MANITOBA FIRST NATIONS BIOMASS PRE-FEASIBILITY STUDY

January 30, 2018

Prepared for

Aki Energy
Dakota Tipi First Nation,
Sagkeeng Anicinabe First Nation,
St. Theresa Point First Nation,
Manitoba Hydro, and
Manitoba Agriculture's Growing Forward

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SUMMARY

Aki Energy has conducted a review of biomass heating systems alternatives for the non-residential buildings on three First Nations communities in Manitoba—Dakota Tipi First Nation, Sagkeeng Anicinabe First Nation, and St. Theresa Point First Nation.

Climate and ecological characteristics of each of these communities as they affect heat energy consumption and biomass production was reviewed. Biomass available for each of these communities was also estimated.

The suitability for heating community buildings in each of these communities were considered:

- 4 at Dakota Tipi
- 14 at Sagkeeng
- 26 at St. Theresa Point

Energy consumption data was made available by Manitoba Hydro for the four Dakota Tipi buildings, for nine of the buildings at Sagkeeng, and for 18 buildings at St. Theresa Point. Regression analysis was used to estimate the portion of that energy consumption that was used for heat in those buildings. The heating energy consumption of the other community buildings in these communities was extrapolated from this Manitoba Hydro data.

A number of existing community buildings in each community were judged as suitable for biomass heating in each community at this time:

- 4 at Dakota Tipi, totalling approximately 1,000 m^2 (11,000 ft^2)
- 10 at Sagkeeng, totalling approximately 15,000 m^2 (160,000 ft^2)
- 17 at St. Theresa Point, totalling approximately 18,000 m^2 (190,000 ft^2)

These buildings consume significant energy for heat:

- 560 mWh/year at Dakota Tipi
- 3,000 mWh/year at Sagkeeng
- 3,600 mWh/year at St. Theresa Point

Eight Biomass District Heating Systems were proposed to meet those heating needs:

- 2 at Dakota Tipi
- 2 at Sagkeeng
- 4 at St. Theresa Point

A RETScreen[1] analysis of each of these eight systems was conducted. Adjustments were made to the RETScreen analysis to allow for uncertainty in the estimates, and for future expansion of the District

[1] "RETScreen" is the short-form name of a software tool that enables us to estimate the feasibility of a renewable energy project. More information on this tool can be found at https://en.wikipedia.org/wiki/RETScreen The full name of the tool that was used in this report is the "RETScreen Expert Clean Energy Management Software".

Heating Systems. An estimate was made of the biomass that could be consumed in these Systems,[2] if they were all built:

- 220 tonnes/year at Dakota Tipi
- 1,000 tonnes/year at Sagkeeng
- 1,100 tonnes/year at St. Theresa Point

An estimate was made of the cost of this fuel:

- $150/tonne for Dakota Tipi
- $170/tonne at Sagkeeng
- $200/tonne at St. Theresa Point

If each community supplied all this fuel itself, this would represent earned revenue retained by the community of:

- $33,000/year for Dakota Tipi
- $170,000/year for Sagkeeng
- $220,000/year for St. Theresa Point

If each community supplied all this fuel itself, harvesting and processing this biomass would result in jobs in each community. However, not all of the earned revenue noted above would go to salaries. The Study projects that approximately 60% would go to salaries for members of the community, creating the following permanent Full-Time Equivalent (FTE) jobs in each community:

- 0.6 FTE in Dakota Tipi
- 3 FTE in Sagkeeng
- 4 FTE in St. Theresa Point

If this work was seasonal, the numbers would be higher—perhaps twice as many, but only lasting 6 months each.

When compared in $/kWh, the cost of heating with biomass is two to three times less than the cost of heating with diesel or propane.

The cost of heating with biomass is similar to the cost of heating with grid-based electricity. Over the next ten years, because electricity rates are expected to rise faster than the rate of inflation, the cost of heating with electricity will become more expensive than the cost of heating with biomass.

In the one community studied where natural gas is available (Dakota Tipi First Nation), the cost of heating with natural gas is currently less than the cost of heating with biomass. However, as the carbon levy grows, this cost difference will narrow. Depending on what happens to the carbon levy in the future, the difference in price between natural gas and biomass may disappear.

The option of building a greenhouse in each community, connecting it to the District Heating Loop and heating it with biomass was considered for each community.

[2] As noted in the main body of this study, these estimates are set deliberately high to compensate for uncertainties. The study details how these compensations are calculated.

Preliminary analysis of similar greenhouses indicate that a greenhouse in one or more of these communities could be economically viable, could create a small number of permanent jobs for First Nations members, and could contribute to healthy diets for community members. The report makes two primary observations regarding greenhouses in these communities:

