



SMALL-SCALE BIOMASS DISTRICT HEATING HANDBOOK

A Reference for Alberta & BC Local Governments

MARCH 2014

Agroforestry & Woodlot Extension Society (AWES)
Agriculture & Food Council of Alberta
Wood Pellet Association of Canada
FPInnovations
Wood Waste 2 Rural Heat

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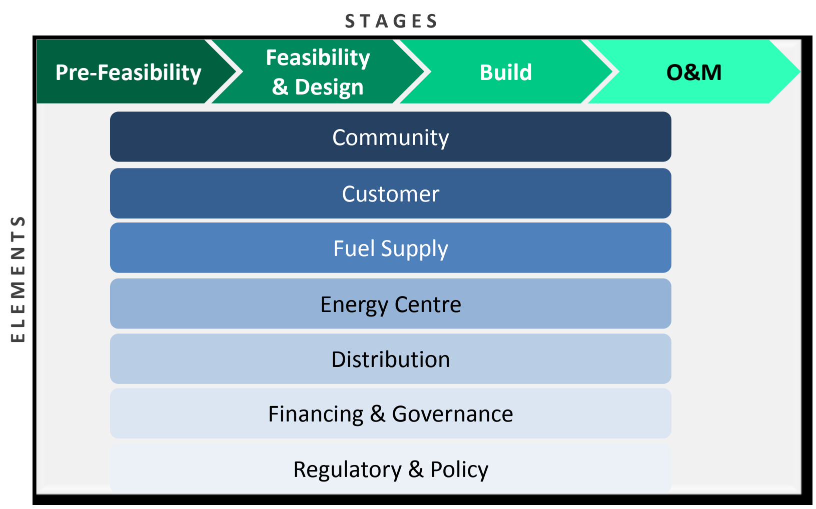
Purpose

The purpose of this handbook is to support a growing number of small communities across British Columbia and Alberta interested in making a business case for biomass district heating (DH). Small-scale biomass DH systems can be a centerpiece of an integrated strategy on clean energy, energy independence and a transition to a green economy. Primary benefits include:

- potential to reduce greenhouse gas emissions,
- local economic development through attracting investment, clean energy job creation, infrastructure development and keeping energy dollars circulating locally, and
- increased energy security.

The scale of DH being considered in this handbook is approximately 150kW to 3MW of heat output.

This handbook is written primarily for local governments and First Nations elected officials and staff to support an active local government and band role in developing clean energy and a green economy. It is a companion piece to the "Small-Scale Biomass District Heating Guide," which provides a high level overview of DH project elements according to developmental **STAGES**, from DH project conception through to utility development.



This handbook provides a more detailed focus on considerations associated with each project **ELEMENT**.

Elements

All **ELEMENTS** of a biomass DH system are inter-related. Each of the elements outlined in the graphic influences project viability and each should be carefully considered throughout biomass DH project planning and implementation.

While each element can be analyzed on a stand-alone basis to identify options, considering all elements in an integrated way is necessary to bring the full picture into focus.

This handbook explores each element in detail and ends with an integrated approach to assessing biomass project viability. Discussion of each element includes:

- why it is important
- key concepts
- optimizing for viability

Community

Community — Taking the time for dialogue on local government priorities , stakeholder considerations, and co-benefits

Pre-Feasibility	Feasibility & Design	Build	O&M
• Sow the seed • Assess community interest in benefits and identify potential concerns	• Confirm project goals, and staff capacity • Articulate and quantify co-benefits • Conduct consultations and confirm next steps	• Continue engagement with stakeholders	• Promote the successful system • Report to the community on benefits

Importance

Community consultation is critical to a project's success – allowing a project to get off the ground, operate effectively and, if an opportunity arises, to expand.

Figure 1: Anti-bioenergy protest, Kamloops. Source: http://noticequietnature.blogspot.ca/

In Western Canada, technically and economically viable bioenergy projects have been challenged because of community concerns about air quality. Vancouver's South East False Creek DH system in Vancouver (originally intended to use biomass) and the Aboriginal Cogeneration project in Kamloops (generating electricity from gasification of creosote-treated railway ties) both ran into problems because of public concerns about air quality impacts.

In the City of Prince George, initial plans to combust biomass at a proposed energy centre were opposed by the public because air quality was already a problem and the public was resistant to anything that could make it worse. The City overcame these concerns by recovering heat from a nearby industrial facility that was already combusting biomass and installing improved flue gas cleaning technology. They were able to illustrate that there would be a net decrease in particulate matter in the air shed, leading to public acceptance of the project.

Although air quality will likely be the primary issue of concern, concerns may also include:

- traffic management during construction
- impact on community areas near construction site
- financial (and other) risks to the municipality and the community

Negative community perception may also affect a system's ability to sign-up customers. System co-benefits (see the co-benefits section of the Small-Scale Biomass District Heating Guide) should be emphasized at every opportunity.

Key Concepts

Key concepts to communicate in stakeholder engagement are:

- Air quality impacts
- Community co-benefits
- Risks and planned mitigation measures
- Municipal long-term vision

Communicating air quality issues can be challenging. Air quality science is complex and includes consideration of both natural background levels of common air contaminants (such as dust) and those arising from new emissions.

Residents can have serious concerns about emissions, particularly with respect to the health impacts of fine particulate matter released from biomass burning or toxins released from burning materials that are contaminated by chlorine or other chemicals. Advising that air quality will be only a little worse than usual or within regulatory levels is often not good enough.

Community health concerns must be addressed through a transparent public consultation process. A trusting relationship between the project proponent and the community should be established in advance. While not directly related to biomass combustion, Chevron's approach to pubic consultation on air quality issues at their Burnaby refinery provides an example of transparent, ongoing public engagement. See the box above for more information. In Alberta, Strathcona County's commitment to ongoing communication with stakeholders is articulated in the county's Community Energy Strategy (Figure 2).

An example of good communication between industry and the public:

"...the Chevron North Burnaby Community Advisory Panel gives us a chance to deal with Chevron directly. I believe they are sincere in wanting to be good neighbours. Their challenge is to address the knowledge gap between what ordinary citizens know about the refinery process and the factual information Chevron employees and regulators use to determine what constitutes a safe operation within an urban environment."

P. Cech, as quoted in "Case Study: Chevron Burnaby Refinery" prepared by Environment Canada at http://ec.gc.ca/energie-energy/default.asp?lang=En&n=D23E8142-1

Optimizing for Viability

To create and maintain a good relationship with the community, it is important to:

- include all affected parties in planning (community members, provincial and local environmental regulators, health authorities, neighbouring businesses etc.)
- communicate early and often. Listen closely to concerns, be transparent in your communication and establish trust
- only use clean, uncontaminated biomass fuel
- strive for the best economically achievable emissions control
- consider risks and mitigation measures from the outset
- highlight community co-benefits from the project

Customer Communication & Education	
Guiding Statement:	Strathcona County communicates effectively with its stakeholders and uses effective mechanisms to facilitate two-way communications. **(Strategic Plan)**
Action 1:	Provide updates and education materials to new and existing customers, as well as to the broader community.
Action 2:	Enhance stakeholder consultation on new projects.
Action 3:	Assist building operators, owners and condo boards in understanding system connections and building operations to maximize efficiencies and costs.

Figure 2: Snapshot of County of Strathcona's Community Energy Strategy, August 2011. Source: http://www.strathcona.ca/files/files/at-lls-arm-110830-report-11-1.pdf

Customer

Customer — Identifying, understanding, evaluating, contracting, serving, and billing customers

Pre-Feasibility	Feasibility & Design	Build	O&M
• Identify and contact likely customers • Conduct heat demand scan • Estimate heat load profile	• Refine heat load profiles • Identify connection requirements and costs • Test market and develop marketing plan • Soft commitment from potential customers	• Marketing • Sign customer contracts • Issue RFP & select vendors • Construction • Testing and commissioning	• Manage customer billing and support

Importance

Customers are an integral component of a DH system. It is important to attract customers at the beginning through competitive pricing and a well-designed contract, and important to maintain customer relations through a well-designed, maintained and operated system.

Key Concepts

Building energy system compatibility and heating loads

In the case of retrofitting existing buildings to connect to a DH system, a key issue is technical compatibility with existing building energy systems. The graphic below outlines different existing heating systems and their compatibility with DH systems.

Legend
✗ – Not feasible, ~ – Technically feasible, but high cost, ✓ – Feasible

Type of building energy system	Biomass DH system compatibility
Electric baseboards / packaged terminal air conditioners (PTACs)	✗ – unless a major (and expensive) building renovation takes place
Rooftop units (RTUs)	~ – can replace RTU with hydronic RTU but, although technically feasible, not generally good retrofit candidate because of high cost
Forced air furnace	✓ – for a single heat coil. Cost increases with additional heat coils.
Any type of hydronic system – e.g. fan coils / radiators fed by boiler, water-loop heat pumps	✓ – DH connection replaces the building's boiler
Domestic hot water	✓ – DH connection replaces the building's boiler / water heater

Understanding **annual heat consumption**, **peak heat demand**, and **customer energy demand profiles** helps to define the business case.

Customers with high annual heat consumption generally improve the business case. After determining a customer's annual heat consumption, consider its potential value with the distribution pipework that would be necessary to connect the load. See the 'Finance and Governance' section for an example calculation on this.

Peak heat demand defines connection requirements for the customer.

The demand profile of customers affects the shape of the heat load duration curve and the economics of the DH system (see the discussion on 'sizing' in the Energy Centre section).

Ideally, a DH system would have customers with a diversity of demand profiles on a daily and seasonal basis. Figure 5 demonstrates how aggregating load profiles can result in a less "peaky" overall demand. Building #1 represents a load profile typical for a commercial building and building #2 for a residential building.

Any opportunity that may have sizable year-round or summer heat demand can offset the fact that most buildings will have higher demands in the winter. Such opportunities could include hospitals, recreation centres, outdoor swimming pools, and greenhouses. To help with establishing a demand profile, space heating, hot water, and process loads can be distinguished.

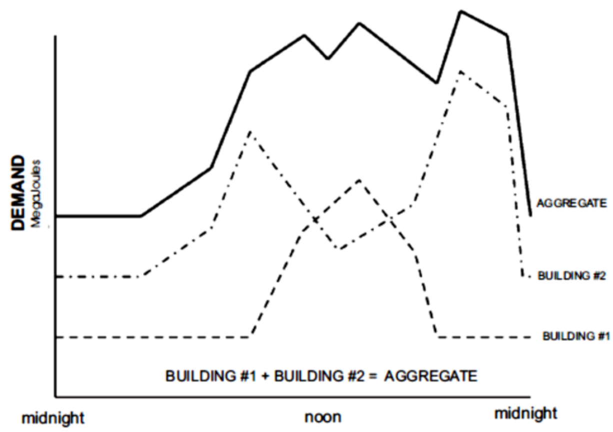


Figure 3: Representation of individual building and aggregated daily energy demand profiles. Source: Ken Church, *Is District Energy Right for your Community?* Municipal World, November 2007. http://www.districtenergy.org/

Energy transfer stations (ETS)

Energy transfer stations transfer heat between the pipe network and the building. They contain a heat exchanger and a heat meter. Figure 4 demonstrates the difference in scale needed for an independent building heating system versus an energy transfer station. In Figure 4, the old boiler can now be removed, and an alternative use found for the space. New buildings connecting to a DH system can be designed for this from the start, reducing space requirements for the plant room and increasing saleable or leasable space.

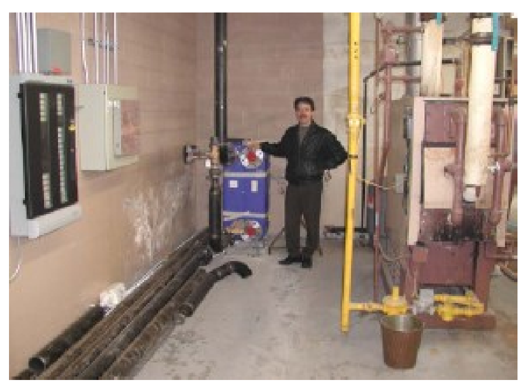


Figure 4: Energy transfer station in an old boiler room. Source: T. Berry, Compass Resource Management, *District Energy Primer*, 2012, p5.

Energy transfer stations can cost $300 to $500 per kW of customer peak demand. Costs include heat exchanger, control valve, meter, controls, all piping and valves, engineering and construction, and contingencies. Costs do not include anything on the secondary (building) side of the heat exchanger such as pumps and controls, or taxes. Some communities, particularly if installing a smaller DH system, may choose to connect buildings directly so that hot water from the DH system circulates directly in the building, instead of transferring energy to the building HVAC system via a heat exchanger. Costs for this type of “direct” connection would be less than $300 per kW of consumer peak demand. [1]

Heat meters

There are three main types of heat meter: magnetic, ultrasonic, and turbine. Turbine meters are less expensive, but have higher maintenance requirements that can more than outweigh initial savings. Ultrasonic and magnetic meters are both acceptable. Ultrasonic meters are cheaper and easier to install, but less accurate.[2] All heat meters need to be calibrated periodically (approximately every five years), and this can be done by sending the original meter back to the factory while a replacement meter is installed.

