Vancouver collected air quality data for carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), inhalable particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$) at four locations in New Westminster (Front Street Parkade, Sapperton Park, City Hall and UFCW). Ambient air quality at these four sites was measured using the Mobile Air Monitoring Unit (MAMU) (data is included in the attachments as Table 8). The highest readings were consistently obtained from the location identified as the "Parkade on Front Street". Due to the fact that the parkade is partially enclosed it is not representative of the New Westminster air shed. There was no detailed data available for the UFCW site. Thus only the Sapperton Park and City Hall data was included in this study. Metro Vancouver's study and our review concluded that the Sapperton site was most representative of the New Westminster air shed.

The MAMU program only collected data for periods of less than a year at each site. In order to draw a full picture of background ambient air quality data in the region, ambient air quality data using the continuous emissions monitoring system (CEM) from two nearby stations, namely South Burnaby and North Delta, were obtained for a consecutive 5 year period from 2008 to 2012 as a supplemental information.

Table 2 below shows the range of the ambient monitoring data that was collected at different sites (excluding the Front Street parkade data) and compares it to the Metro Vancouver (MV) and BC ambient air quality objectives (AAQO). Cells highlighted in yellow indicate readings that were above the BC or MV AAQO.

[1] Glossary of emission control technologies is presented in Section 6.0

Table 2: Ambient Air Quality

Air Contaminant	Averaging Time	BC Ambient Air Quality Objectives		MV Ambient Air Quality Objectives	Range of Monitoring Readings
		Level	µg/m³	µg/m³	µg/m³
Carbon Monoxide (CO)	1-hour	A	14,300	30,000	687 - 3,366
		B	28,000		
		C	35,000		
	8-hour	A	5,500	10,000	615 - 1,029
		B	11,000		
		C	14,300		
Nitrogen Dioxide (NO_2)	1-hour	MAL	400	200	88 - 343
		MTL	1,000		
	24 hour	MAL	200	n/a	98 - 188
		MTL	300		
	Annual	MAL	60	40	34 - 37
		MTL	100		
Sulphur Dioxide (SO_2)	1-hour	A or Lower	450	450	8.3 - 29
		B or Upper	900		
		C	900		
	24-hour	A or Lower	160	125	5.9 - 10.4
		B or Upper	260		
		C	360		
	Annual	A or Lower	25	30	1.6
		B or Upper	50		
		C	80		
Ozone (O_3)	1-hour	MDL	100	160	80 - 126
		MAL	160		
		MTL	300		
	8-hour	CAAQS	123	126	75 - 108
	24-hour	MDL	30	n/a	68 - 83
		MAL	50		
	Annual	MAL	30	58	22 - 34
Inhalable Particulate Matter (PM_{10})	24-hour	AQO	50	50	26.8 - 40
	Annual	n/a	n/a	20	12
Fine Particulate Matter ($PM_{2.5}$)	24-hour	AQO	25	25	11.3 - 31
		CAAQS	28		
	Annual	AQO	8 (6)*	8 (6)*	4.1 - 9
		CAAQS	10		

* Note: Metro Vancouver and BC Ministry of Environment set annual planning goal for $PM_{2.5}$ as 6 µg/m³.

Where:

MDL = National Maximum Desirable Level (NAAQO)

MAL- National Maximum Acceptable Level (NAAQO)

MTL- National Maximum Tolerable Level (NAAQO)

CAAQS - Canadian Ambient Air Quality Standards

AQO - Provincial Air Quality Objective (BC)

A, B, and C - Provincial Level A, B and C Pollution Control Objectives (BC)

The monitoring data indicates that the CoNW airshed already has levels of fine particulate and nitrogen dioxide at or near the MV AAQO. This represents the current baseline air quality.

Three basic scenarios were considered in this Air Quality Impact Study:

Scenario 0	Use natural gas boilers to generate heat to meet the forecast community heat requirement
Scenario 1	Use a biomass (wood chips) boiler to provide heat and augment this with a natural gas boiler to meet peak demand
Scenario 2	Recover heat from the sewage and augment this with a natural gas boiler to meet peak demand.

Scenarios 1 and 2 were further divided where into 1a and 2a to provide estimates of the start-up energy demand (2020) and 1b and 2b represent the full build out (2036).