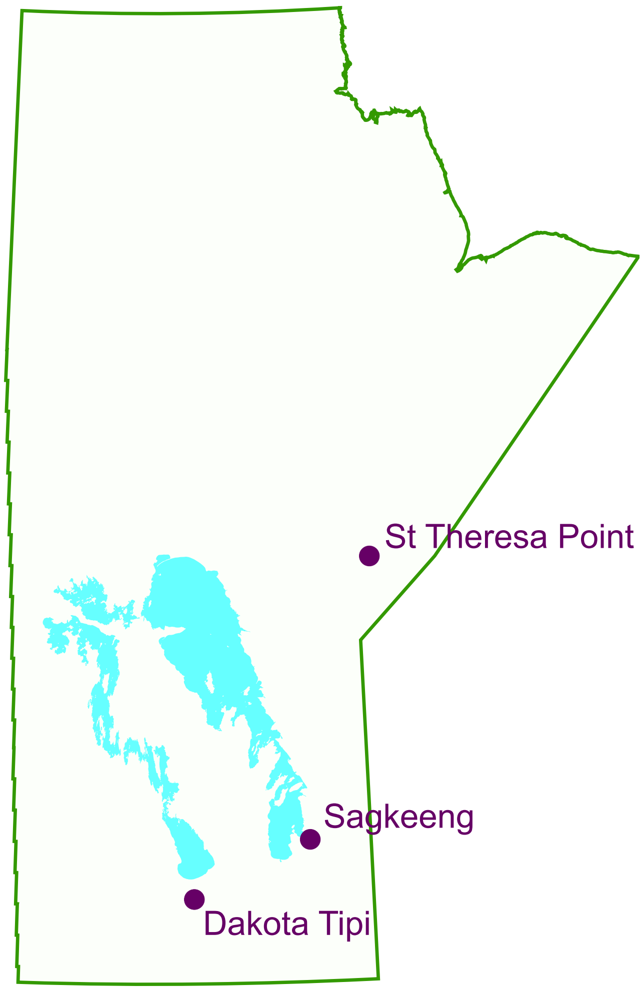
1. Each greenhouse should grow a different mix of produce.
2. Greenhouses are not easy to operate over the long term. They need to be evaluated against other economic development opportunities, and other healthy food initiatives available to each community in a feasibility study customized to each community.

Next steps are recommended for each community.

1 BACKGROUND

Three communities were involved in this study—Dakota Tipi, Sagkeeng, and St Theresa Point.

Figure 1. First Nations Communities Involved

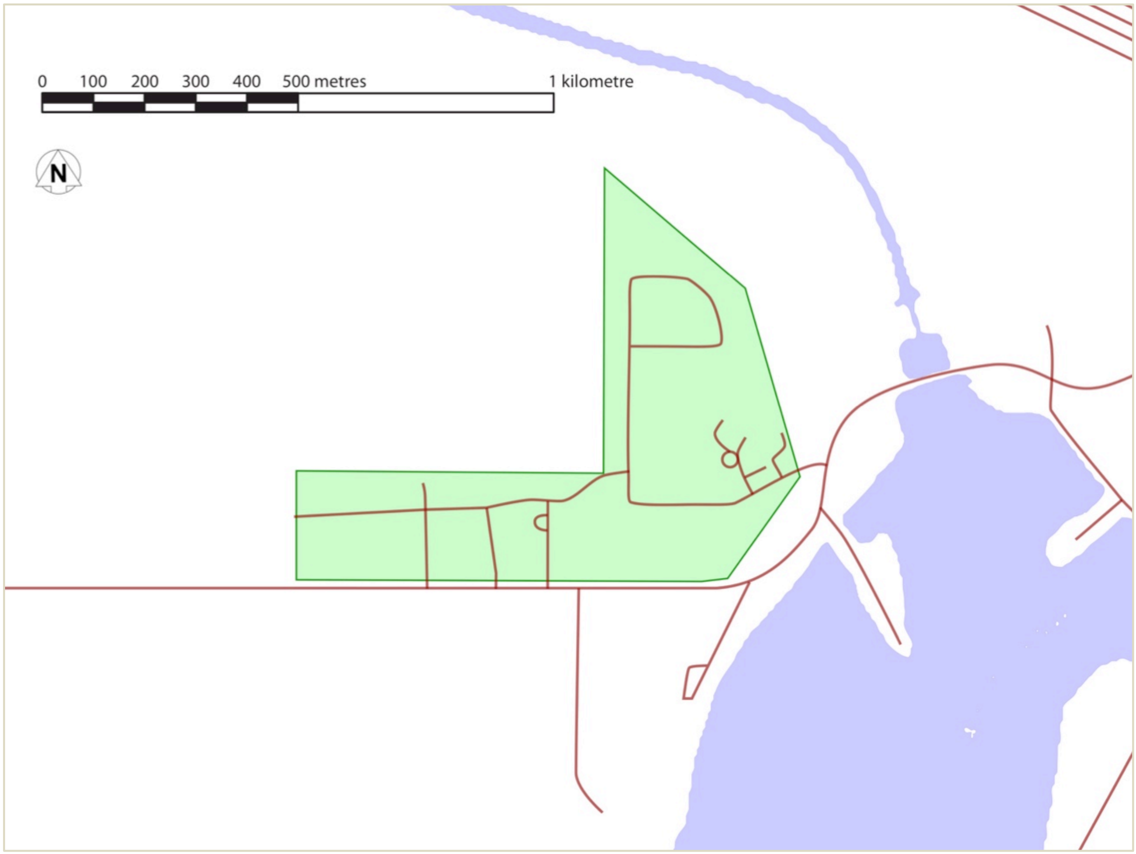


These three communities were studied, in part, because of the variations between them. They differ in their access to natural gas, their access to all-weather roads, size, and ecology. Having communities involved which have these variations benefitted the study because it enabled the study to examine options which may be feasible for a range of First Nations communities across Manitoba.

1.a Dakota Tipi First Nation

Dakota Tipi First Nation is a community situated on 60 ha of reserve land, just south of Portage La Prairie, approximately 80 km west of Winnipeg.

Figure 2. Map of Dakota Tipi First Nation



In 2015, Indigenous and Northern Affairs Canada (INAC)[3] recorded the First Nation has having 398 registered members, 195 of whom werelisted as living on reserve.

In 2011, the Statistics Canada's Census recorded 164 people living in the Dakota Tipi community and calculated that the community had a median age of 23.9 years.[4]

[3]Indigenous and Northern Affairs Canada. "Registered Population: Dakota Tipi". http://pse5-esd5.ainc-inac.gc.ca/FNP/Main/Search/FNRegPopulation.aspx?BAND_NUMBER=295&lang=eng accessed July 27, 2016.