Very small biomass DH systems may find metering too expensive or burdensome and may choose to apply an allocated charge based on the size of the heated area or another aspect, such as the capacity of the connection, instead.

Contracts, connection charges, and billing

Customer contracts may include a thermal energy charge (indexed to fuel prices), a standing charge based on the capacity of the connection (linked to CPI), and an ongoing maintenance charge. Customer contracts should be long term, preferably of the same duration as the capital amortization period, (e.g. 20 years). Provisions to cover fixed costs of the DH system, including financing obligations, are generally included even in the event of the customer ceasing to use the DH system.

The standing charge recovers the proportion of the total cost of capital that can be attributed to each customer. Its inclusion incentivises customers to not contract for excessive capacity and to possibly take measures to reduce peak demand before connecting. This can free DH system capacity for other customers.

Connection charges are sometimes requested to help offset capital costs, particularly for customers that wish to connect but for whom revenue from thermal energy sales will not justify connection costs. In cases where a new building developer will sell the building or units to new owners, a connection fee ensures that the developer pays for the capital cost of connecting to the DH system (similar to when a heating plant is required for the development). Ensuring that only operating, and not capital costs, are passed on to the new building owner helps avoid creating an impression that DH is more expensive than conventional heating. However, this approach, as with all matters related to contracts and financing, needs to be carefully considered.

Charges should be based on long-term levelized cost of service to keep costs more affordable for the first customers, with a revenue deficiency deferral account to be repaid as more customers connect later. Some further information on contracts, including examples of what several district energy systems have done, can be found in the Pacific Institute for Climate Solutions White Paper *The Regulation of District Energy Systems* (May 2013) by Peter Ostergaard.[3]

Billing normally occurs on a monthly basis.

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[1] From interviews and/or correspondence with staff at FVB Energy, 2013-2014

[2] The Carbon Trust, *Biomass heating: A practical guide for potential users* (CTG012), 2008, p.92. www.carbontrust.co.uk

[3] Prepared for Pacific Institute for Climate Solutions and posted at: http://pics.uvic.ca/research/publications/white-papers

Optimizing for Viability

It is imperative that there is success in developing a customer base for the DH system and that the technical viability of customer connections is guaranteed by an experienced engineer or installation firm in communication with the customer.

A communications and marketing strategy helps to ensure success in building a customer base. Maintaining community support and being open and forthcoming with information will help attract potential customers. Understanding customers, their behaviour and technical constraints is also important. It may be important to emphasise value over price and to ensure that the contract is well-designed. If the DH proponent is well known and trusted within the community, this can help to encourage connections. Supportive municipal policies can also help encourage connections to new buildings. For more information on supportive policy, see the 'Regulations and Policy' section.

In small communities, potential customers can be identified through local knowledge and by verifying the type of HVAC system each building has. Providing information to potential customers about bioenergy and DH are will be necessary, as will reaching out to potential customers on an individual basis.

Local and provincial government buildings can provide anchor loads, with other buildings in the community providing additional loads. The potential difficulty of attracting customers should not be underestimated. For owners of existing buildings or developers of new ones, energy efficiency initiatives often suffer from a low priority compared to other concerns. Signing contracts with potential anchor customers prior to DH construction help manage financial risk.

For ongoing viability of the DH system, carefully consider contract elements – particularly index to fuel prices and volume or price guarantees – to ensure that cash flow meets expectations. Cooperation agreements will help ensure that customer's equipment behaves in the way that is anticipated.

Fuel Supply

Fuel Supply — Understanding and monitoring short and long term availability, type, moisture content, cost, consistency

Pre-Feasibility	Feasibility & Design	Build	O&M
• Identify waste heat • Estimate fuel needs • Identify biomass sources and pricing	• Conduct fuel supply analysis • Soft commitment from potential fuel suppliers	• Confirm fuel supply (finalize contract) • First fuel delivery for testing / commissioning	• Manage fuel deliveries

Importance

Forest biomass as a fuel is distinct when compared to other sources of energy, such as heating oil or gas, due to the complex make-up of supply chains and varying raw material demands of different utilization sites.

Many heating plant operators are used to working with oil and gas – which have national and international supply structures in place and logistics solutions already established. When dealing with the use of forest biomass for energy, the situation is very different. There are diverse forms and qualities of raw material, more complex and less developed supply structures and varying demands on the final quality of the product by different customers.

Consequently, developing efficient and robust supply structures is a demanding task when establishing new energy systems based on forest biomass. There can be shortages of local expertise in the development of reliable supply structures in countries without any prior experience in the production of forest biomass for energy. There are cases where establishment of supply structures or heating plants has failed due to the lack of appropriate technology, expertise and knowledge about the supply systems and available resources.

System proponents must ensure that there is enough fuel available in the short and long-term. A high margin of security in supply may be required by funding / financing partners. Biomass fuel supply chains will need to be thoroughly analyzed. Modelling of long term supply should cover at least 20 years and the analysis should be completed separately for each community involved.

Biomass fuel supply analysis should consider:

- quantity – look for long-term fuel availability locally and consider seasonal variations
- quality – the fuel must meet the quality specifications of the anticipated bioenergy system type
- cost – the price of fuel must be economically viable; consider raw material price fluctuations from competing demands
- logistics – biomass delivery and storage and, in case there is no existing fuel supply, drying, grinding/chipping, (potentially pelletization) and transportation of raw fuel

Table 1: Sources of Biomass Fuel

	Sources of Wood Fuel for Combustion	Sources of Agri-based Fuel for Combustion
Waste Residues	• Non-merchantable fiber such as roadside accumulations of low quality trees not processed for lumber and salvage material • Undersized trees • Trees killed by insects, disease or fire • FireSmart residues (from forest clearing to reduce forest fire hazard near communities) • Woody waste at mill sites • Hog fuel • Clean construction waste	• Cereal grains or canola straw • Crop milling residues (wheat and oats) • Purpose grown crops such as switch grass (not currently in production)
Manufactured Pellets	As of 2013: • Thirteen facilities in BC • Three facilities in Alberta	• No production in BC or Alberta as of 2013

Wood pellets have advantages over chips on quality and logistical issues and usually have cheaper fuel handling systems. However, wood chips usually have a lower cost than wood pellets (e.g. in Europe wood chips are generally half the price of pellets). Lower costs may help to justify a wood chip system over a wood pellet system.

The amount of biomass consumed by a community DH system is usually small compared to what is produced by the forestry and agricultural industries. For example, operating biomass DH systems in BC only consume a few hundred to a few thousand tonnes of biomass each year. [4] Sawmills, on the other hand, can produce a few hundred thousand bone dry tonnes[5] (BDt's) of residues and a few hundred thousand BDt's of non-marketable wood per year.[6] Most unmarketable wood residue and unusable agricultural residue in BC and Alberta is either burned or disposed of by other means. Despite this, these residues are not usually available for free.

Key Concepts

Context

Canada has a world-leading wood pellet industry (see box next page). Both BC and Alberta have extensive forest resources, and forestry and wood products industries. Alberta also produces a significant amount of agricultural biomass residue, which is largely unused for energy (as of 2013). Consequently, there is an opportunity in both Alberta and BC to take advantage of existing biomass streams for new district heating systems.

[4] From interviews and/or correspondence with staff at Fink Machine and Revelstoke Community Energy Corporation, 2013-2014

[5] A bone dry tonne (BDt) is the weight of the fuel at 0% moisture content.

[6] BC Bioenergy Network & Envirochem Services Inc., *Biomass Availability Study for District Heating Systems*, 2012. www.bcbioenergy.ca

The scale of Canada's wood pellet industry

As of 2012, Canada had 42 wood pellet plants with 3 million tonnes annual production capacity. In 2010, Canada's pellet plants operated at about 65% capacity - producing about 1.3 million tonnes per year, while in 2011 almost 1.9 million tonnes of production was exported.

British Columbia accounts for about 65% of Canadian capacity and production, while Alberta, Quebec, New Brunswick, Nova Scotia, and Newfoundland collectively account for 35%. There are currently (2013) three pellet plants in Alberta and eleven in BC (see Appendix 1).

Pellet plants in BC tend to be large. An average BC plant produces about 150,000 tonnes annually. Two new BC plants are being built with annual capacity of 400,000 tonnes.

Pellet plants in Alberta produce in the range of 25,000-60,000 tonnes annually.

Pellet plants in Eastern Canada tend to have about 50,000 tonnes capacity; the two largest eastern plants produce 100,000 tonnes annually.

Wood chips and wood pellets

Biomass boilers typically use either wood chips or wood pellets and briquettes. Logs / cordwood do not fit into either of these categories and are not usually used in automated biomass boilers at this scale.

Despite the general guidance given in the following table, individual circumstances can vary widely and need to be verified in prefeasibility and feasibility studies.

Figure 5: Wood chip and wood pellet. Source: FPInnovations

Table 2: Chip vs. Pellets

Category	**Chip** (including shavings)	**Pellet**
Production	Wood chip is generally produced by a wood chipper or a hammer mill.	The production process for wood pellet is more energy intensive. They are made by compressing saw dust or wood shavings, usually in large industrial facilities.
Energy density	8 - 15 GJ / tonne 1.6 – 3.8 GJ / m^3	17 - 18 GJ / tonne 11 – 11.7 GJ / m^3
Density	Approx. 200-250 kg / m^3	Approx. 650 kg / m^3
Moisture content	Normally 20-50%	Approx. 5-10%
Ballpark cost, delivered	$50-100 / BDt $2-8 / GJ	$150-310 / BDt $8-18 / GJ
Availability	It can be hard to produce chips precisely meeting European specifications. Chips of less rigid specifications can be obtained from suppliers of wood chips, including saw and pulp mills and secondary wood product manufacturers. The tighter the specifications and consistency required for wood fuel, the more expensive it will generally be. Delivery distance also affects cost.	Wood pellets for small scale applications (pellet stoves) are usually widely available. Larger scale deliveries are often still a challenge in BC and Alberta because there are no supply structures in place, so it may be expensive to procure large amounts of pellets locally. Delivery distance affects cost.
Sourcing	Usually has to be local, as low energy density by volume makes it uneconomic to transport large distances.	Local only if it is sourced from a local wood pellet production facility, but pellets have a distinct advantage over chip in that their higher energy density by volume means they can be economically transported much greater distances.
Fuel quality consistency	Variable, particularly unless dealing with an experienced and well trained fuel supplier.	Usually pellets are uniform and consistent.
Fuel standards	Specifications for wood fuels can be requested from wood chip suppliers, although presently it is unlikely that European specifications can be precisely met. See following section on ‘quality considerations of solid biomass fuels’.	Wood pellets made for energy purposes are normally manufactured according to strict European standards, making it relatively easy to source good quality wood pellets. See following section on ‘quality considerations of solid biomass fuels’.
Handling	Chips have less capacity to flow than pellets, and are more prone to “bridging” (i.e. blocking due to their uneven particle size distribution). Fuel handling systems that can handle chip are usually more robust and, consequently, more expensive.	Wood pellets flow much better than chips, and can also break apart more easily. For this reason purpose built wood pellet delivery, storage, and fuel feed mechanisms are designed differently than for wood chips. Fuel handling systems designed only for wood pellets are less expensive.

Sources: Interviews and correspondence with FPInnovations, Wood Waste 2 Rural Heat, Biomass Energy Centre, Ledcor, and BC Bioenergy Network & Envirochem Services Inc. (*Biomass Availability Study for District Heating*, 2012)

Defining "wood chips"

The definition of wood chip used in this handbook includes a variety of types that are often differentiated, including for example: shavings, hog fuel, and wood chips derived from secondary product manufacturing or clean demolition, land clearing, and construction waste. However in forestry, wood chip can be used to mean a by-product from sawmills, used for purposes such as pulp. In the bioenergy industry, wood chip can be used to mean relatively unprocessed wood of small dimensions from any source (except for sawdust), and the term is used to distinguish it from wood fuels with large dimensions like logs or more processed wood fuels such as pellets or briquettes.

Agricultural residues

Agricultural residues that can be burned in a bioenergy system include cereal grains or canola straw, crop milling residues (e.g. from wheat and oats), and purpose grown crops such as switch grass (although these are not currently in production in BC or Alberta). Agricultural residues can be burned in their unprocessed form or processed as pellets or briquettes.