Biomass emissions are a function of the type of boiler that is selected and the emission control device(s) that are deployed. Estimates of emissions for Business As Usual, three basic types of biomass burners and Sewer Heat Recovery are compared in Table 3 (Start Up) and Table 4 (Build Out). The selection of boiler type has the greatest impact on carbon dioxide and nitrogen oxide levels.

Table 3: Estimated Start Up Emissions

CAC Emissions	*Start Up (2020) Emissions (tonnes/year)*				
	Business As Usual	*Biomass (Grate Burner)*	*Biomass (Two Stage Burner)*	*Biomass (Fluidized Bed)*	*Sewer Heat Recovery*
Filterable $PM_{2.5}$	0.05	11.41	3.36	4.36	0.02
Filterable PM_{10}	0.05	13.23	3.90	5.06	0.02
Filterable PM	0.05	15.06	4.43	5.75	0.02
CO	6.19	29.83	5.64	10.36	2.28
NOx	7.31	12.96	6.14	11.26	2.69
SO_2	0.04	1.16	1.16	1.16	0.02
VOC	0.40	0.94	0.94	0.94	0.15
CO_{2e}	8,730	3,550	3,550	3,550	3,210
Net CO_{2e} Reduction from Business As Usual (%)	-	59%[1]	59%[1]	59%[1]	63%

Note 1: GHG Emissions from transportation of wood fuel to the boiler were not included here so actual reduction in CO_{2e} would be lower

Table 4: Estimated Build Out Emissions

CAC Emissions	*Build Out (2036) Emissions (tonnes/year)*				
	Business As Usual	*Biomass (Grate Burner)*	*Biomass (Two Stage Burner)*	*Biomass (Fluidized Bed)*	*Sewer Heat Recovery*
Filterable $PM_{2.5}$	0.07	22.29	6.56	8.51	0.02
Filterable PM_{10}	0.07	25.85	7.60	9.87	0.02
Filterable PM	0.07	29.41	8.65	11.23	0.02
CO	9.64	56.90	9.62	18.44	3.05
NOx	11.38	23.68	10.34	19.87	3.60
SO_2	0.070	2.25	2.25	2.25	0.02
VOC	0.63	1.74	1.74	1.71	0.20
CO_{2e}	13,587	4,964	4,964	4,964	4,301
Net CO_{2e} Reduction from Business As Usual (%)	-	63%[1]	63%[1]	63%[1]	68%

Note 1: GHG Emissions from transportation of wood fuel to the boiler were not included here so actual reduction in CO_{2e} would be lower

4.0 Emission Control Technologies to Meet By Law 1087

Metro Vancouver By-Law 1087 has set limits on particulate matter, and nitrogen oxides (NOx) for natural gas and biomass burners. These limits are compared to typical emissions for a low NOx natural gas boiler and the three types of biomass boilers in Table 5. This table clearly shows that some emission control measures will need to be employed for the reduction of particulates from a biomass boiler and possibly for NOx.

Table 5: Typical Biomass Boiler Emissions (without emission controls)

Emission Parameter	*Natural Gas Boiler*		*Biomass Boiler Type*			
	Low NOx Boiler	*By Law 1087*	*By Law 1087*	*Grate Burner*	*Fluidized Bed*	*Two-stage Combustor*
	mg/m³					
Condensable PM			15			
PM (filterable + condensable)	12	12				
Filterable $PM_{2.5}$				98.5	98.5	75.8
Filterable PM_{10}				114.2	114.2	87.88
Filterable PM		10	10	130	130	100
CO			250	1746	175	70
NOx	60	60	160	226	182	70
VOC (total volatile organic compounds)			• 9 for photo-reative •11 for non-photo-reactive •20 for total VOC			

Note: Typical biomass boiler emissions from: Emissions from Wood-Fired Combustion Equipment, Envirochem, 2008

Emission control devices for particulate removal include, cyclones, multiclones, scrubbers, fabric filters (bag houses) and electrostatic precipitators. These devices can be used in combination (i.e. multiclones followed by an ESP) for greater efficiency. If only one control is required the ESP is the device that might be able to meet the particulate emission requirements of By-Law 1087 depending on the type of biomass boiler selected. Removal efficiencies for these devices are indicated in Table 6 below.