[4] Statistics Canada. "Dakota Tipi 1, IRI Manitoba". https://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=4609027&Geo2=PR&Code2=62&Data=Count&SearchText=&SearchType=Begins&SearchPR=01&B1=All&Custom=&TABID=1 accessed July 27, 2016.

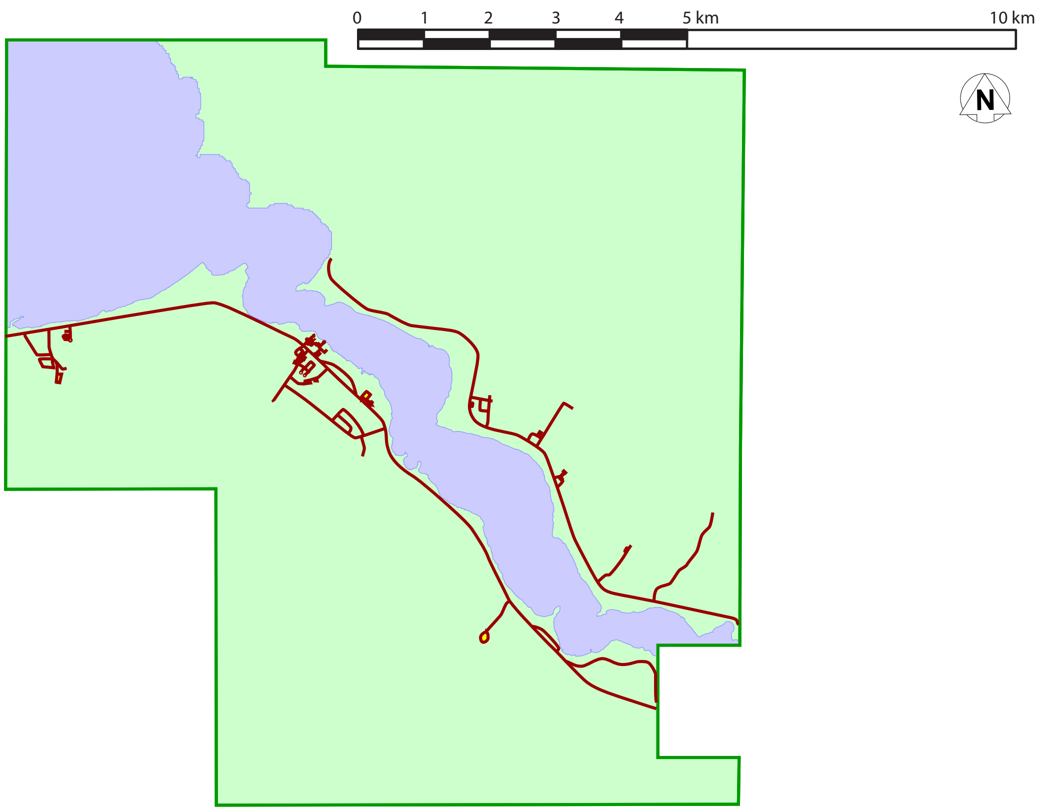
Unlike the other two communities involved in this study, Dakota Tipi is connected to Manitoba Hydro's natural gas pipeline distribution system, within Manitoba Hydro's "Portage" service area.[5]

The community is located less than1 km south of the Trans-Canada Highway and so is very easily accessible by all-weather road.

1.b Sagkeeng Anicinabe First Nation

Sagkeeng Anicinabe First Nation (listed in INAC data as "Fort Alexander") is a community situated on 8,771 ha of reserve land, just south of Portage La Prairie, approximately 100 km northeast of Winnipeg and just west of Powerview/Pine Falls.

Figure 3. Map of Sagkeeng Anicinabe First Nation



In 2015, INAC[6] recorded Sagkeeng has having 7,784 registered members, 3,416 of whom were listed as living on reserve.

[5] Manitoba Hydro. "Natural gas distribution." https://www.hydro.mb.ca/corporate/facilities/manitoba_hydro_naturalgas.shtml accessed July 27, 2016.

[6] Indigenous and Northern Affairs Canada. "Registered Population: Fort Alexander." http://pse5-esd5.ainc-inac.gc.ca/FNP/Main/Search/FNRegPopulation.aspx?BAND_NUMBER=262&lang=eng accessed July 27, 2016.

The south portion of the community, which includes most of the buildings that might be feasible for biomass heating, is easily accessible by Provincial Trunk Highway 11, an all-weather road.

The north portion of the community, which includes a school which may be feasible for biomass heating, is accessible by the Northshore Road, which is also an all-weather road.