Outside of North America, the agricultural-biomass pellet industry is now in rapid development, with over 400 agricultural pellet plants globally. In Europe, straw is now beginning to be pelletized on a large scale and is becoming available for domestic and industrial markets. In areas with a shortage of wood residue, agricultural pellets can provide an affordable and local source of fuel. [7] Pelletization helps to solve some of the issues involved in using unprocessed agricultural residues, such as high mineral content and high fuel variability. [8]

In most years, crop farming in Alberta produces about 15.8 million tonnes of cereal and canola straw as a by-product. After deducting the volumes of these residues required for current levels of livestock production and sustainable soil erosion protection, it's estimated that 7.7 to 13.2 million tonnes of this straw could be sustainably recovered for other uses. [9] Farmers can also focus a portion of their production specifically on growing energy crops on land not well suited for other crops.

Two major studies have examined the opportunity for creating an agriculture residue-based bioheat industry in Alberta. The studies, which also provide a window on the opportunity for Canada as a whole, were conducted by Resource Efficient Agricultural Production (REAP), a Canadian agency focused on developing bioenergy opportunities for rural development and greenhouse gas mitigation. The first study was an assessment of the agri-fibre biomass residue resources available in the province. The second study added to that investigation with an assessment of the technology options available for turning these resources into more viable energy sources.

The findings indicated that Alberta has substantial agri-fibre biomass residue that could be used as fuel for bio-energy and showed that technology improvements now coming on stream will help to further the opportunity to use agri-fibre biomass residue for heat and energy. Bioheat from agro-pellets in particular has potential as one of the most economically efficient and environmentally friendly means to displace fossil fuels.

The main technical challenges regarding agro-pellets are the production of a high quality fuel and technological improvement for small-scale combustion devices. The REAP report notes that an understanding of design features that are necessary to be incorporated in the combustion technologies

[7] Straw Pellets Ltd. website, accessed December 2013. www.strawpelletsltd.co.uk
[8] Alberta Agriculture & Rural Development: *AgTech Innovator* - April 2009. www1.agric.gov.ab.ca
[9] Ibid.

to burn agro-pellets is now well grounded in the manufacturing sector. Incremental improvements in efficiency, convenience, and lower particulate loads are being made with a series of technological innovations in the combustion chamber design and air control systems for commercial systems. Economics however may present the biggest challenge in the short term.

The potential represents a leadership opportunity for Alberta and Canada within the North American context.

Based on ballpark estimates of prices in 2008 and experience in other districts, the studies estimated pelletized crop milling residues could be produced for about $100/tonne or the equivalent of $5.55/GJ in Alberta. Unprocessed agricultural residues could be available for even less.

Quality considerations of solid biomass fuels

Currently, there are no standards for the production of wood pellets, wood chips, or agricultural fuels in BC or Alberta; however, Canada is working to adopt the forthcoming international ISO standards on solid biofuels in the near future. At present, most Canadian wood pellets are exported to Europe and meet standards used in Europe, leading to a highly consistent product. (Note that the USA has its own quality standard for wood pellets.)

Biomass fuel quality is closely linked to system success because fuel quality and type has to be an exact fit for the selected bioenergy system. In most cases, smaller automated bioenergy systems have more stringent fuel specifications than larger bioenergy systems and cannot handle fuel variations. To ensure fuel compatibility it is important to work closely with consultants, biomass boiler suppliers / installers, and wood fuel suppliers.

The following wood chip and agricultural fuel qualities should be carefully considered:

- moisture content
- size and shape
- raw material, contaminants and chemical composition

Moisture content

The importance of moisture content is shown in Figure 6. Moisture content is the key factor for determining the energy content of any biomass product so this chart provides a guide for both wood and agricultural residues. Energy content per tonne of biomass decreases as moisture content increases.

Biomass should be as dry as possible before transport, to minimize transportation costs by reducing weight (by essentially avoiding the transport of water). If the moisture content of a fuel being delivered to a system will vary considerably, (e.g. wood chip moisture content can vary over the course of a year) then the system will need an experienced operator that has the ability to manage the moisture content along the supply chain. In practice, biomass should be dried for at least one season to reduce moisture content. In Scandinavia, moisture content is usually reduced from 50% to 30% so that biomass heating plants can operate efficiently.

Moisture content – wet or dry basis?

Moisture content is calculated as the fresh mass minus the bone/oven dry mass, divided by either the fresh mass (wet basis) or the bone/oven dry mass (dry basis). Usually wet basis is used in the bioenergy industry and that convention is followed in this handbook. Also see equations in 'Appendix 2 – Useful Equations'.

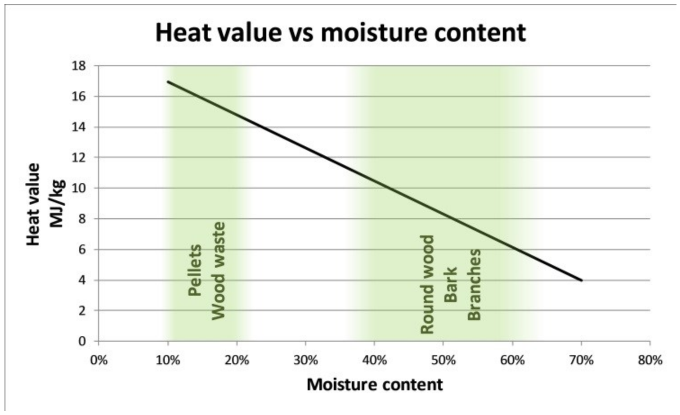


Figure 6: relationship of heat value and moisture content for biomass. Source: Natural Resources Canada and FVB Energy via Canadian District Energy Association *Biomass for District Heating* module.

Size and shape

Size and shape of fuels are important for the boiler and the fuel feed system, with smaller bioenergy systems being more demanding than larger systems. The fuel size should be as uniform as possible to avoid problems in the fuel handling system. A common specification for wood chip systems is that chips must be a maximum of three inches in length. Another important specification for the supply of wood chips can be the amount of fines (fine particles) that are permitted as a percentage of the total, as a high proportion of fines can increase particulate emissions during combustion. Regarding shape, long stringy pieces of wood chip might be able to get through a 3 inch screen but could then jam up a fuel feed auger or the hopper. Consequently, fuel specifications of the biomass system to be installed will determine where the fuel will be sourced from or what equipment should be used for fuel production.

Figure 7: wood chip dimensions. Source: FPInnovations

Raw material, contaminants and chemical composition

Biomass raw materials are essential because they basically determine ash, air quality, and fuel handling. Bark, for example, has high ash content and may contain minerals that – depending on the boiler – can cause plugging and corrosion. Even "clean" demolition, land clearing, and construction wood waste can be contaminated with paint, plastics, and nails or other metals and it should not be used in standard biomass heating systems. Where the biomass was stored – on paved ground, dirt, or on gravel – is also important. Storing on pavement is the best way to avoid contamination. If biomass is contaminated with stones, components of the boiler such as the fuel feed and/or ash removing mechanisms can be damaged.

Figure 8: Different kinds of chip. To the left the smaller chip meets the European 'G30' standard and to the right the 'G50' standard.
Source: Wood Waste 2 Rural Heat

Bone Dry Tonnes or Oven Dry Tonnes?

Because of the difference moisture content can make to the calorific value of fuels by weight, for comparison purposes people often refer to Bone Dry Tonnes (BDt's) or Oven Dry Tonnes (ODt's). ODt's refers to taking a sample of fuel, and keeping it in an oven at 105°C until no further weight change is detected. BDt's is the weight of the fuel at 0% moisture content. ODt and BDt can be used interchangeably. In this handbook, we use BDt.

A boiler may have fuel specifications for the chemical composition of biomass, such as those for ash content and certain elements such as nitrogen (N), sulphur (S), chlorine (Cl) and potassium (K). These elements may cause operations and maintenance issues with the boiler (clogging gas passages and causing corrosion) and may increase air emissions.

Agricultural residues typically have higher contents of these elements arising from the use of fertilisers and pesticides/herbicides in agriculture. The presence of these elements leads to higher emissions of NOx, SOx, and HCl than in wood fuel, while increased levels of potassium (K) are correlated with both increased particulate emissions and slagging (by lowering the melting temperature of the ash).

High chlorine (Cl) content in fuel can corrode boiler surfaces and form dioxins.[10] Assessments of the environmental impact of burning agricultural residue and current state-of-the-art of combustion technologies indicate that pellets made from agricultural residues (and in general other ash-, N-, K- and Cl-rich fuels) should be used primarily in grate combustion (see 'Energy Centre' section) or fluidised bed boilers equipped with sophisticated combustion control systems and flue gas cleaning systems. It's unlikely that a clean source of wood fuel will contain these chemicals but wood fuel that has had contact with salt water (e.g. some hog fuels) must be avoided due to increased chlorine content.

Fuel supply purchases and contracts

Wood fuel supply contracts in BC are not usually long-term – for example, greenhouses in BC's Lower Mainland generally have short-term contracts for wood fuels. In BC, the Revelstoke Community Energy Corporation is an exception – it has a 20 year fuel supply agreement with the local sawmill, Downie Timber.

Project financers or funders may require a long-term wood fuel supply contract. One strategy to ensure a long term supply is to develop a contract with a local community forest or woodlot. Another option to support financing is to demonstrate that sufficient additional back-up sources of wood are available through secondary wood product manufacturers, harvest residues of traditional timber harvesting operations, or through wildfire mitigation activities.

[10] European Pellet Centre website, accessed December 2013. www.pelletcentre.info

There are fewer examples of bioenergy systems in Alberta but the fuel supply contract situation appears to be similar to BC. There are no contract standards as of 2013. When a system must obtain fuel from an outside source, this is often achieved on a spot purchase basis. Strathcona County's DH system has a relatively short-term (about two year) contract in place for a supply of wood chip derived from old pallets.

Figure 9: Measuring moisture content of woodchip using the oven dry method. Source: The Ashden Awards for Sustainable Energy (photo of Midlands Wood Fuel Ltd.)

Longer-term contracts for agricultural residues may be harder to arrange than wood supply contracts because of annual variations in crop production and variations in the amount of land a farmer may have under production each year.

Contracts should include specifications for fuel quality, even if they are only minimum requirements. However, signing a contract with strict specifications might only be possible if a local government is installing a large system or is situated in an area with a well-developed fuel supply market.

Fuel purchases should ideally be conducted on either a dry weight or energy content basis; using a green weight basis could incentivise delivery of fuel with high moisture content. In practice, it would be wise to advise suppliers on how much will be paid for deliveries with different moisture contents.

The most commonly used method to determine moisture content is to take several samples from a delivery vehicle and determine moisture content using the oven dry method, shown in Figure 9. Moisture content of delivered fuels should be measured at the same time as other fuel attributes, such as size distribution and the presence of obvious contaminants such as rocks, organic matter and sand, are determined by inspection. More information about biomass sampling can be found in FPInnovations' *Biomass Sampling Procedures and Analysis* document.

Biomass logistics & supply

Biomass handling should always be minimized to reduce costs and to avoid fuel deterioration. Wood pellets, for example, tend to break up every time they are handled; they can break up at every fuel transfer point and from rubbing together during transport. When they break up, a very fine dust is produced which is difficult to contain and can present a significant fire and explosion risk.[11]

It is important to ensure that a supplier of biomass fuel is able to deliver in a timely manner and that biomass will be available in sufficient quantities whenever it is required. Some biomass fuels, for example, agricultural residues, may only be available on a seasonal basis.

All stakeholders in the supply chain play a role in ensuring delivery of a high quality fuel that meets boiler requirements.

[11] Biomass Handling website, accessed December 2013. www.advancedbiomass.com

Getting involved in fuel supply

If a local government must get involved in fuel supply, additional logistical items that should be considered include:

- ability to purchase suitable fuel
- existing or needed distribution systems
- distance and terrain associated with fuel transport
- fuel processing

Transportation costs will affect affordability. The closer a source of fuel is to the end use, the lower costs will be. Terrain can also affect accessibility and fuel consumption of transport vehicles.

A large proportion of available wood fibre in the forestry sector, particularly higher quality sources that are competitively priced, may already be tied up in formal or informal agreements. If it is necessary to access non-merchantable material from forestry operations, a wood fuel supplier will require an agreement with the tenure holder. If an agreement is not possible and the slash is not being utilised, tenure for that slash may be formulated with provincial governments. In BC, for example, this may be achieved through either a 'Fibre Forestry Licence to Cut' or a 'Fibre Supply Licence to Cut'.

The location of fuel processing facilities affects cost as well. Processing fuel near its source will reduce transportation costs because fuel density is increased. Processing near source, however, will be more challenging for fuel sources that are characterized by low volumes distributed over a large area.

If the fuel is too wet at the time of processing, and long-term storage is expected, then fuel must be carefully managed to avoid contamination, composting and potential fire risk. For wood, it is generally easiest to dry it before processing.