Table 6: Emission Control Removal Efficiencies

Wood-fired boilers	*Technology*	*Efficiency*	*Reference*	*Comments*	*Meets By-law 1087*
PM Control	ESPs (electrostatic precipitators	90-99%	US EPA AP42, Chapter 1.6	-	Possible
	Fabric filters	>=80%	US EPA AP42, Chapter 1.6	Limited application due to fire danger	No
	Multiclones	25-65%	US EPA AP42, Chapter 1.6	capture 91% of PM_{10} and 54% of $PM_{2.5}$ with fly ash reinjection; capture 32% of PM_{10} and 16% of $PM_{2.5}$ without fly ash reinjection	No
	Wet scrubbers/ Venturi Scrubbers	>=85%	US EPA AP42, Chapter 1.6	Capture 98% of PM_{10} and $PM_{2.5}$	No
NOx Control	Selective non-catalytic reduction (SNCR)	30-80 %	US EPA AP42, Chapter 1.6	Used to reduce NOx emissions to lowest levels	Not Necessary
	Selective catalytic reduction (SCR)	35-75%	US EPA AP42, Chapter 1.6	Post combustion NOx reduction, NH_3 to NOx ratio of 0.4 to 3.2	Not Necessary
Natural Gas Boilers	***Technology***	***Efficiency***	***Reference***	***Comments***	***Meets By-law 1087***
NOx Control	Flue gas recirculation (FGR)	60-90%, combined FGR + low NOx burners	US EPA AP42, Chapter 1.4	Most Prevalent Control Technology	Possible
	Low NOx Burners	40-85%			Yes
	SNCR	25-40%		-	Yes
	SCR	80-90%		-	Yes

5.0 Conclusions

From an emissions perspective, there are less emissions and a greater reduction in greenhouse gas emissions with the sewage heat recovery option. However, this does not consider installation and operating costs, which are beyond the scope of this study. If a biomass boiler system is selected, a two-stage boiler type generates fewer emissions and may be able to achieve the particulate requirements of Metro Vancouver's By-Law 1087 with just an electrostatic precipitator. Grate and Fluidized Bed boilers would need to employ a combination of emission controls to meet the particulate requirements of By-Law 1087 (i.e. ESP + Fabric Filter or ESP + Multiclones). The natural gas boiler should be at least a low NOx boiler type due to the fact that the air shed is already near the MV AAQO levels for NOx.

6.0 Glossary of Terms[2]

Bag – Baghouse

An air pollution control device that traps particulates by forcing gas streams through large permeable bags usually made of glass fibers.

Cyc – Cyclone

An air pollution control device that removes larger particles -- generally greater than one micron -- from an air stream using a cyclonic airflow and centrifugal force to separate particles.

ESP – Electrostatic Precipitators

An air pollution control device that removes particulate matter from an air stream by imparting an electrical charge to the particles for mechanical collection at an electrode.

MC – Multiclones

A bank of small high efficiency cyclones for removing larger particles from an air stream using cyclonic airflow and centrifugal force.

Scr – Scrubbers

For biomass boilers a wet scrubber design type would be used. These air pollution control devices use a high energy liquid spray to precipitate aerosol, particulates and readily soluble gaseous pollutants from an air stream.

WESP – Wet Electrostatic Precipitators

Air pollution control device where the air stream is misted before entering an electrostatic precipitator.

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[2] http://www.arb.ca.gov/html/gloss.htm#E

Attachments

Table 7: Biomass and Heat Extraction Projects in the Pacific Northwest

Facility	Location	Energy Source	Application	Boiler Type	District Energy System (Yes/No)	Capacity (MW)	Year Installed	Emission** Control Equipment
British Columbia								
Lions Gate Wastewater Treatment Plant	West Vancouver	Wastewater/ sewage	Methane gas from anaerobic digestion is used to generate heat and electricity used to run the plant.	-	No	Total electricity generated from all five Metro Vancouver sewage treatment plants (in 2012) = 11 MW	1961	N/A
Iona Island Wastewater Treatment Plant	Richmond	Wastewater/ sewage	Methane gas from anaerobic digestion is used to generate heat and electricity used to run the plant.	-	No		1963	N/A
Lulu Island Wastewater Treatment Plant	Richmond	Wastewater/ sewage	Methane gas from anaerobic digestion is used to generate heat and electricity used to run the plant.	-	No		1973	N/A
Northwest Langley Wastewater Treatment Plant	Langley	Wastewater/ sewage	Plan to go to methane gas from anaerobic digestion to generate heat and electricity used to run the plant.	-	No		1976	N/A
Annacis Island Wastewater Treatment Plant	Delta	Wastewater/ sewage	Methane gas from anaerobic digestion is used to generate heat and electricity used to run the plant.	-	No		1976	N/A
William Lake Generating Station	William Lake	Biomass	Biomass-fired power plant	Water-cooled vibrating grate boiler	Yes	60 MW	1988	MC and ESP
Lonsdale Energy Corporation	North Vancouver	Natural gas, **waste heat**, solar energy	District energy system created by City of North Vancouver to supply energy to the community	-	Yes	6MW	2003	N/A
SunSelect Produce Inc.	Aldergrove, Delta	Biomass	Biomass boilers to heat greenhouses	Grate burner	No	14 MW	2004, 2008	WESP