1.c St. Theresa Point First Nation

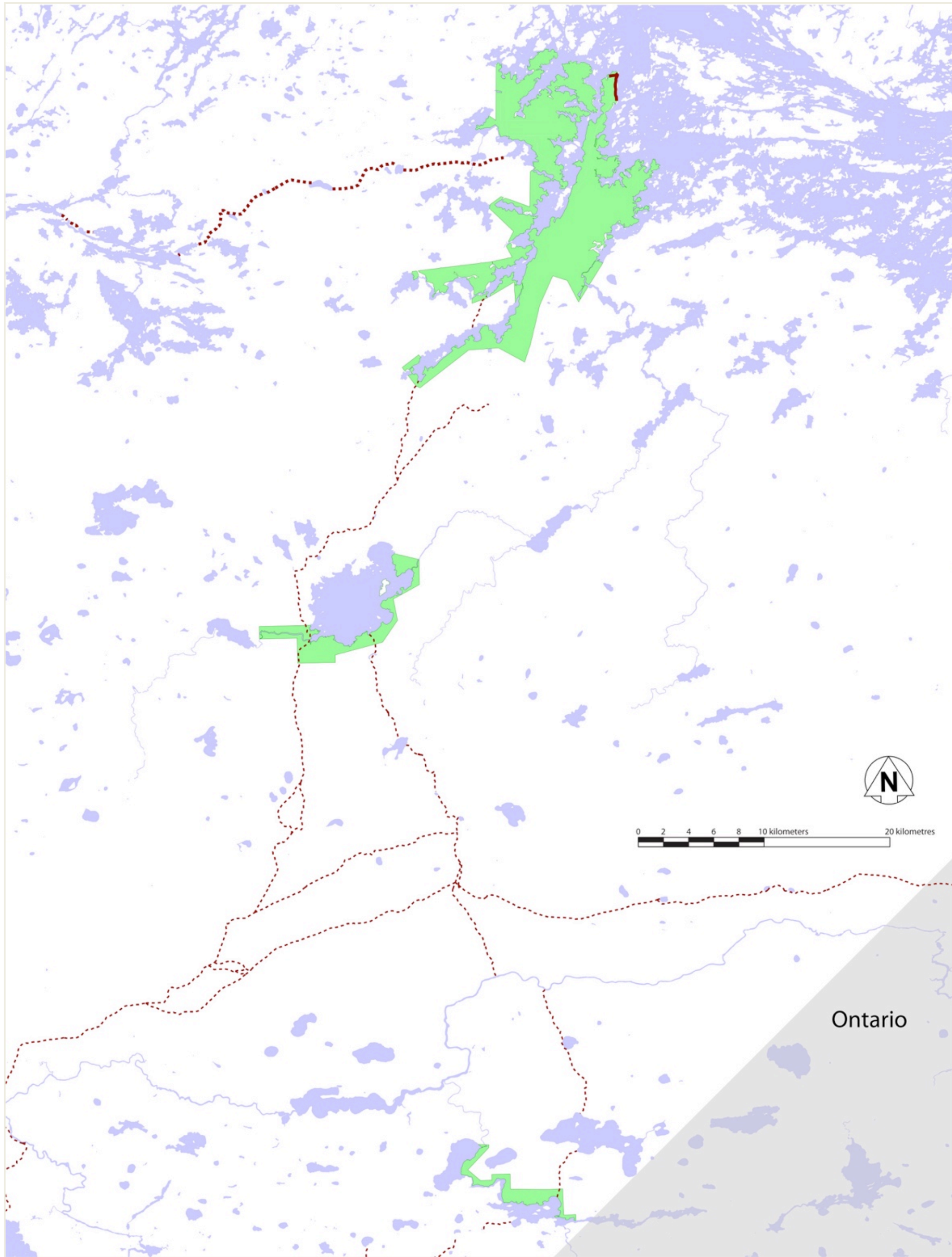
St Theresa Point First Nation has three areas of reserve land:

Table 1: St Theresa Point Reserve Lands[7]

No.	*Name*	*Location*	*Hectares*
09378	Cantin Lake	south shore and east shore of Cantin Lake	1,912
09338	Mukwa Narrows	140 km east of Negginan & northwest of Elliot Lake	890
09147	St Theresa Point	west shore of Island Lake	2,885

[7] Indigenous and Northern Affairs Canada. "Reserves/Settlements/Villages: St Theresa Point." http://pse5-esd5.ainc-inac.gc.ca/FNP/Main/Search/FNReserves.aspx?BAND_NUMBER=298&lang=eng accessed July 27, 2016.

Figure 4. Map of St Theresa Point First Nation Reserve Lands



In 2015, INAC recorded[8] the First Nation as having 4,196 registered members, 3,904 of whom were listed as living on reserve. Virtually all of the community members live on the

[8] Indigenous and Northern Affairs Canada. "Registered Population: St Theresa Point". Government of Canada. http://pse5-esd5.ainc-inac.gc.ca/FNP/Main/Search/FNRegPopulation.aspx?BAND_NUMBER=298&lang=eng accessed July 27, 2016.

reserve land on the west shore of Island Lake, identified in the table above as “09147 St Theresa Point”.

In 2011, the Statistics Canada’s Census recorded 2,871 people living in St Theresa Point and calculated that the community had a median age of 20.1 years.[9]

St Theresa Point is not accessible by all-season road. It is accessible for approximately 6 weeks a year by winter road. The primary winter road to St Theresa Point comes from Norway House, approximately 250 km to the west.

St Theresa Point is also accessible by air through an airport located on St. Mary’s Island. Connection between the airport and the St Theresa Point community is by boat and, when available, by winter road across Island Lake.

St Theresa Point is on the main Manitoba Hydro electrical grid, which provides virtually all the heat used in the community.

Within the community, all the buildings studied are accessible by all-season gravel road.

St Theresa Point’s three reserve land areas are connected by gravel roads of uncertain passability.

[9] Statistics Canada. “NHS Profile, St. Theresa Point, IRI, Manitoba, 2011”. Government of Canada. https://www12.statcan.gc.ca/nhs-enm/2011/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=4622801&Data=Count&SearchText=&SearchType=Begins&SearchPR=01&A1=All&B1=All&Custom=&TABID=1 accessed July 27, 2016.

2 CLIMATE CHARACTERISTICS

There are many aspects of climate that could be included in this analysis.