Before making any investments in the fuel supply chain, it is essential to know what kind of biomass is needed so that the proper harvesting equipment is purchased. For wood fibre, chipping and grinding each produce a different quality of fuel. Grinding may have more difficulty in producing smaller chips and is also more likely to produce long stringy particles of chip that may jam up augers. Chipping is also sensitive to raw material quality because wood chippers will not tolerate contamination (e.g. stones and nails).

If production of an agricultural biomass pellet is desired, there may be additional technical challenges resulting from a lack of North American expertise in this area.

An example of a community that is involved in the fuel supply chain is the Village of Telkwa in BC. They are able to source suitable raw material in the immediate area (a community forest) and they have bought a chipper to process material for their own small-scale biomass district heating system.

Forest energy supply chains

There is a sequence of operations conventionally performed to move raw forest biomass from a source to a heating plant. Each of the following steps depends upon available forest resources:

- collecting forest biomass according to demand and quality requirements,
- preparing biomass according to quality requirements and for efficient transportation, and
- transporting biomass to the energy centre and storing it.

In the case of forest harvest residues, the collection of biomass is comparatively simple since the biomass is already 'harvested' during regular timber harvesting, although proper pre-concentration and pre-piling of harvest residues from timber harvesting is essential to ensure further efficient processing.

In the case of a biomass operation such as forest 'thinning', a separate harvesting operation has to be carried out, which leads to higher costs.

Another important aspect of the preparation phase is proper storage and drying of biomass to improve fuel quality and reduce transportation costs. Biomass should be stored for at least one or two drying seasons (April – September) to reduce moisture content to approximately 30%, which will reduce transportation costs and improve biomass heating value. In Europe, a paper cover is often used to improve biomass drying and to prevent snow and ice from entering piles. In the Canadian context, recent tests in Quebec have also shown promising results and FPInnovations is carrying out field tests to investigate the feasibility of covering biomass in Western Canada.

The most critical and challenging phase of the biomass supply chain is transportation. Most existing supply chains have developed around solving this problem. The transportation challenge is based upon two issues – low energy density per volume of fuel and fuel moisture content. To increase transportation efficiency, it is necessary to find ways to increase fuel density and reduce moisture content prior to transport.

Figure 10: Roadside chipping operation in Finland using a farm tractor. Source: FPInnovations

Chipping is considered an essential step in the supply chain since a large number of outside factors, such as raw material available, equipment used, and how the work is organized, affects it. Over time, practices in many countries have demonstrated that chipping or grinding at the roadside, with subsequent transportation to the heating plant, is a reliable, universal and cost efficient method to produce forest biomass for energy. This approach could work in BC and Alberta if necessary technology investments are made.

Figure 11: Trace Resources roadside grinding operation, Merritt, BC. Source: BC Bioenergy Network & Envirochem Services Ltd., *Biomass Availability Study for District Heating Systems*, 2012. www.bcbioenergy.ca

The reasons why roadside chipping has been so successful are multifold. The main advantage is enhanced transport economy due to the higher payload of the transport vehicle. Moreover, roadside chipping allows for the delivery of chips to different customers and enables limited storage capacity at the plant.

Another advantage is that roadside chipping relies on proven and reliable technology which, in return, limits downtime of the machines. Roadside chipping can be carried out using a wide variety of mobile chippers, ranging from farm tractor based chippers in smaller scale operations to large-scale chippers for industrial production of forest chips. Small scale chippers could provide a reasonable solution in BC and Alberta; however, it is essential that they are equipped with a screen. Usually, the chips are blown directly into a truck or container, then transported from the roadside landing to the energy centre.

The chip storage area and access to it must be properly designed to ensure that a truck can be unloaded easily and quickly.

Optimizing for Viability

Before a district energy system is built, a proponent must have confidence that a long term supply of fuel, of the right price and quality, is available. A supply of least 20 years is recommended. A reliable fuel supply is critical to the success of a bioenergy system and the challenges around building a viable fuel supply chain are not always fully appreciated from the outset. The complexity of obtaining a reliable fuel supply will vary from one community to another. If an existing source of reliable fuel is unavailable, a local government will need to be willing to produce its own fuel, which means investing in the development of a reliable a supply chain. The dynamic nature of the forestry industry should also be taken into account because of the potential for wood fuel value to change.

Once a local government has determined what fuels are available in nearby, it can look at which bioenergy systems are compatible with those fuels.

To help with system selection, samples of locally available fuels can be sent to boiler installers / suppliers for a burn test and to check compatibility with the boiler and fuel handling system. Experiences in BC, however, have shown that this test will not provide full certainty. A local government could also contact other organisations that have installed the same boiler to discuss fuel issues and exchange fuel samples.

Local governments should work closely with local fuel suppliers to ensure delivery of the right kind of fuel. Deliveries of fuel should have their quality monitored (moisture content and particle size distribution) at the energy centre to ensure that fuel is meeting expectations. Initial monitoring should also take place during fuel production because it can be difficult to reject a load of fuel once it has arrived at the energy centre. However, energy centre operators must maintain the right to refuse a delivery over quality issues. Because it is difficult to see beyond the top layer of a fuel delivery, the fuel should also be monitored as it is being consumed.

There have been a number of studies in recent years exploring the availability of agricultural residues for combustion. However, the type of processing required so that these residues will burn efficiently and the type of equipment (or adjustments to current equipment) required for combustion is relatively limited, as of 2013, in on-the-ground systems in operation. Further work is required to determine long term, reliable supplies of agricultural residues as well as distribution systems that will work for relatively small amounts of fuel distributed over a large geographic area.

Energy Centre Sizing, selecting, costing, configuring, operating and maintaining

Pre-Feasibility	Feasibility & Design	Build	O&M
• Identify potential sites for energy centre • Estimate size and type • Develop ballpark pricing	• Refine energy centre design options and sizing of base and peaking boilers	• Issue RFP & select vendors • Construction • Testing and commissioning	• Manage the energy centre

Importance

Appropriate design, construction and operation of an energy centre will ensure technical and financial success of the system.

Key Concepts

Components of a biomass district heat energy centre are described in the following table.

Table 3: Components of Biomass DH Energy Centre

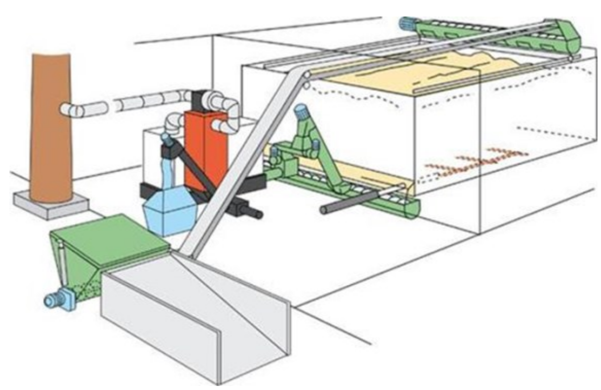


Figure 12: Energy centre for a 2 MW wood fuel boiler, showing wood fuel delivery area, fuel store, fuel transfer / feed mechanisms, ash handling system, and flue. Source: Natural Resources Canada and FVB Energy via Canadian District Energy Association *Biomass for District Heating* module.

Component	Description
Biomass boiler	The central component of the entire biomass DH system. Various types of boiler are available, although most biomass boilers at this scale of ~100kW to ~3MW are likely to be a variation of a grate type furnace with a fire tube or water tube boiler. (See Figure 13.) Grate type furnaces have a wider tolerance of fuel type compared to some other boiler types (e.g. plane grate, or stoker burner). Also see following section on sizing, for how to size a biomass boiler.
Back up / peaking boiler	A critically important component is a boiler for backup and/or peaking. These are generally heated by natural gas, propane, or heating oil. See following section on sizing. Having sufficient backup may also be a condition for financing the system.

Biomass fuel store, and fuel transfer / feed system	Biomass fuel will be unloaded into the store, where it's automatically fed into the boiler. The biomass fuel store needs to be appropriately located to allow a delivery vehicle to easily manoeuver and deliver. Appropriate design of the fuel store and feeding mechanism are critical. They must be designed so that fuel can be delivered with a minimum of time and effort on the part of the biomass fuel supplier (e.g. the store should be able to easily accept a full load delivery from the fuel supplier). The fuel feed mechanism must be as reliable and simple as possible and be suited to the biomass fuel that will be delivered. Some fuel feed / transfer systems are better able to handle a range of particle shapes and sizes than others, e.g. walking floor and ram stoker. Special design considerations may be required for different types of biomass (e.g. although all biomass fuels should be kept dry, this is imperative for wood pellets). The size of the fuel store is also important. If it is too small then logistical problems may result. If it is too large then there is the risk of biological activity, particularly with higher moisture content biomass fuels.
Flue gas cleaning	In some cases flue gas cleaning may not be required, but generally, it is recommended. Three technologies are available: • Cyclone filter – cheapest but least effective. Robust. Efficient for large particles. Suitable for smaller systems. For chip, reduces particulates to 70-80 mg/MJ depending on fuel ash content. For pellet, to ~40 mg/MJ. • Bagfilters – most effective, but sensitive to high temperatures. Efficient for large and small particles. Relatively high maintenance. For chip, reduces particulates to 1-10 mg/MJ. For pellet, to ~5 mg/MJ. Ranges depend on bag type and fuel ash content. • Electrostatic precipitator – most expensive, but very effective. Relatively resistant to high temperatures. Efficient for large and small particles. Likely too expensive for smaller plants. Reduces particulates to 1-20 mg/MJ depending on fuel ash content.
Ash handling system	Ash handling is mainly determined by the size and type of boiler, as well as flue gas cleaning equipment. Most systems use an auger to move the ash to a bin, which needs to be manually emptied periodically.
Burn back safety device / Fire protection system	Necessary to stop fire from burning back from the boiler's combustion chamber along the fuel feed mechanism to the fuel store. This can take the form of dousing with water, and/or automatic fuel feed shut off mechanisms.

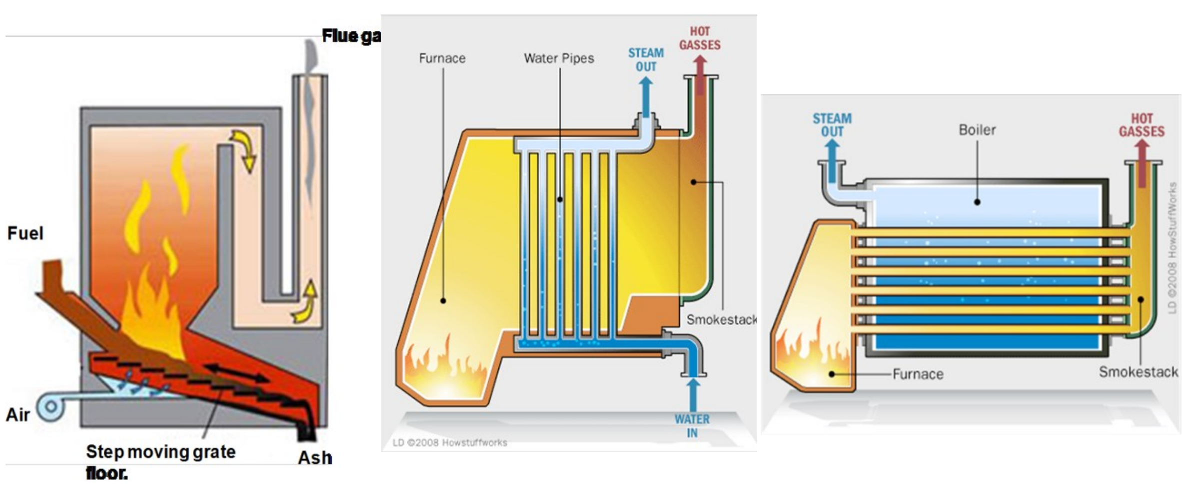


Figure 13: Left – grate furnace, centre – fire tube boiler (up to ~25MW), and right – water tube boiler (from ~2MW +). Furnace and boiler components combine to form what is normally referred to as a "boiler".
Source: Natural Resources Canada and FVB Energy via Canadian District Energy Association *Biomass for District Heating* module.