Facility	*Location*	*Energy Source*	*Application*	*Boiler Type*	*District Energy System (Yes/No)*	*Capacity (MW)*	*Year Installed*	*Emission** Control Equipment*
Okanagan College Wastewater Heat Recovery	Kelowna	Wastewater/ sewage	Heat recovery from wastewater/sewage to heat the campus	-	Yes	N/A	2004	N/A
Revelstoke Community Energy Corporation	Revelstoke	Biomass	District energy system through wood-waste biomass boiler	Grate burner	Yes	1.5MW	2005	MC and ESP
Tolko Industries Ltd.	Kamloops	Biomass	Biomass gasification system for onsite production of wood products	Updraft fixed bed gasifier	No	28 MW	2006	None
Richmond Plywood Corporation Limited	Richmond	Biomass	Wood-fired steam boiler used for heating the facility	Grate burner	No	41 MW	2007	MC and ESP
Nakusp Secondary School	Nakusp	Biomass	Nakusp Energy Corporation's combined wood and solar heating plant serves the Nakusp Secondary School	N/A	No	0.18 MW	2007	Cyclone
Dockside Green	Victoria	Biomass	Biomass gasifier and Cogeneration plant	Updraft fixed bed gasifier -	Yes	2 MW	2009	N/A
Kruger Products	New Westminster	Biomass	Direct-fired biomass gasification system for the mill	Updraft fixed bed gasifier	No	17.2 MW	2009	ESP
Dockside Green Power Energy LLP	Victoria	Biomass	Biomass gasification system providing heating and hot water	Updraft fixed bed gasifier	Yes	2 MW	2009	ESP
Nazko Valley Elementary School & Community Centre	Quesnel	Biomass	A Pyrot wood-fired boiler system was commissioned to provide space heating for the 17,000-square-foot building.	Grate burner	No	0.3 MW	2009	MC and Fabric Filter
Baldy Hughes Therapeutic Community	Prince George	Biomass	Installation of a pellet fired boiler and district heating system by Del-Tech Energy	N/A	Yes	0.75 MW	2009	N/A

Facility	*Location*	*Energy Source*	*Application*	*Boiler Type*	*District Energy System (Yes/No)*	*Capacity (MW)*	*Year Installed*	*Emission** Control Equipment*
Biomass Secure Power Inc. and Lower Nicola Indian Band	Merritt	Biomass	Biomass cogeneration and pellet plant in Merritt	N/A	No	12MW	2010	N/A
City of Vancouver's False Creek Neighbourhood Energy Utility	Vancouver	Wastewater/ sewage	Wastewater/Sewer heat recovery technology providing heating and hot water to community	-	Yes	2.8 MW	2010	N/A
Whistler Athletes' Village District Energy Sharing System (WAVDESS)	Whistler	Wastewater/ sewage	District heating system using wastewater to heat the village (Cheakamus Crossing)	-	Yes	1.8 MW	2010	N/A
Capital Regional District's Saanich Peninsula Wastewater Treatment Plant	North Saanich	Wastewater/ sewage	District heating from wastewater/sewage provide heating to nearby buildings	-	Yes	N/A	2011	N/A
UBC Okanagan	Kelowna	Waste heat	Geoexchange/District energy system for the campus	-	Yes	N/A	2011	N/A
Tom Forsyth Memorial Arena	Burns Lake	Biomass	Installation of biomass heating system using pellet boilers to heat to change rooms and stadium seats at the Tom Forsyth Memorial Arena	Grate burner	No	0.18 MW	2011	Cyclone
Northern Lights College	Dawson Creek	Biomass	Biomass boiler system designed and installed by Ventek to product energy needs for the campus	Grate burner	Yes	0.54 MW	2011	MC and Fabric Filter
Alexis Creek Elementary School	Alexis Creek	Biomass	Pellet boilers installed by Ventek Energy Systems to heat the school	Grate burner	No	0.22 MW	2011	MC and Fabric Filter
University of Northern British Columbia	Prince George	Biomass	Biomass gasification plant to provide heat for campus and downtown Prince George	Updraft fixed bed gasifier	Yes	4.4 MW	2011	ESP