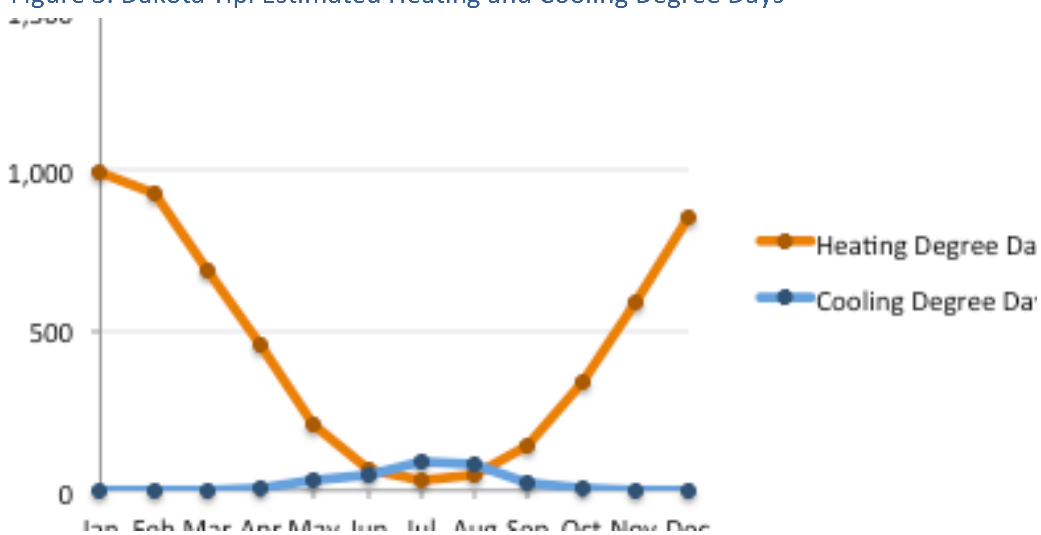
The most important variable affecting heating requirements (and therefore energy requirements and biomass supply requirements) are Heating Degree Days[10] (HDD).

The other key variable is monthly average temperature data, including the average coldest night of the month. This will determine what months of the year the Biomass District Heating System needs to be operational, and the coldest temperature at which the equipment must be operational.

2.a Dakota Tipi

The closest source of Heating and Cooling Degree Days data relevant to St. Theresa Point First Nation is the Portage La Prairie Airport's weather station (CYPG). Given that the Airport is only 5 km away from Dakota Tipi, the data can be expected to be directly applicable.

Figure 5. Dakota Tipi Estimated Heating and Cooling Degree Days[11]



[10] The website *Degree Days* (www.degreedays.net/introduction) provides a good definition of Heating Degree Days and Cooling Degree Days, and an explanation of how they are calculated. "Heating Degree Days" (HDD) are a measure of how much (in degrees), and for how long (in days), the outside air temperature was below a certain level. "Cooling Degree Days" (CDD) are a measure of how much and for how long the outside air temperature was above a certain level. HDD and CDD are commonly used in calculations relating to the energy consumption required to heat and cool buildings. The amount of heat required increases with the HDD number; the amount of air conditioning that may be required increases with the CDD number. For this report, we used the standard of 18.0°C for HDD.

[11] Data is based on the nearest weather station with available Heating and Cooling Degree Days data—CYPG at Portage La Prairie Airport. The values are the mean of three years of data—2014, 2015, and 2016—with a base temperature of 18.0°C. Source: DegreeDays (www.degreedays.net), which uses temperature data from Weather Underground (www.wunderground.com).

Table 2: Dakota Tipi Estimated Air Temperature Monthly Averages (°C)[12]

averages	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Hottest day	2	3	11	23	30	33	36	37	32	24	11	3
Daily high	-8	-5	0	12	20	25	28	29	22	12	1	-6
Daily low	-17	-15	-8	0	6	11	13	12	7	1	-6	-13
Coldest night	-30	-27	-21	-9	-3	2	6	4	-2	-8	-17	-26

[12] This is average data for the last 30 years. “Daily high" is the maximum temperature of an average day for each month over those 30 years. Likewise, "Daily low" is the average minimum temperature of an average day for each month. “Hottest day” is the average of the hottest day of each month over the last 30 years and “Coldest night” is the average of the coldest night of each month. This table shows data from Portage La Prairie Airport. Source: Meteoblue (https://www.meteoblue.com/en/weather/forecast/modelclimate/portage-la-prairie-southport-airport_canada_6296251).

2.b Sagkeeng

The closest source of Heating and Cooling Degree Days data relevant to Sagkeeng Anicinabe First Nation is the Victoria Beach Weather Station. Given that it is only 10 km away from the community, the data can be expected to be directly applicable.

Figure 6. Sagkeeng Estimated Heating and Cooling Degree Days[13]

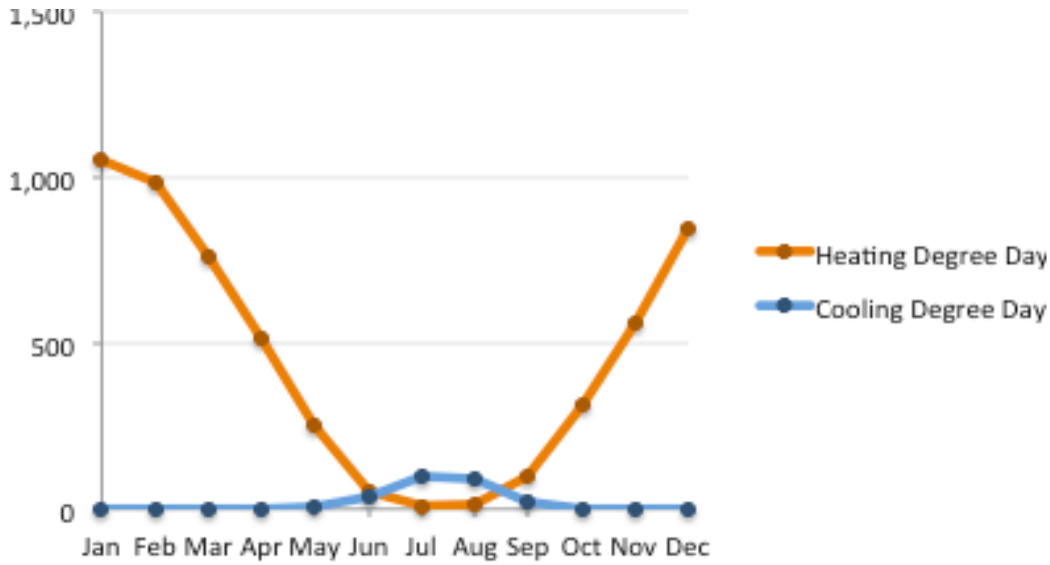


Table 3: Sagkeeng Estimated Air Temperature Monthly Averages (°C)[14]

averages	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Hottest day	1	1	9	22	29	32	34	35	30	22	10	2
Daily high	-8	-6	0	11	19	24	27	27	20	11	1	-6
Daily low	-18	-16	-9	-1	6	11	13	12	7	1	-6	-14
Coldest night	-30	-28	-24	-10	-4	2	6	3	-3	-7	-16	-26