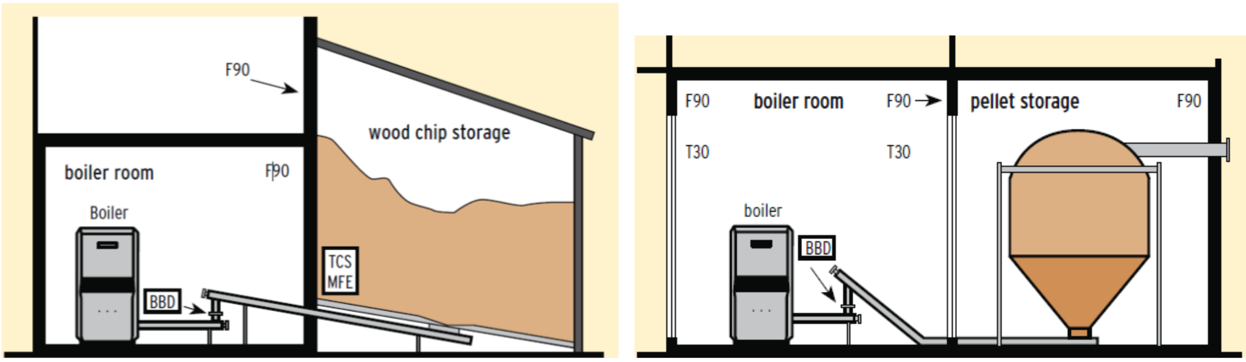


Figure 14: Examples of Austrian design of wood chip (up to 400kW) and wood pellet (up to 150kW) systems. F90 – an Austrian fire resistant wall specification, T30 - fire stop door spec, BBD – burn back safety device, TCS – temperature control device in fuel storage, MFE – manual fire extinguisher. Source: OÖ Energiesparverband. http://www.esv.or.at/english/home/

Sizing

Biomass and peaking boiler size should be based on the estimated heat load duration curve. The heat load duration curve reflects a DH system's customer base and preferred business case, as well as other project objectives. The heat load duration curve shown in Figure 15 depicts a heat load with a peak of 6 MW. This peak load only occurs for a very short period of the year and lower loads will be typical.

Fossil fuel boilers are usually much cheaper per kW of rated capacity than biomass boilers. Matching a biomass boiler for the peak load, even if biomass is a much cheaper fuel than the conventional alternative, does not usually provide the best business case because it leaves a lot of unused bioenergy capacity at all the other times of the year.

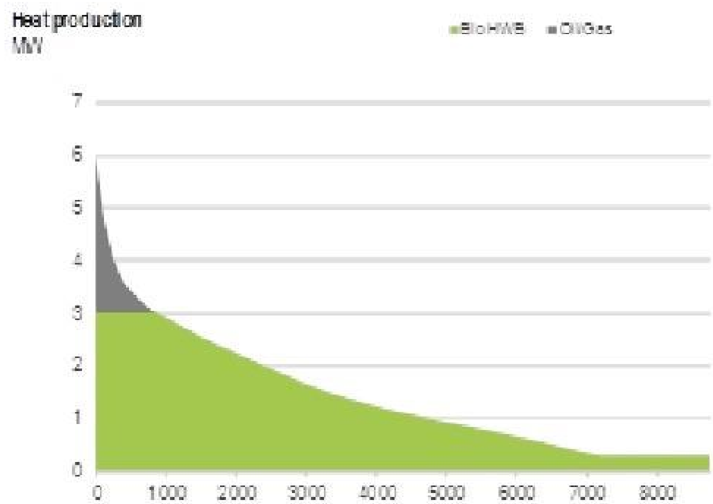


Figure 15: Typical heat load duration curve. Green is met by biomass, blue by heating oil or natural gas. Source: Natural Resources Canada and FVB Energy via Canadian District Energy Association *Biomass for District Heating* module.

In the example shown in Figure 15, the biomass boiler is sized for 3 MW (half the maximum demand), but will still only run at full capacity for less than 1,000 hours per year. The remaining 3 MW of the maximum demand will be met by an oil, propane, or natural gas fuelled boiler for the short period it is required. This example also helps illustrate the importance of trying to obtain a customer base that reduces unused boiler capacity year-round. This can be achieved through ensuring customers have diversified heat loads (see 'Customer' section). Note that biomass fuel boilers generally do not turn down as well as fossil fuel boilers, so it may not be economically or technically feasible to size the biomass boiler to meet peak demand on its own.

The fuel store at the energy centre is usually sized to provide enough fuel for 2-4 weeks of continuous operation for smaller systems (<500kW boilers), and approximately 3 days for larger systems (1-2

MW+).[12] The fuel store can also be sized at 1.5 times the capacity of the biomass fuel delivery vehicle – whichever is larger. Sizing it in this way ensures that the biomass fuel delivery vehicle can always deliver a full load, thus saving on delivery costs. [13]

Some fuel stores may have 'dead' areas where fuel cannot be collected from, which can vary with the shape of the store and the mechanism used to collect the fuel. This is unlikely to account for more than 30% of total volume. This situation can occur with a rotating spring arm agitator fuel feed system and, to a lesser extent, with other fuel feed systems. [14]

The expected moisture content of the delivered fuel and biomass boiler efficiency must also be taken into account. For example, an 85% efficient 3 MW biomass boiler using wood chips with a 50% moisture content will have a max fuel flow of 1.4 tonnes/hour, or 6.3 m^3/hour (depending on the species of wood) and will use approximately 450m^3 of biomass over 3 days of continuous operation. Assuming 20% dead area in the fuel store, total required fuel store volume is 570m^3. If chips at 30% moisture content can be guaranteed over the long-term, the system will require a total fuel store volume of approximately 400m^3.

Figure 16: Lillooet 400kW pellet boiler, with ash auger and ash bin in foreground. Source: Green Energy as a Rural Economic Development Tool Project, D. Dubois, Case Study: *District of Lillooet - Biomass Heating System*, p.9

Ash

Various types of ash will be created by the bioenergy system. 'Bottom ash' will be the most prevalent, then the finer cyclone fly ash and, potentially, filter fly ash (depending on whether the flue gas is cleaned or not). Filter fly ash might have a heavy metal content too high for any use in which case it would have to be landfilled. Provided the biomass fuel used is from a clean, uncontaminated source, uses may be found for the other types of ash. They could be used for filler in road construction, to cover landfills, or, if from wood fuel combustion, may be returned to the forest to prevent soil mineral loss.

Cost

Energy centre cost range is $1,000 to $1,700 per kW of total plant capacity. This cost includes biomass boiler(s), alternative fuels (i.e. natural gas or fuel oil), peaking and/or backup boilers, all piping, controls, pumps, etc. necessary for a full working system, fuel storage for three days, electrostatic precipitator for particulate matter (PM 10) control, engineering, construction, and contingencies. Costs do not include taxes or land acquisition costs. If an electrostatic precipitator is not required, costs should be at the lower end of the range. For boilers of approximately <300kW, capital costs for biomass fuel storage and handling will be fixed and the overall cost per kW is likely to be on the high end of the range.

[12] The Carbon Trust, *Biomass heating: A practical guide for potential users* (CTG012), 2008, p.57. www.carbontrust.co.uk

[13] (Source: Wood Waste 2 Rural Heat)

[14] BioRegional Development Group & SE Wood Fuels and Creative Environmental Networks, *Biomass for London: wood fuel demand and supply chains*, 2008, p. 26. www.lep.org.uk/

Optimizing for Viability

In the feasibility and design stage, it is imperative that the energy centre is designed by an experienced engineer and/or biomass installation firm, in communication with other parties such as the fuel supplier.

A generally recommended approach for the development of DH systems is to start small but consider the ability to scale up in the future. It is possible to start a DH system with just one or two buildings and then expand later. From the perspective of the energy centre, this does not mean purchasing equipment designed to meet a hypothetical future load but it does mean ensuring that there is the ability to expand the energy centre systems in the future.

If minimizing air emissions is a priority, then the boiler and flue gas cleaning equipment should be designed for the biomass fuel to be used and efforts should be made to burn only that fuel. Changes in the fuel being used could lead to increased emissions.[15]

Identifying needed skills, available training, and local support should be an integral part of system planning. It is also important to identify professional operations personnel committed to seeing the system function well. Rural and remote communities without ready access to technical support should keep operations simple and not use complex boiler arrangements or fuel handling systems.

Before operations begin, consider establishing a formal policy or procedure that describes under what conditions the DH system could switch from using biomass as its primary energy source to the backup energy source. A situation could develop where the backup energy source becomes more affordable than biomass, making it financially attractive to operate using that energy source. Community members, local government, DH system customers and operator, and the fuel supplier should have a clear understanding of this policy this ahead of time to minimise surprises and controversy at a later date, particularly since primarily burning fossil fuels will increase a system's GHG emissions and reduce consumption of biomass fuel.

[15] Envirochem Services Inc., *Emissions from Wood-Fired Combustion Equipment*, 2008. http://www.env.gov.bc.ca

Distribution Network

Distribution — **Optimizing type, length, and cost of pipe**

Pre-Feasibility	Feasibility & Design	Build	O&M
• Estimate layout of distribution network, type of pipe, and installation costs	• Refine network design and pricing	• Issue RFP & select vendors • Construction • Testing and commissioning	• Manage the distribution network

Importance

The distribution network of hot water supply and return pipes distributes energy from the energy centre to the customers and has a significant impact on technical and financial viability of a project. Managing the extent of the network in relation to the amount of energy to be sold is one of the key factors affecting the economic viability of a DH system. The design of the system mainly depends upon the energy source and expected loads.

Figure 17: Left – thin-walled steel carrier pipe with bonded hard polyurethane insulation, built-in leak detection system, and bonded high-density polyethylene outer jacket. Right – insulated steel pipe being lowered into place in a trench. Source: Natural Resources Canada and FVB Energy via Canadian District Energy Association *Biomass for District Heating* module.

Figure 18: Left – rolls of insulated PEX pipe, with bonded insulation and bonded jacket. Right – insulated PEX pipe in a trench, prior to backfilling. Source: Urecon.

Key Concepts

Key concepts and descriptions of the distribution network are included in the table below.

Table 4: Distribution Networks

Key concepts	Description
Distribution pipe	The distribution pipe supplies the hot water to the customer. The two main types of pipe for consideration are insulated steel pipe and insulated PEX (plastic cross linked polyethylene). PEX should mainly be considered for smaller DH systems, where high temperatures and flows are not needed. Differences between PEX and steel are: • Connection and civil works costs for PEX pipe are less than for steel, and it's easier to install (PEX comes in long rolls, e.g. 100m, while steel comes in shorter lengths, e.g. 12m, that need to be welded together). • Overall installed costs per metre for PEX less than steel. • PEX cannot maintain temperatures as high as steel. PEX can be used up to 95°C, but to maintain longevity it is better to operate it at lower temperatures. PEX suffers from a pressure derating at higher operating temperatures. Steel can supply water at 95°C without issue. The lower temperature differential, or ΔT, that can be achieved with PEX means that for the same delivered energy a larger pipe diameter and more energy for pumping are required. • PEX cannot maintain pressures as high as steel, which can limit the flow rate and its use with elevation changes. • PEX pipe does not come in diameters as large as steel can. • PEX is a relatively new product with an expected life of over 40 years, if well maintained. Steel should have a greater longevity.
Flow rate	Flow rate is a combination of the flow velocity and the diameter of the pipe.
Delta T (ΔT)	The temperature difference of the supply and return hot water. This, combined with the flow rate, shows the maximum flow of energy (in kW) that can be extracted from the district energy pipe.
Routing	Routing is important in order to minimise pipe costs, which is a function not just of pipe length but also of connections (the number of connections adds proportionally more to the cost of routing with PEX pipe than for steel). Also important to consider issues which may increase civil engineering complexity and costs, e.g. other underground utilities, and streets requiring traffic management.
Minimum slope	This refers to the requirement that the pipe network is drainable. All pipes must have a minimum slope towards a point or points where they can be drained.
Communication	Communication between the customers and the energy centre is used to enhance operations. Typically, this communication includes: energy demand, flow, supply and return temperatures. Communication is not critical to the operation of the distribution network and may not be cost effective for smaller systems.
Leak detection and location	The pipe network can contain an integrated leak detection system that is able to detect leaks and locate them. This leak detection system is recommended but is not critical to the operation of the distribution network.
Isolation valves	Isolation valves can be added to the distribution network to enhance operation. They are recommended but not critical to the operation of the distribution network.
Vault / manhole	These may be necessary for inspection & maintenance of isolation valves, service valves or expansion joints.
Location provider	Required to meet the requests for underground pipe locations. All underground utilities must locate their facilities in the field if required.

Sources: FVB Energy, and Natural Resources Canada and FVB Energy training materials

Typical design conditions for steel pipe are shown in Table 5:

Issues that affect the chosen diameter of the pipe are:[16]

- supply & return temperature differential (ΔT)
- maximum allowable flow velocity
- pressure at design load conditions
- differential pressure requirements

Table 5: Steel Pipe Design Conditions

Component	Specifications for steel pipe
Pressure gradient:	
Mains	150 Pa/m
Service lines	250 Pa/m
Typical velocity range:	1.5 – 3.5 m/s
Temperatures:	
Max supply temp	95°C
Min supply temp (off peak)	65°C
Max return temp	55°C
Min return temp	45°C
System design pressure	1600 kPa
Max system operating pressure	1450 kPa
System test pressure	1.5 x Design pressure
Depth of bury to top of pipe	
Normal depth of bury	900 – 1200 mm
Minimum depth of bury	600 mm
Minimum slope for drainage	0.5%

Source: Natural Resources Canada and FVB Energy

Estimated costs for district energy pipes are shown in Tables 6 and 7:

Table 6: Piping Cost Estimates – Steel Pipe

Inner diameter of steel pipe	Cost per trench meter	kW Capacity (30-40 delta T)
80 mm	$1,120 to $1,900	765 to 1,016
100 mm	$1,210 to $2,040	1,520 to 2,020
150 mm	$1,580 to $2,670	2,655 to 3,530

Source: FVB Energy

[16] Natural Resources Canada and FVB Energy via Canadian District Energy Association *Biomass for District Heating* module.