Facility	*Location*	*Energy Source*	*Application*	*Boiler Type*	*District Energy System (Yes/No)*	*Capacity (MW)*	*Year Installed*	*Emission** Control Equipment*
Fink Enderby District Energy	Enderby	Biomass	Biomass district energy system using wood-fired boilers	Grate burner	Yes	0.54 MW	2011	MC and Fabric Filter
UBC Bioenergy Research and Demonstration Facility (BRDF)	Vancouver	Biomass	Biomass-fuelled combined heat and energy system to provide heating and electricity for campus	Updraft fixed bed gasifier	Yes	5 MW	2012	ESP
UniverCity at SFU	Burnaby	Biomass	Biomass-based district energy system providing heating and hot water for campus	N/A	Yes	2.5 MW	2012	N/A
Lillooet Community Biomass Energy Project	Lillooet	Biomass	Upgraded the Lillooet Recreation Centre heating system by using a new wood pellet boiler	Grate burner	Yes	0.4 MW	2012	MC and Fabric Filter
City of Prince George	Prince George	Biomass	District Energy System using wood fibre-based heating system to provide carbon neutral green energy to buildings in downtown Prince George	N/A	Yes	4.4 MW	2012	ESP
Greater Nanaimo Pollution Control Centre Cogeneration Project	Nanaimo	Wastewater/ sewage	Regional District of Nanaimo's cogeneration system at the Greater Nanaimo Pollution Control Centre that creates electricity by using biogas to heat buildings and to fuel the boilers	-	No	3.2 MW	2012	Scrubber and Biofilter
Village of Telkwa Biomass District Energy	Telkwa	Biomass	Biomass fueled heating system that supplies heat to the Village office, school, pub and 4 residences	N/A	Yes	0.06MW	2012	N/A
Gilbert Trunk Sewer Heat Extraction Feasibility Study	Richmond	Wastewater/ sewage	River Green district energy utility using wastewater/sewer heat recovery	-	Yes	4 MW	2014/5	N/A

Facility	Location	Energy Source	Application	Boiler Type	District Energy System (Yes/No)	Capacity (MW)	Year Installed	Emission** Control Equipment
BCIT's District Energy and Biomass approved to be part of the Factor Four Strategic Plan (SEMP)	Burnaby	Biomass	Wood waste-to-energy project using biomass boiler to heat the campus	Grate burner	Yes	0.25 MW	Expected completion 2014	MC and ESP
Washington State								
SDS Lumber/Gorge Energy Division	Bingen	Biomass	Biomass heating system for the sawmill	Hog fuel boiler	No	9 MW	1978	MCs and ESP
Weyerhaeuser Longview Mill	Longview	Biomass	Biomass heating system for the mill	Hog fuel boiler	No	44 MW	1978	ESP
West Point Treatment Plant	Seattle	Wastewater/ Sewage	Cogeneration system and fuel cell to produce electricity and heat for plant use	-	No	10.1 MW	1983	Odor scrubber and Carbon Adsorbers
Tacoma Steam Plant No. 2	Tacoma	Biomass, Refuse-derived fuel (RDF), and coal	Multi-fueled generating facility	Bubbling Fluidized Bed Combustion (FBC) boilers	No	50 MW	1988	Cyclone and Fabric Filter
Port Townsend Paper Company	Port Townsend	Biomass	Biomass cogeneration project	Hog fuel boiler	No	15 MW	1990	MC and VScr
Kimberly Clark Paper Mill	Everett	Biomass	Combined Heat and Power system for the mill	Stroker Grate	No	52 MW	1996	Bag house
Georgia-Pacific Consumer Products (Camas) LLC	Camas	Biomass	Cogeneration heating system in this pulp and paper mill	Fluidized bed boiler	No	52 MW	1996	Bag house
Grays Harbor Paper LP	Hoquiam	Biomass	Biomass heating system used for the mill	Hog fuel boiler	No	7.5 MW	2000	MC and Scrubber