2.c St. Theresa Point

The closest source of Heating and Cooling Degree Days data relevant to St. Theresa Point First Nation is the Island Lake Airport's weather station (CYIV). Given that it is only 15 km away from the community and that, like St. Theresa Point, the Airport is situated

[13] Data is based on the nearest weather station—CWII at Victoria Beach. The values are the mean of three years of data—2014, 2015, and 2016—with a base temperature of 18.0°C. Source: DegreeDays (www.degreedays.net), which uses temperature data from Weather Underground (www.wunderground.com).

[14] This is average data for the last 30 years. "Daily high" is the maximum temperature of an average day for each month over those 30 years. Likewise, "Daily low" is the average minimum temperature of an average day for each month. "Hottest day" is the average of the hottest day of each month over the last 30 years and "Coldest night" is the average of the coldest night of each month. This table shows data from the Victoria Beach weather station. Source: *Meteoblue* (https://www.meteoblue.com/en/weather/forecast/modelclimate/victoria-beach_canada_6174051).

immediately adjacent to Island Lake, this climate data can be expected to be directly applicable.

Figure 7. St. Theresa Point Estimated Heating and Cooling Degree Days[15]

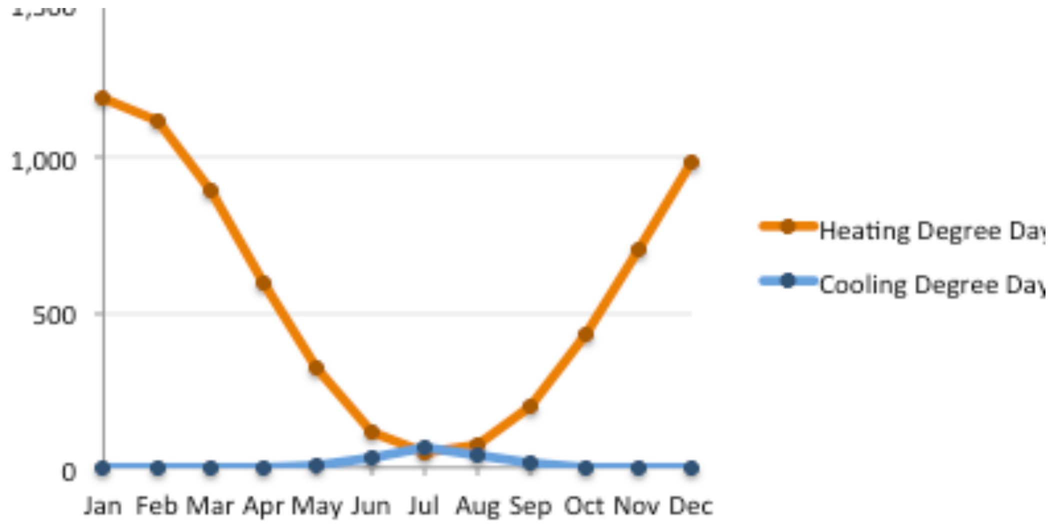


Table 4: St. Theresa Point Estimated Air Temperature Monthly Averages (°C)[16]

averages	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Hottest day	-1	-1	3	16	27	30	32	32	26	17	5	-1
Daily high	-13	-10	-4	5	15	22	25	23	16	7	-3	-10
Daily low	-24	-22	-15	-5	4	11	14	12	6	0	-10	-20
Coldest night	-37	-36	-33	-18	-7	1	7	5	-2	-8	-22	-32

15 Data is based on the nearest weather station with available Heating and Cooling Degree Days data—CYIV at Island Lake Airport. The values are the mean of three years of data—2014, 2015, and 2016—with a base temperature of 18.0°C. Source: DegreeDays (www.degreedays.net), which uses temperature data from Weather Underground (www.wunderground.com).

16 This is average data for the last 30 years. "Daily high" is the maximum temperature of an average day for each month over those 30 years. Likewise, "Daily low" is the average minimum temperature of an average day for each month. "Hottest day" is the average of the hottest day of each month over the last 30 years and "Coldest night" is the average of the coldest night of each month. This table shows data from Island Lake Airport. St. Theresa Point Airport data is available, but Island Lake Airport data is used instead, for two reasons. First, a comparison made between the St. Theresa Point Airport data and the Island Lake Airport shows that they are virtually identical. Of the 48 data points shown here, all except *one* are identical. (The only difference: The mean daily maximum for February is -10°C at the Island Lake Airport, and -9°C at the St. Theresa Point Airport.) Second, Heating and Cooling Degree days for St. Theresa Point Airport is not available from DegreeDays, and climate data for St. Theresa Point Airport is not available through RETScreen. Using Island Lake data allows for consistent data use. Source: *Meteoblue* (https://www.meteoblue.com/en/weather/forecast/modelclimate/island-lake-airport_canada_6296211).