Table 7: Piping Cost Estimates – PEX Pipe

Inner diameter of PEX pipe	Cost per trench metre	kW Capacity (25 delta T)
60 mm	$930 to $1,570	423
100 mm	$1,150 to $1,950	1,281

Source: FVB Energy

Commodity costs for insulated steel and PEX pipes vary significantly based on diameter, volume ordered, and supplier. They can be of the order of $50-300 per metre. Both heat supply and return pipes are needed, although sometimes a 'double' pipe which contains both supply and return in the same insulation casing can be suitable. These cost more than single pipe but provide commodity and connection savings compared to individual supply & return pipes. Costs for connection hardware, such as valves, tee's, elbows, and splice kits, can add significantly to the total cost, but this will vary based on the nature of the project. The City of Prince George saw their per metre commodity costs for insulated steel pipe almost double after connection hardware was included.

Discussion with experienced civil works professionals should take place regarding minimizing potential local civil works costs. Cost for connection of DH pipe and civil works can vary greatly between projects, and can depend on the location of the community, scale of the DH system, and whether the pipes can be routed through soft ground, or along streets and sidewalks.

The 540kW biomass DH system installed by Fink Machine in the small rural community of Enderby, BC, had extremely low costs for the distribution network. The system's full installed costs for a distribution network based on PEX pipe routed through mainly soft ground, including the costs for the Energy Transfer Stations at the buildings, were $400 per trench metre. [17] These costs are in the same range as costs in Austria for biomass DH systems in rural communities.

As Canadian experience with installing DH systems grows and a wider range of DH products become available on the market, costs in Canada should trend closer to European costs. Civil works costs for piping in dense urban environments will likely always remain higher due to the costs of avoiding existing utilities and restoration costs. As connection and civil works costs form the greatest proportion of the full installed cost, this is also the area where greatest savings can be made.

Installation of pipes involves the following processes:[18]

- excavation & restoration
- pipe connections (for steel, welding)
- inspection & testing
- cleaning & flushing (i.e. washing out the pipe and flushing out any foreign objects prior to use)

Operation of pipes involves the following processes:[19]

- draining & venting
- vault inspection & maintenance
- water quality program monitoring
- valve exercise program
- location provider

[17] From interviews and/or correspondence with staff at Fink Machine, 2013.
[18] Natural Resources Canada and FVB Energy via Canadian District Energy Association *Biomass for District Heating* module.
[19] Ibid.

Optimizing for Viability

In the feasibility and design stage it is imperative that the DH pipe network is designed by an experienced professional engineer and/or biomass system installation firm. The industry accepted code for DH piping systems is ASME B31.1.

For economic viability, it is very important to minimize pipe costs (which are strongly linked to distance of installed pipe) relative to energy delivered. In other words, seek a high delivered-energy-to-pipe-cost ratio. For this reason, it is beneficial to locate an energy centre near an area of high energy density.

A community should not be discouraged by high quoted costs for DH pipe but instead obtain estimates from other sources. If estimates are consistently too high to justify proceeding, revisiting the project periodically may see that the full costs for installing DH pipe have reduced closer to European levels. Having municipal staff conduct the civil works and connections is another option.

A generally recommended approach for the development of DH systems is to start small but with the ability to scale up. It is possible to start a DH system with just one or two buildings, and then expand later. The cost to connect dispersed facilities may be prohibitive at the outset, but become economically viable as time progresses. Supportive community planning measures and policies can provide significant assistance to the growth of a DH system over time.

Finance & Governance

Finance & Governance	Grants, ownership models, decision-making and rate-setting, business case / model and risk management

Pre-Feasibility	Feasibility & Design	Build	O&M
• Consider governance and financing / funding options & preferences • Develop approximate business case	• Develop business plans options and conduct sensitivity analysis • Detailed assessment of governance and financing / funding options	• Confirm budget & governance structure • Apply for financing / funding • Develop organisational structure	• Ongoing financial monitoring and reporting

Importance

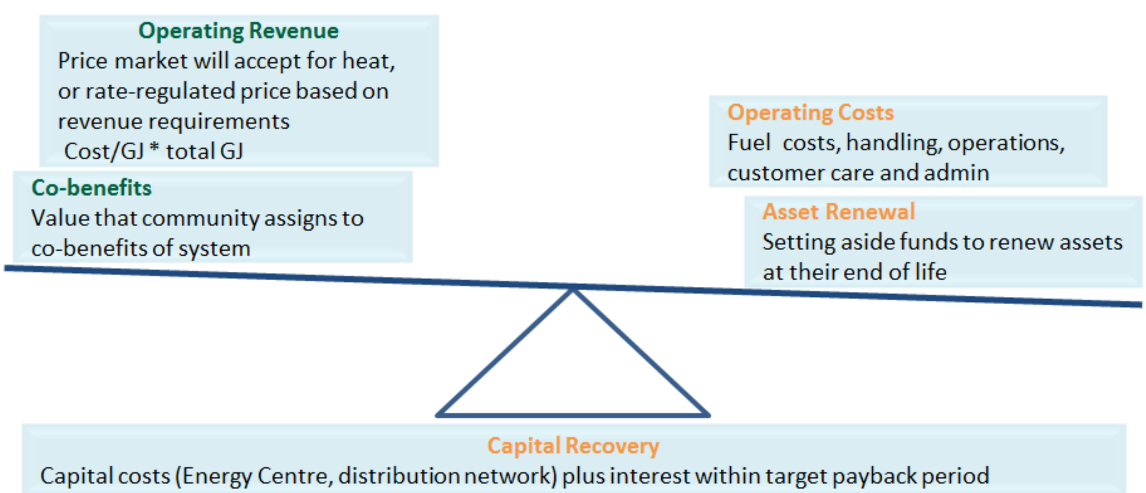
Financing can be a limiting factor to successful implementation of biomass DH in a community, closely followed by governance. A successful governance model (ownership, contracting, accountability and decision-making rights) is critical to achieving a long term enterprise. A governance structure is best determined in detailed planning stages so that it can support further decision making. There are usually few technical limitations to implementing biomass DH in small communities.

A best practice is to obtain professional assistance in developing a workable business model and to either have this work reviewed by peers or request a second opinion to validate and test assumptions.

Key Concepts

Finance

The financial model for a DH system must achieve a balance between revenue and costs, co-benefits, and risk management over the life of the system, as illustrated in the graphic below.



Initial capital investment in a project must be recovered within an acceptable payback period through the accumulated annual difference between benefits and co-benefits (which include operating revenue) over costs (which include operating costs and a replacement reserve fund for asset renewal).

Capital costs are typically in the range of $1 million to $10 million depending on the size and configuration of the system. Total system cost, much like a mortgage, depends on the interest rate applied to any borrowing.

Grants can reduce the amount of capital that must be recovered and should be investigated in the early stages of system planning. Governance, particularly the selected ownership model, may affect which grants can be applied for. In addition to grants, low or no interest loans may be available, such as those provided by Federation of Canadian Municipalities' Green Municipal Fund, which can reduce the total cost of the system. Local governments in British Columbia have access to low interest financing through the Municipal Finance Authority, although there are significant limitations on the amount of debt that can be taken on.

Capital costs of the heat distribution system often limit which buildings can be economically connected to the system. The example below illustrates this simple economic limitation, regardless of how the distribution system would be financed.

Table 8: Example of Distribution Cost Calculations

Customer Type	Avg natural gas / yr in GJ	in Mw.h	20 yr GJ	Service line Length	$/m	Total	Pipe $/GJ
Commercial	582	162	11,640	30	800	$ 24,000	$ 2.06
Residential	90	25	1,800	30	800	$ 24,000	$ 13.33

In Table 8, annual average natural gas usage per residential and commercial connection was calculated using community energy and emissions inventories compiled by the Province of BC. While these inventories overstate total heat consumption to some degree (because of the inclusion of other natural gas uses such as cooking), they are useful to complete an order of magnitude calculation.

An average distribution pipe cost of $800 per metre is used in the table for illustrative purposes because it is lower than most large systems and higher than the lowest cost system implemented in BC. For this calculation, each building is assumed to be 30 metres (about 100 feet) from the nearest part of the distribution network, requiring a service line run of 30 metres to each building. A simple assumption is made that the owner of the system would want to recover initial capital investment for the distribution network over 20 years. For simplicity, this calculation does not include interest cost or establishing a fund to renew the service line at end of life. When the capital cost (as described above) is divided by energy use over 20 years, it results in a range of $2 to $13 per GJ to recover capital costs for the service line to each building. Capital cost of the energy center and distribution network would also need to be recovered, as would annual fuel and operating costs.

In this example, residential heat consumption is so small it would be difficult to recover the cost of providing a distribution connection. Because, by comparison in BC, natural gas is delivered in the $10/GJ range and propane is delivered in the $23/GJ range with variations depending on specific location, customer type, and market conditions. In Alberta, gas rates as of December 2013 were ranging from $3.20 to $3.85/GJ.

Fact: It is difficult to charge enough for heat to recover capital for small connections.

Illustrative Scenarios

The following page provides two realistic scenarios for a small system connecting fewer than ten buildings in relatively close proximity. For simplicity and readability, neither scenario considers debt servicing costs or development of a fund to renew capital assets as they reach the end of their service life. Both reflect a simple cash-flow analysis (earnings before interest, depreciation, and amortization) and do not fully reflect costs of a fossil fuel peaking boiler to service peak loads. In this way, they are both highly simplified and optimistic.

Scenario A reflects the lowest end of the cost ranges including:

- ✓ a 500 metre distribution network that is not expandable, does not require resurfacing of streets, and has no elevation changes so that it can use the least capital cost pipe – flexible PEX – which has pressure and heat limitations
- ✓ lower end of energy centre cost range
- ✓ relatively dry inexpensive fuel source
- ✓ several part-time staff, consultants and professional services equivalent to one full time position
- ✓ heat sales at $25/GJ, which is a small premium over current propane prices
- ✓ co-benefits assumed to be $10,000 per year

Scenario B reflects a mid to high cost profile including:

- ✓ a higher cost energy centre and a 700 metre more robust and expandable distribution network
- ✓ higher fuel costs
- ✓ lower volume of heat sales (same tonnes of biomass but lower heat value due to moisture content)
- ✓ heat sales at $20/GJ reflecting a modest discount from typical propane costs
- ✓ $5,000 per year in co-benefits included in the financial calculation

Table 9: Cost/Revenue/ Benefits Comparison for Scenario's A and B

Scenario A - LOWEST COST		
	Amount	**Description**
Capital Cost		
Energy Centre	$ 1,000,000	540kW biomass boiler plus b/u, housing, balance of centre
Distribution Network	$ 250,000	500m flexible PEX, flat ground, no street crossing (min cost)
Customer Retrofits	$ 50,000	
	$ 1,300,000	
Annual Operating Costs		
Fuel	$ 48,000	800 tonnes of 30% MC local chip @ 60.00/odt
Operations & Admin	$ 100,000	Approx. 1 FTE, several p/t staff, services, expenses
	$ 148,000	
Annual Revenue and Benefits		
Heat Sales	$ 260,000	10,400 GJ @ $25/GJ (2900 MWh ~ 60% annual use of boiler)
Co-benefits	$ 10,000	deemed value of co-benefits
	$ 270,000	
EBITDA	$ 122,000	Earnings before Interest, Taxes, Depreciation, Amortorization
Simple Payback	11	Based on EBITDA and NO fund to renew assets

Scenario B - MODERATE COST		
	Amount	**Description**
Capital Cost		
Energy Centre	$ 1,800,000	540kW biomass boiler plus b/u, housing, balance of centre
Distribution Network	$ 550,000	700m steel, some streets, expansion potential
Customer Retrofits	$ 200,000	
	$ 2,550,000	
Annual Operating Costs		
Fuel	$ 64,000	800 tonnes of 40% MC local chip @ 80.00/odt
Operations & Admin	$ 100,000	Approx. 1 FTE, several p/t staff, services, expenses
	$ 164,000	
Annual Revenue and Benefits		
Heat Sales	$ 160,000	8000 GJ @ $20/GJ (2900 MWh ~ 60% annual use of boiler)
Co-benefits	$ 5,000	deemed value of co-benefits
	$ 165,000	
EBITDA	$ 1,000	Earnings before Interest, Taxes, Depreciation, Amortorization
Simple Payback	2,550	Based on EBITDA and NO fund to renew assets

Fact: These modest changes shift the simple payback (cash flow-basis only) from 11 years to 2,550 years. Best practice is to spend time validating assumptions.