Facility	Location	Energy Source	Application	Boiler Type	District Energy System (Yes/No)	Capacity (MW)	Year Installed	Emission** Control Equipment
Sierra Pacific Industries Aberdeen	Aberdeen	Biomass	Combined Heat and Power system using pellet boiler combustion	Fixed bed boiler (stoker)	No	18 MW	2003	MC with ESP
South Treatment Plant	Renton	Wastewater/ Sewage	Cogeneration system and fuel cell to produce electricity and heat for plant use	-	No	8 MW	2004	Scrubbing using iron and carbon filter
Hampton Timber Mill	Darrington	Biomass	Biomass heating system for the mill	Hog fuel boiler	No	7 MW	2006	Bag house, Wet Scrubber and Cyclone
Sierra Pacific Industries Inc.	Mt. Vernon	Biomass	Combined Heat and Power system using boiler combustion	Fixed bed boiler (stoker)	No	28 MW	2007	MC with ESP
Kettle Falls Generating Station	Kettle Falls	Biomass	Biomass and natural gas-fired electric generating facility	Traveling grate, spreader stoker boiler	Yes	53 MW	2008	ESP
Seattle Steam Company	Seattle	Biomass	District heating system using wood-fired boiler serving and located in Seattle's central business district	Fluidized bed boiler	Yes	35 MW	2009	Bag house
Simpson Tacoma Kraft	Tacoma	Biomass	Cogeneration plant to produce electricity and steam from biomass	Traveling grate spreader stokers	No	55 MW	2009	ESP
Budd Inlet Treatment Plant	Olympia	Wastewater/ Sewage	Cogeneration system consisting of a new gas treatment system, a new 335 kW reciprocating engine with a heat recovery unit, and two small 1.5 MM Btu natural gas boilers	-	No	0.335 MW	2009	Odor scrubber and Carbon Adsorbers
Longview Fibre Co	Longview	Biomass	Upgraded the iomass heating plant used for the plant	Fluidized bed boiler	No	25 MW	2010	Scrubber

Facility	Location	Energy Source	Application	Boiler Type	District Energy System (Yes/No)	Capacity (MW)	Year Installed	Emission** Control Equipment
Cosmo Specialty Papers	Cosmopolis	Biomass	Biomass heating system in this pulp and paper mill	Hog fuel boiler (fluidized bed)	No	15 MW	2011	MC, Bag house, and Scrubber
Spokane Regional Water Reclamation Facility	Spokane	Wastewater/ Sewage	Digester gas production and co-generation systems to produce electricity to help run the facility	-	No	0.265 MW	2011	Primary clarifiers capped by low-profile covers and the enclosed area ventilated to control odor
Nippon Paper Industries	Port Angeles	Biomass	Biomass cogeneration facility for mill's energy needs	Hog fuel boiler	No	20MW	2013	ESP and Scrubber
Idaho State								
Potlatch Corporation	St. Maries	Biomass	Biomass heating system from this pulp and paper mill	Grate-type stoker boiler	No	113.8 MW	1950	MC and ESP
Pacific Crown Timber Products	Plummer	Biomass	Biomass-fueled cogeneration system	Hog fuel boiler	No	6.5 MW	1983	MC
Evergreen Forest Products Inc.	Tamarack	Biomass	Co-generation facility	Traveling Grate Spreader Stoker	No	6 MW	1983	MC and Wet Scrubber
Pocatello Water Pollution Control Facility	Pocatello	Wastewater/ Sewage	Digestion process produces biogas which fuels cogeneration engines that produce electricity used within the facility	-	No	0.46 MW	1985	N/A
Sandpoint Wastewater Treatment Facility	Sandpoint	Wastewater/ Sewage	Heat recovery from wastewater/sewage	-	No	0.065 MW	2012	Biofilter