3 ECOLOGICAL CHARACTERISTICS[17]

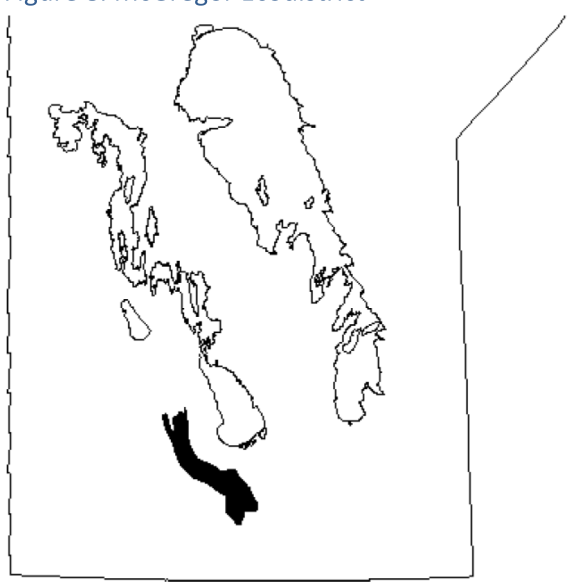
Each of the three communities studied are in different ecological zones. This was done deliberately in order to assess a cross-section of areas in Manitoba where biomass use for heat might be feasible.

3.a Dakota Tipi

Located south of the southern edge of Lake Manitoba, Dakota Tip lies within the Prairies Ecozone, which extends north from the Canada-United States border and arcs from the western edge of Alberta to eastern Manitoba. This zone comprises the northern extension of the former open grasslands of the Great Plains of North America.

Within that broad ecozone, Dakota Tipi is located within the Lake Manitoba Plain Ecoregion, and more particularly within the McGregor Ecodistrict.

Figure 8. McGregor Ecodistrict



The mean annual precipitation in this ecodistrict is approximately 500 mm, of which about one-quarter falls as snow. Precipitation varies greatly from year to year and is highest from late spring through summer.

The vegetation in this ecodistrict has been strongly modified by cultivation, with only minor areas of native vegetation remaining in an unaltered state. The native vegetation consisted of areas of tall prairie grasses, meadow grasses and sedges, interspersed with

[17] Ecological information in this section is drawn largely from Smith, R.E., *et al.* 1998. "Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, An Ecological Stratification of Manitoba's Natural Landscapes: Research Branch Technical Bulletin 1998-9E". Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada, Government of Canada. http://sis.agr.gc.ca/cansis/publications/ecostrat/provDescriptions/mbteee/mbteee_report.pdf accessed October 1, 2016.

areas of willow and stands of trembling aspen and balsam poplar with associated shrubs such as snowberry, red-osier dogwood, willow and saskatoon and associated herbs.

3.b Sagkeeng

Located southeast of the southern edge of Lake Winnipeg, Sagkeeng lies within the southern edge of the Boreal Shield Ecozone, which stretches from northern Saskatchewan to Newfoundland.

Within that broad zone, Sagkeeng is located within the Lake of the Woods Ecoregion.

Figure 9. Lake of the Woods Ecoregion

The average annual precipitation in this ecoregion ranges from about 540 to 650 mm, and varies greatly from year to year. Precipitation is highest during the growing season.

The forest cover of this ecoregion is very mixed. Bur oak, trembling aspen, red (green) ash and jack pine are common in the area in and around Sagkeeng. Red pine and eastern white pine are also present in the region.

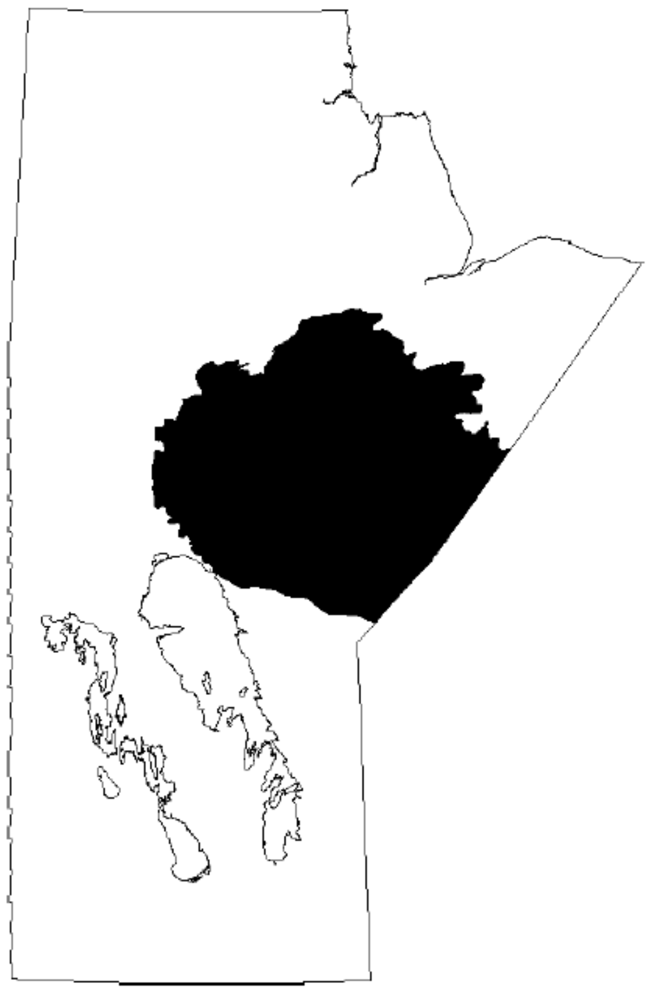
Poorly to very poorly drained sites, especially areas of shallow and deep peat, have a tree cover dominated by black spruce and/or tamarack.

3.c St. Theresa Point

St.Theresa Point lies east of the northern edge of Lake Winnipeg.The climate for ecology of the St Theresa Point area is significantly different from that of Sagkeeng.

Within that broad Boreal Shield Ecozone, St Theresa Point is located within the Hayes River Upland Ecoregion.