As noted previously, these scenarios are highly simplified and do **NOT account for:**

- ✓ debt servicing costs
- ✓ renewal of capital assets at end of their useful life
- ✓ full costs of fossil fuel boiler and fuel for meeting peak demands
- ✓ more complete and **recommended** financial measures such as net present value (NPV) and internal rate of return (IRR)

Offsets

These scenarios also do not include the value of offsets generated from switching to a renewable heat source.

All public sector buildings in BC, including provincial government buildings, schools, hospitals, crown corporations, colleges and universities, will require renewable energy benefits to help meet their carbon neutral commitments, as will many local governments. Offsets represent a value of up to $25/tonne of GHG emissions for public sector entities. This is equivalent to $1.50 per GJ of propane. If private sector buildings are connected to a publicly owned biomass DH system, a local government may be able to count these emission reductions towards its own carbon neutral goals as a 'local reduction project'. For further information, see the carbon neutral section of www.toolkit.bc.ca.

It may be possible to qualify for offsets in Alberta. For further information, see Alberta's Ministry of Environment and Sustainable Resource Development at http://environment.alberta.ca/02275.html.

Funding Sources

The graphic below illustrates some of the funding opportunities available at each stage of a DH initiative. This is not a comprehensive list but does identify a sample of funding opportunities.

Studies

- Utility grants
- Development trusts
- Federation of Canadian Municipalities Green Municipal Fund
- Borrowing
- Funding as part of local government budget
- Gas tax
- Provincial grants such as Infrastructure Planning

Capital

- Federation of Canadian Municipalities Green Municipal Fund
- Utility Grants
- Borrowing
- Private sector risk capital or investment
- Gas tax
- Offsets?

Operations

- Customer charges
- Taxes
- Community economic development
- Offsets?
- Co-benefits

Governance

Governance includes ownership and decision-making rights and accountabilities. There is no single correct approach for all cases. The Table 10 outlines some of the trade-offs that can be considered for each ownership option. The table is organized with ownership options across the top.

In the table green is better, orange is worse, and yellow is in between.

Table 10: Governance/Ownership Model Trade-Offs

Consideration	100% local government owned (LG department)	100% LG owned (LG owned company)	100% private Utility owned	Joint Venture / P3
Financial				
Access to capital – initial build	Yellow	Yellow	Green	Green
Access to capital – expansion	Orange	Orange	Green	Green
Cost of borrowing	Green	Green	Yellow	Yellow
Non-tax revenue source	Green	Green	Yellow	Yellow
Access to grants	Green	Green	Yellow	Yellow
Local government financial risk	Green	Green	Yellow	Yellow
Can withstand years of losses	Green	Green	Yellow	Yellow
Ability to capture offset attributes	Green	Green	Yellow	Yellow
Operational				
Technical expertise	Orange	Orange	Green	Green
Operational flexibility	Orange	Yellow	Green	Yellow
Admin and monitoring scale	Orange	Yellow	Green	Yellow
Insulation from operational risk	Orange	Yellow	Green	Yellow
Alignment with public interest	Green	Yellow	Orange	Yellow
Simplicity				
Complexity of structure	Green	Yellow	Yellow	Orange
Overall simplicity for LG/FN	Green	Yellow	Yellow	Orange
Other				
BCUC regulatory burden	Green	Green	Yellow	Green
Transparency of rate setting	Yellow	Green	Green	Green
Limits political interference	Orange	Orange	Green	Yellow
Political risk	Orange	Orange	Green	Yellow

Governance decisions will have a lasting impact over the life of the system and are generally worth taking time up front to fully consider.

Optimizing for Viability

Finance

Some considerations to increase the potential financial viability of a system include

✓ Know what you are buying and structure contracts accordingly:
- City of Prince George's DH system buys heat from a local mill, putting the responsibility for heat generation and fuel supply on the mill. In contrast, Revelstoke has a fibre supply agreement with a local mill to provide fuel for the system. There are many ways to structure DH system contracts.
- If you are buying biomass fuel, buy on a dry tonne basis and not on a green tonne basis. If there is a fuel supply contract, include penalty clauses if the fuel delivered is outside of the agreed-upon specifications.

✓ Sizing:
- Start small and build with flexibility to meet new demand. Size the heat plant for the load that will be connected when it is turned on, not for a full build-out that could take years or decades if growth patterns change.
- Biomass heat plants usually have higher capital costs and lower operating / fuel costs than fossil fuel boilers. To optimize the chances of financial viability, design the system so that the high

capital cost biomass asset is being utilized most of the time and the fossil fuel system is used only when demand peaks.
    - Identify customer energy efficiency retrofits BEFORE sizing the system so as to not oversize for the demand after energy efficiency is optimized at the client sites.
- ✓ Pricing
    - Set rates based on long-term levelized cost of service with deferral accounts for losses in early years of the system and with clearly defined processes for adjusting rates as required. Do not set rates as a percentage of electricity, natural gas, or propane costs.
    - Get current information on overall heat consumption for several years for potential customers, to be clear on the value proposition
- ✓ Include co-benefits whenever possible.
- ✓ Plan for continuous optimization and system re-commissioning to keep the system running optimally.
- ✓ Balance the increased fuel cost of pellets against the increased cost of fuel monitoring and handling that may be required with other fuel sources.
- ✓ Minimize the size of the distribution network to minimize capital costs and do the math on how much a connection will cost before committing to it. If a building cannot currently be economically connected to the DH system, there may be the possibility of installing a biomass boiler at the building with a plan to connect to the DH system at a future date if it becomes economically viable.

Governance

Key considerations when deciding on an ownership and financing structure include:

- ✓ The energy utility business model includes a large initial capital cost followed by years of losses before positive net revenues (or positive cash flows) are achieved. An energy utility is a long-term play.
- ✓ Return is typically directly linked to risk. Not all investments share the same risk profile; some will earn more return.
- ✓ Local governments can have access to low cost debt. In BC they have access to the Municipal Finance Authority, but this comes with strict borrowing limits (25% of the previous year's revenue) which can limit the size of the utility and the ability to expand in future years.
- ✓ Ownership structure of the utility can affect tax treatment which can be the difference between a utility that is viable and one that is not. First Nations and Local Governments do not pay the same income tax, property tax, or franchise fees on rights of way as private sector companies.
- ✓ Ownership is not a decision that can be put off until the end of building the system. Some grants will require certain ownership structures and utilities offering to pay for the cost of initial studies will often require an exclusive right to develop the system if it is viable.
- ✓ Set aside more time than you think you'll need for public consultation.
- ✓ If there is a need for multiple equity partners, consider a limited liability partnership as the corporate structure to more clearly insulate parties from risks and to take advantage of any profits being taxed in the hands of the partners rather than the company. Electricity generation is the most common type of utility requiring multiple equity partners.
- ✓ If multiple energy utilities are being contemplated or if there is a desire to further insulate the utility from local political shifts, consider establishing a development corporation to be the entity that negotiates and holds the equity positions in the partnerships.
- ✓ Seek professional tax, business, and legal advice when considering establishing an energy utility or project.
- ✓ Energy Service Companies (ESCOs) will write performance contracts to reduce or eliminate risk on energy utilities…for a price.

Regulations and Policy

Regulatory & Policy — **Protecting customers, air, and workers. Local supportive polices and regulations**

Pre-Feasibility	Feasibility & Design	Build	O&M
• Identify regulatory requirements that may be required • Identify potential community planning / policy measures	• Specify regulatory requirements with appropriate authorities / legal advisors • Confirm community planning / policy measures	• Acquire permits / approvals • Design contract structure • Implement supportive planning / policy measures	• Air quality monitoring, if required • Consider expansion opportunities • Manage rate reviews • Stay current on evolving regulations

Importance

DH systems may be subject to regulatory oversight from agencies responsible for public utility regulation, air quality, worker safety, and construction access. Compliance with Provincial and Federal regulations and policy is essential for a biomass DH system to be able to proceed.

Fact: Regulations are expected to evolve. Seek legal advice or check with the authority that has jurisdiction at an early stage in planning the project to understand current regulations.

Local governments may choose to establish policy frameworks and incentives to encourage and support DH.

Key Concepts

BC Utilities Commission

The BC Utilities Commission (BCUC) regulates public utilities, defined as any company that sells heating or cooling services to a customer. However, if a municipality or regional district chooses to provide energy services, the service is exempt from BCUC regulation. For DH systems not provided by a municipality, permission to construct and operate (also known as a Certificate of Public Convenience and Necessity, or CPCN) and approval of rates is required. There are also limitations on disposing of assets or selling shares. (Note that there is an important difference between owning a system and providing a service. The City of Langford provides heat from the Westhills district energy system without owning it so the district energy system is exempt from BCUC regulation.)

The BCUC's quasi-judicial processes have been developed to regulate large utilities like BC Hydro or FortisBC. Because of the increasing number of small district energy utilities, BCUC is in the process of evolving their approach to regulating these small systems. As noted in the AES Inquiry Report (Dec.27, 2012[20] p.77), "*Commission Staff will be conducting consultations on a scaled regulatory framework for [DES] utilities, following the conclusion of this Inquiry. This process will, with further input from stakeholders, establish the form of regulation required, in accordance with the Principles and Guidelines*

[20] BC Utilities Commission, IN THE MATTER OF FORTISBC ENERGY INC. INQUIRY INTO THE OFFERING OF PRODUCTS AND SERVICES IN ALTERNATIVE ENERGY SOLUTIONS AND OTHER NEW INITIATIVES REPORT, December 27, 2012

set out in Section 2. The framework that results from this consultation process will be brought to the Commission for approval."

Alberta Utilities Commission

The Alberta Utilities Commission regulates the utilities sector and natural gas and electricity markets. Its mandate is to protect social, economic and environmental interests of Alberta where competitive market forces do not. The AUC regulates investor-owned electric, gas and water utilities, and some municipally owned electric utilities, to ensure that utility services are safe and reliable and marketed at just and reasonable rates. The AUC also oversees the tolls, tariffs and service regulations of energy transmission through natural gas pipelines and electric transmission lines and has jurisdiction over the siting of facilities including electric transmission facilities, electric power plants and natural gas transmission pipelines.

The AUC establishes mandatory requirements and standards of practice for the retail electric and natural gas markets through the use of a rule-making procedure involving a consultative process with stakeholders and interested parties. The Regulatory Policy Division also conducts research on current and emerging issues on matters related to the operation of the retail natural gas and electric markets and maintains contact with regulated entities, stakeholder groups and regulatory agencies in Alberta and other jurisdictions as a means of remaining current on topical issues.

The AUC has the responsibility to provide an adjudicative function with respect to the contravention of specific electric and gas utilities legislation, AUC Decisions and Orders, ISO Rules, and agency and market participant conduct. The AUC also hears objections and complaints regarding market rules and standards.

Fact: Contact the appropriate regulator and/or seek legal advice to determine the current state of small district energy systems regulation.

In Alberta, several policies and programs (some with funding support) have been created to support the use of bio-energy. These include:

1. The Biomass Protocol – this mechanism can help monetize carbon reductions. The 2013 price is $15/tonne but it is likely to increase soon, potentially as high as $40/tonne. See: http://carbonoffsetsolutions.climatechangecentral.com/offset-protocols/approved-alberta-protocols
2. The Climate Change Emissions Management Fund – this fund makes periodic thematic based calls for proposals. Currently there is an open call for biological systems. Proponents must demonstrate significant GHG reductions. See: http://ccemc.ca/apply/
3. The Bioenergy Producer Credit Program – this program prices biomass electricity at $0.02 per kilowatt hour and $0.50 per GJ of heat. This fund is currently subscribed but money may become available for highly viable and strongly supported projects. See: http://www.energy.alberta.ca/BioEnergy/1400.asp

Air quality

In BC, air quality regulation has evolved to address combustion emissions other than those from small DH systems. As biomass DH continues to grow, BC legislation will continue to evolve and begin to address this emerging area more specifically. Metro Vancouver regulates air quality within its boundaries and has some experience with regulating biomass burners used to heat greenhouses.

Fact: Contact the appropriate provincial (or local) air quality regulator and seek legal advice on the current state of regulation.

If a biomass DH system is used exclusively to provide comfort heat, it likely falls within the comfort heat exemption of the BC Environmental Management Act[21] S. 6 (5)(k). This exemption means the DH system would not be required to obtain a permit or authorization under BC's EMA. The comfort heating exemption would not exempt a DH system from the EMA prohibition on causing "pollution", defined as "the presence in the environment of substances or contaminants that substantially alter or impair the usefulness of the environment."