Facility	*Location*	*Energy Source*	*Application*	*Boiler Type*	*District Energy System (Yes/No)*	*Capacity (MW)*	*Year Installed*	*Emission** Control Equipment*
Oregon State								
Dillard Complex	Roseburg	Biomass	Biomass heating system for the facility	N/A	No	45 MW	1955	N/A
Boise Cascade Medford Operations	Medford	Biomass	Biomass cogeneration facility	Wood-fired boiler	No	7 MW	1961	ESP
Willow Lake Wastewater Treatment Facility	Salem	Wastewater/ Sewage	Wastewater/Sewer heat recovery	-	No	0.84 MW	1963	Scrubber
Tillamook Lumber Company	Tillamook	Biomass	Biomass heating system for the facility	Wood fueled boiler	No	9 MW	1978	Cyclone and/or Bag house
Willamina Lumber Company	Willamina	Biomass	Biomass heating system for the facility	Hog fuel boiler	No	9 MW	1978	MC and ESP
Lane Plywood Inc.	Eugene	Biomass	Biomass heating system for the facility	N/A	No	0.46 MW	1983	N/A
Eugene-Springfield Regional Treatment Plant	Springfield	Wastewater/ Sewage	Wastewater/Sewer heat recovery	-	No	0.84 MW	1984	Scrubber
Tri-City Water Pollution Control Plant	Oregon City	Wastewater/ Sewage	Tri-City uses biogas to produce electricity and heat for various plant processes	-	No	0.25 MW	1986	N/A
Prairie Wood Products	Prairie City	Biomass	Biomass heating system for the facility	Wood-fired boiler	No	7.5 MW	1986	MC and ESP
Collins Products	Lakeview	Biomass	Biomass heating system for the facility	Hog fuel boiler	No	7.5 MW	1990	MC
Warm Springs Forest Products	Warm Springs	Biomass	Biomass heating system for the facility	Hog fuel boiler	No	6 MW	1990	MC with ESP
Wauna Paper Mill	Wauna	Biomass	Biomass heating system for the facility	Fluidized bed boiler	No	36 MW	1996	Bag house

Facility	Location	Energy Source	Application	Boiler Type	District Energy System (Yes/No)	Capacity (MW)	Year Installed	Emission** Control Equipment
Rock Creek Wastewater Treatment Facility	Hillsboro	Wastewater/ Sewage	Wastewater/Sewer heat recovery	-	No	1 MW	1997	N/A
Columbia Blvd. Wastewater Plant	Portland	Wastewater/ Sewage	Wastewater/Sewer heat recovery	-	No	0.2 MW	1999	N/A
Corvallis Wastewater Plant	Corvallis	Wastewater/ Sewage	Heat is provided from the hot water loop that obtains its heat from the cogeneration jacket water and exhaust heat recovery system	-	No	0.055 MW	2004	Bioscrubbing tower and Biofilter
Gresham Wastewater Plant	Gresham	Wastewater/ Sewage	Digesters turns methane gas into electrical power and heat used at the facility	-	No	0.395 MW	2005	Biofilter
Sun Studs/Swanson Lumber	Roseburg	Biomass	Biomass heating system for the facility	Hog fuel boiler	No	3.3 MW	2006	MC
Douglas County Forest Products	Winchester	Biomass	Biomass heating system for the mill	Hog fuel boiler	No	6 MW	2006	ESP
Evergreen Bio Power Co. (Freres Lumber Co.)	Lyons	Biomass	Biomass energy facility	Hog fuel boiler	No	10 MW	2007	MC and ESP
Oregon State University Energy Center	Corvallis	Biomass	Combined Heat and Power	Hog fuel boiler	Yes	9 MW	2009	
Seneca Sustainable Energy LLC	Eugene	Biomass	Biomass combined heat and power plant that will generate enough electricity to light 13,000 houses annually	Rotating grate stoker boiler	Yes	18.8 MW	2011	MC and ESP
Medford Regional Water Reclamation Facility	Medford	Wastewater/ Sewage	Wastewater/Sewer heat recovery generate 2/3 of electricity needs of the plant by using a new methane burner	-	No	0.75 MW	2012	N/A

Facility	*Location*	*Energy Source*	*Application*	*Boiler Type*	*District Energy System (Yes/No)*	*Capacity (MW)*	*Year Installed*	*Emission** Control Equipment*
Integrated Biomass Resources LLC	Wallowa	Biomass	Biomass heating system for the facility	Power boiler	No	1 MW	2013	Bag house and Scrubber
Interfor Pacific International	Gilchrist	Biomass	Biomass heating system for the facility	Hog fuel boiler	No	1.5 MW	N/A	Bag house
Pendleton Wastewater Treatment Facility	Pendleton	Wastewater/ Sewage	Wastewater/Sewer heat recovery	-	No	0.125 MW	N/A	N/A
Durham Wastewater Plant	Tigard	Wastewater/ Sewage	Wastewater/Sewer heat recovery	-	No	2 MW	N/A	N/A

* **N/A** - Information not available or cannot be found

** ESP = Electrostatic Precipitator; WESP = Wet ESP; MC = multiclone;

Table 8: MAMU Data vs BC and MV AAQO

Air Contaminant	Averaging Time	BC Ambient Air Quality Objectives		MV Ambient Air Quality Objectives	Sapperton Park (Jan 12, 2009 - Dec 8, 2010)	City Hall (MAMU) Site (Nov 2009 to Aug, 2010)	South Burnaby (Burnaby South Secondary School, 2008-2012)		North Delta (116 St. and 86 Ave.), 2008-2012	
		Level	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³ (Max)	µg/m³ (98th Percentile)	µg/m³ (Max)	µg/m³ (98th Percentile)
Carbon Monoxide (CO)	1-hour	A	14,300	30,000	3,366	1,491	1,498	687	n/a	n/a
		B	28,000							
		C	35,000							
	8-hour	A	5,500	10,000	n/a	n/a	1,029	615	n/a	n/a
		B	11,000							
		C	14,300							
Nitrogen Dioxide (NO2)	1-hour	MAL	400	200	113	88	343	134	282	121
		MTL	1,000							
	24 hour	MAL	200	n/a	n/a	n/a	179	98	188	106
		MTL	300							
	Annual	MAL	60	40	34	34	37	n/a	36	n/a
		MTL	100							

Air Contaminant	Averaging Time	BC Ambient Air Quality Objectives		MV Ambient Air Quality Objectives	Sapperton Park (Jan 12, 2009 - Dec 8, 2010)	City Hall (MAMU) Site (Nov 2009 to Aug, 2010)	South Burnaby (Burnaby South Secondary School, 2008-2012)		North Delta (116 St. and 86 Ave.), 2008-2012	
		Level	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³ (Max)	µg/m³ (98th Percentile)	µg/m³ (Max)	µg/m³ (98th Percentile)
Sulphur Dioxide (SO2)	1-hour	A or Lower	450	450	n/a	29	33.3	8.3	n/a	n/a
		B or Upper	900							
		C	900							
	24-hour	A or Lower	160	125	n/a	n/a	10.4	5.9	n/a	n/a
		B or Upper	260							
		C	360							
	Annual	A or Lower	25	30	n/a	n/a	1.6	n/a	n/a	n/a
		B or Upper	50							
		C	80							
Ozone (O3)	1-hour	MDL	100	160	112	106	126	80	124	82
		MAL	160							
		MTL	300							
	8-hour	CAAQS	123	126	n/a	n/a	104	75	108	77
	24-hour	MDL	30	n/a	n/a	n/a	83	68	83	69
		MAL	50							
	Annual	MAL	30	58	22	n/a	34	n/a	34	n/a

Air Contaminant	Averaging Time	BC Ambient Air Quality Objectives		MV Ambient Air Quality Objectives	Sapperton Park (Jan 12, 2009 - Dec 8, 2010)	City Hall (MAMU) Site (Nov 2009 to Aug, 2010)	South Burnaby (Burnaby South Secondary School, 2008-2012)		North Delta (116 St. and 86 Ave.), 2008-2012	
		Level	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3 (Max)	µg/m^3 (98th Percentile)	µg/m^3 (Max)	µg/m^3 (98th Percentile)
Inhalable Particulate Matter (PM10)	24-hour	AQO	50	50	n/a	n/a	40.0	26.8	n/a	n/a
	Annual	n/a	n/a	20	n/a	n/a	12	n/a	n/a	n/a
Fine Particulate Matter (PM2.5)	24-hour	AQO	25	25	31	30	19.8	11.3	n/a	n/a
		CAAQS	28							
	Annual	AQO	8 (6)*	8 (6)*	5	9	4.1	n/a	n/a	n/a
		CAAQS	10							

Where:

MDL = National Maximum Desirable Level (NAAQO)

MAL- National Maximum Acceptable Level (NAAQO)

MTL- National Maximum Tolerable Level (NAAQO)

CAAQS - Canadian Ambient Air Quality Standards

AQO - Provincial Air Quality Objective (BC)

A, B, and C - Provincial Level A, B and C Pollution Control Objectives (BC)