Some projects may trigger permit requirements under BC's EMA if the heat is not being used for space heating, such as heating water in a municipal pool. If that is the case, then proponents can expect to be regulated at best achievable technology (BAT) levels. The determination of BAT includes economic considerations. The Ministry of Environment recently received technical advice on BAT emission levels for particulate matter (PM) that is summarized here: http://www.env.gov.bc.ca/epd/industrial/pulp_paper_lumber/pdf/emissions_report_08.pdf.

Note that this regulation may require periodic monitoring of emissions which may require bringing in specialized expertise.

Fact: For a small biomass DH system, air quality management can provide a significant challenge to the business case.

Regulation of biomass DH systems should not be confused with the planned regulation of outdated outdoor wood boilers under BC's Solid Fuel Burning Domestic Appliance Regulation (SFBDAR). Revisions to the SFBDAR are being undertaken with a view to avoiding overlap with small DH systems. Nonetheless, some small DH may be captured under the requirements of the revised SFBDAR when it comes into force (likely 2014).

Air quality regulations in Metro Vancouver

Metro Vancouver is unique in that it is the only Regional District that regulates air quality instead of the Province of BC.As with the Province of BC, it is reasonable to expect that air quality regulation in Metro Vancouver will continue to evolve.

In Metro Vancouver, Boilers and Process Heaters Emission Regulation Bylaw No. 1087, 2008, for biomass boilers <50MW, states that: *"Operators of boilers or process heaters fuelled by biomass must not cause or allow the emissions from any boiler or process heater to exceed the following emission limits:*

(1) the concentration of filterable particulate matter in flue gases must not exceed 18 mg/m^3

(2) opacity must not exceed 5%."

For the agricultural sector, Agricultural Boilers Emission Regulation Bylaw Consolidated, 2009, (consolidation of bylaws 1098 and 1109), for biomass boilers <50MW, states emission limits of 50 mg/m^3 for boilers ≤3MW, and 35 mg/m^3 for boilers >3MW, with a maximum opacity in both cases of 10%.

Additional provisions are contained within bylaws, for example provisions on regular testing. The bylaws also allow for discretion by the District Director, whose decisions may be appealed to the Environmental Appeal Board.

Contact Metro Vancouver or seek legal advice on the current state of regulation.

Note that Metro Vancouver has calculated the regional cost of fine particulate (PM2.5) at $813/tonne, which is mainly attributed to regional health costs. This value is strongly related to the nature of the air shed, and so it cannot be assumed that fine particulate has the same cost in other air sheds.

Air emissions in Alberta are regulated by the Ministry of Environment and Sustainable Resource Development under the *Environmental Protection and Enhancement Act (1992).*Various sources are

[21] BC Environmental Management Act, Chapter 53, Part 2, Prohibitions and Authorizations, Waste disposal, Section 6 (5) (k)

regulated to minimize emissions and ensure that ambient air quality is maintained within specified objectives. Similar to BC, there is no specific set of regulations governing biomass DH energy centres but a number of regulations and codes of practice may apply depending upon the material being combusted:

- Environmental Protection and Enhancement Act Industrial Release Limits Policy – Alberta Environment regulates emissions either directly or in conjunction with other agencies based on the industrial sector
- Regulating GHG emissions and determining offset credits – Quantification Protocol for Diversion of Biomass to Energy from Biomass Combustion Facilities[22]
- Code of Practice for Energy Recovery,[23] effective September 2005 regulates air (and other) emissions from facilities burning more than ten (10) tonnes of waste per month
- Alberta substance release regulation (2006)

Workers Safety

Like any commercial or industrial operation, the construction and operation of the DH system will be subject to approvals and determination of staffing requirements by the appropriate provincial safety authorities.

Local government policy

Refer to the local government's zoning bylaw to determine whether the potential locations for the energy centre conform to the bylaw or require a rezoning application and approval. There may also be restrictions on building setbacks, the height of the chimney stack, and outside storage. Current zoning may restrict the energy centre to areas with buildings that are not good DH loads (e.g. warehouses), and away from areas with buildings that could be good DH loads. Building community support for the project (see "Community" section) will help overcome possible policy barriers. This can be a lengthy process in a community that has not anticipated use of DH systems. There are good examples of DH systems located in urbanized and residential areas that can support your application. One good example is Seattle Steam, which generates heat from biomass in downtown Seattle (see http://www.seattlesteam.com/environmental-stewardship.htm)

To permit the installation of DH infrastructure on or under municipal property, DH will usually require an operating agreement, municipal access agreement, and/or road use permit with the local government. Building permits and development permits for above ground structures may also be needed.

Local governments also have a number of tools at their disposal to encourage or support DH in their jurisdiction. For example, encouraging or mandating connections to new buildings. A specific policy or suite of policies will depend on local circumstances.

Optimizing for Viability

Understanding current applicable regulations and considering these in system design are critical to avoiding costly surprises at a later date.

Fact: Policies and regulations change. Seek legal advice or check with the regulatory authority early in the project planning phase.

[22] Alberta Environment & Sustainable Resource Development, Specified Gas Emitters Regulation, Quantification Protocol for Diversion of Biomass to Energy from Biomass Combustion Facilities, 2007. http://environment.alberta.ca/02302.html

[23] Alberta Queen's Printer, Code of Practice for Energy Recovery, effective September 2005 (Under the Environmental Protection & Enhancement Act) http://www.qp.alberta.ca/documents/codes/ENERGY.pdf

To support financial viability of a DH system, municipal zoning should allow for construction of the energy centre close to heating loads. In addition, supportive municipal policies can provide significant assistance to the growth of a DH system over time, by encouraging or mandating (e.g. via local service area bylaws in BC) new customers.

Assessing Viability

Below is a simple checklist to help communities assess whether biomass DH could be suitable for their communities.

Benefit	Score 1-3
Community	
1. Support for the idea of a DH system with municipal staff and council	
2. Local attitude likely favourable to bioenergy	
3. Extent of community leadership in renewable energy projects	
4. If energy planning, reduction of greenhouse gas emissions, or clean or renewable energy forms part of local planning documents	
5. Support for DH system with local business leaders; or there will be local interest in local economic development projects	
Customers	
6. Buildings with large heat loads close together (e.g. pool, hospital, hotel, seniors home within 1-2 blocks) that may be interested in connection	
7. Potential customers represent a mix of building types requiring heat at different times	
8. New construction or revitalisation initiatives may take place near to the potential DH system	
Finance and Governance	
9. Community not connected to natural gas network	
10. Grant funding available, or private sector interest in full or part ownership	
Fuel Supply	
11. Supplies of waste biomass available (e.g. secondary wood product manufacturers, waste wood from saw mills, logging slash, clean construction & demolition waste, farms)	
12. Is there a nearby source of biomass? Type? Quality? Quantity? Availability?	
13. Could a long-term feedstock supply contract be negotiated?	
Energy Centre	
14. Experienced & reliable installation firm available	
15. Capable & reliable personnel willing to conduct ongoing maintenance, and to be trained in maintenance of biomass fuel energy systems	

Lessons Learned

Case study research completed by Community Energy Association in 2012 made recommendations and documented lessons learned from 12 DH projects and electricity generating projects across BC.[24] These are included in the sidebar. This research was conducted by Community Energy Association on behalf of the Southern Interior Beetle Action Committee (SIBAC) and project partners.

Recommendations include:

- First, reduce demand by making buildings the most efficient they can be and then size the district system accordingly. This may be achieved with the assistance of energy service companies (ESCOs).
- Be clear on the goals of the DH system and do the analysis required to achieve those goals.
- Both short and long term views should be considered when planning and designing a system.
- Size initial plant to meet initial base demand and scale plant up as demand scales up.
- Design biomass plant for base demand and use other energy sources for peaking.
- Set rates based on levelized cost of service.
- Use multiple grants from a variety of sources "stacked" together to provide matching funding.

Lessons learned from DH and Power projects in BC:

- It is important to conserve energy first and innovate second.
- Project and utility developers have emphasized the importance of leadership, communication and accountability. Partnerships and good relationships between partners are key.
- Local capacity and experience, including local suppliers, is an advantage for any project. Local fuel sources lead to economic benefit but making sure fuel sources are reliable is absolutely essential.
- Do your homework, but don't overdo it. While feasibility studies are essential, they cannot predict everything. Several case study participants noted that both good and bad luck on timing had significant impacts on projects.
- When dealing with multiple funding partners, hitting milestones during project development can be challenging.
- Develop an informed, confident community, especially youth members.
- Projected profits can be very good at convincing council to take a risk but setting customer rates is complex.
- Project scale affects both affordability and benefits. Scalability – the ability to expand a system in the future – is essential. Often one successful project leads to another.
- Both developing and operating a system involves steep learning curves.

[24] Community Energy Association for Green Energy as a Rural Economic Development Tool project, Green Energy Projects and Utilities: An Investment and Governance Guide for BC Local Governments and First Nations, Volume 1: Making Investment and Governance Decisions, 2013. http://www.ruralbcgreenenergy.com/projects-reports-tools

Conclusions

Small communities across Alberta & BC are addressing climate action, energy security, and local economic development in an increasingly integrated way by beginning to connect formerly separate planning and regulatory silos. DH is one part of this emerging, integrated approach to managing energy in a community.

Many small communities have access to forms of biomass such as wood chips, pellets, sawdust, and agricultural sources. These benefits of using these fuels will be attractive to many communities, especially to those not on the natural gas network. In these cases, biomass would be by far the cheapest available fuel.

Agricultural residues show strong promise as biomass fuels and significant research efforts are underway to overcome challenges associated with air emissions and impacts on combustion equipment. This particular sector could become a promising source of fuel for small community biomass DH systems, especially in areas with large amounts of waste agricultural residues.

Because biomass heating systems are still a relatively new technology in BC and Alberta, information dissemination and training will help promote development. Communities that have not embarked on a bioenergy project previously may benefit from the expertise of well qualified consultants and a dedicated project champion who will lead the project and help to overcome any issues. Community engagement early on will help gain support for the project.

Appendix 1 – Pellet Producing Facilities in Alberta and BC [25]

This is a snapshot of the industry as of December 2013. Production volumes are in tonnes per year.

British Columbia
1. Okanagan Pellet Company, Kelowna - 50,000
2. Pacific Bioenergy, Prince George - 400,000
3. Pinnacle Pellet, Armstrong - 50,000
4. Pinnacle Pellet, Burns Lake - 400,000
5. Pinnacle Pellet, Strathnaver BC - 200,000
6. Pinnacle Pellet, Quesnel - 90,000
7. Pinnacle Pellet, Williams Lake - 150,000
8. Pinnacle/Canfor Houston Pellet, Houston - 150,000
9. Premium Pellet, Vanderhoof - 140,000
10. Princeton Co-generation, Princeton - 90,000
11. Vanderhoof Specialty Wood Products, Vanderhoof - 30,000
Alberta
12. Foothills Forest Products, Grande Cache - 25,000
13. La Crete Sawmills, La Crete - 35,000
14. Vanderwell Contractors, Slave Lake - 60,000

[25] http://www.pellet.org/images/CBM_Pelletmap2012FINAL.pdf

Appendix 2 – Useful Equations

Moisture content

Wet basis is the formulation most commonly used in the bioenergy industry and that convention is followed in this handbook.

Wet basis

$$Delivered\ moisture\ content\ (wet\ basis) = \frac{Delivered\ mass\ - Bone\ dry\ mass}{Delivered\ mass}$$

Dry basis

$$Delivered\ moisture\ content\ (dry\ basis) = \frac{Delivered\ mass\ - Bone\ dry\ mass}{Bone\ dry\ mass}$$

Fuel usage

$$Fuel\ usage\ [\frac{tonnes}{yr}] = \frac{Delivered\ heat\ from\ biomass\ plant\ [\frac{GJ}{yr}]}{Energy\ content\ of\ fuel\ \left[\frac{GJ}{tonne}\right]\ x\ Plant\ efficiency[\%]}$$

For energy content of fuels see the chart in Figure 6. Moisture content is the key determining factor for determining the energy content of a form of biomass, and so the chart serves as a guide for both wood and agricultural residues. (Note that 1 MJ/kg = 1 GJ/tonne; because 1000 MJ = 1 GJ, and 1000 kg = 1 metric tonne. Also note that 1 GJ = 0.278 MWh.)

Plant efficiency could be assumed at 85%.

Biomass fuel cost

$$Fuel\ cost\ \left[\frac{\$}{yr}\right] = Fuel\ usage\ \left[\frac{tonnes}{yr}\right] x\ Cost\ per\ unit\ of\ fuel\ \left[\frac{\$}{tonne}\right]$$