Figure 10. Hayes River Upland Ecoregion



The mean annual precipitation in this ecoregion ranges from 435 to 580 mm and varies greatly from year to year. Precipitation is highest during the growing season.

The ecoregion is extensively forested and the forest is dominated by medium to tall closed stands of black spruce, jack pine and some paper birch, with understories of feather moss, rock cranberry, blueberry, Labrador tea and lichen.

White spruce, balsam fir and trembling aspen occur in the warmer, moister sites in the southern sections, which include St Theresa Point lands, especially along rivers.

Black spruce is the climax species, but frequent forest fires have reduced the distribution of mature stands.

Drier sites support black spruce and/or jack pine stands with more open canopies. Bedrock exposures have few trees and are covered with lichens.

Stunted closed and open stands of black spruce with Labrador tea, blueberry, bog rosemary and sphagnum mosses form the vegetation on bogs. Sedges, brown mosses, shrubs and tamarack in varying mixtures form the dominant vegetation on fens.

4 BIOMASS CHARACTERISTICS & AVAILABILITY[18]

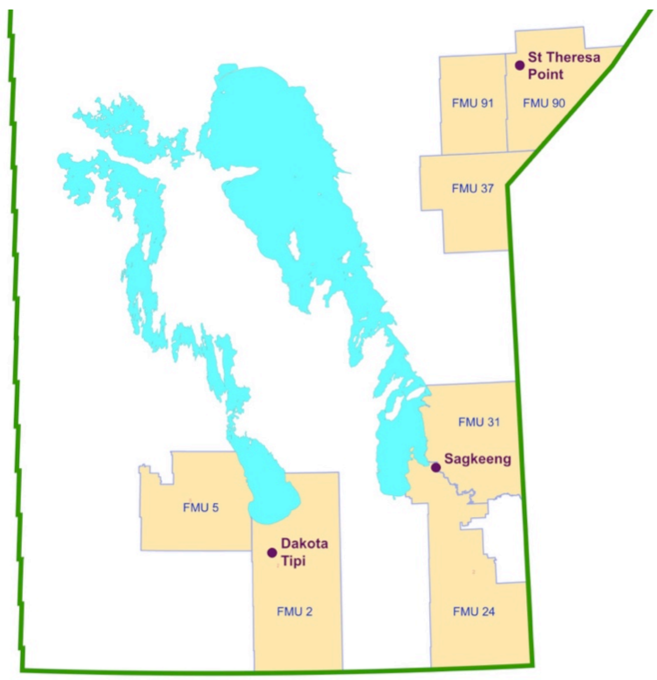
Each of these communities has biomass available in their area, although the nature and availability of that biomass varies significantly between the three regions.

To understand the biomass available, it can be helpful to distinguish between three sources:

1. **Commercial Biomass**

   - Biomass that is, or could be, available from commercial producers. This includes pellets from the agricultural industry, wood pellets derived from the forestry industry, and wood chips from the forestry industry.
   - Biomass (usually processed into wood chips) that could potentially be available from harvesting in Forest Management Units (FMUs) which are managed under forestry permits of the Forestry Branch of the Government of Manitoba.[19]

Figure 11. Relevant Forestry Management Units (FMUs)



[18] Information in this section is drawn from Smith, R.E., *et al*., from the "Biomass Inventory and Mapping Analysis Tool". Agriculture and Agri-Food Canada, Government of Canada. http://www.agr.gc.ca/atlas/bimat accessed October 1, 2016, and from direct observation.

[19] More information available at https://www.gov.mb.ca/conservation/forestry/manage/sections_fmus.html.

2. Residual Biomass

- Biomass left over from commercial processes such as farming and forestry that currently has limited commercial value, but is often recognized by the biomass industry as having potential as fuel.
- Residual biomass includes straw, stover from agriculture, and roadside and mill residue from forestry.
- The Biomass Inventory and Mapping Analysis Tool (BIMAT) captures data on this category of biomass.[20]

3. Unrealized Biomass

- Biomass that is available but is not processed for commercial purposes. Often, there is little awareness in the biomass industry or the general public that this material could be made into a viable biomass fuel.
- The primary unrealized biomass considered in this study is cattails.

4.a Dakota Tipi Biomass

The area around Dakota Tipi is predominantly farmland, growing wheat, other cereal grains, oilseeds and hay crops. There is some limited wooded area in the region. There is also extensive cattail growth in the area.

4.a.1 COMMERCIAL BIOMASS IN DAKOTA TIPI AREA

At least two types of commercial biomass is available in the Dakota Tipi area.

First, Can-Oat Milling produces oat hull pellets in Portage la Prairie, 7 km away from Dakota Tipi. Other agricultural pellets suitable for biomass are available from other locations further away in Manitoba.

Second, wood pellets are manufactured by the Prairie Pellet Company 60 km away in Elm Creek.

A third option may be available—applying for harvesting permits from FMU 2 and FMU 5. Spruce Woods Provincial Forest, which is within FMU 5, is approximately 120 km west of Dakota Tipi.

4.a.2 RESIDUAL BIOMASS IN DAKOTA TIPI AREA

The BIMAT calculates that significant agricultural residue suitable for biomass use exists in the Dakota Tipi area.

[20] "Biomass Inventory and Mapping Analysis Tool". Agriculture and Agri-Food Canada, Government of Canada. http://www.agr.gc.ca/atlas/bimat accessed October 1, 2016.

Table 5: Agricultural Biomass Available Within 30km Radius of Dakota Tipi

straw & stovers	*annual average*	*1-in-10 year low*	*1-in-20 year low*
Barley	25,130	7,420	4,395
Wheat	121,128	10,220	0
Flaxseed	7,488	1,697	952
Oats	28,706	3,414	259
Corn	0	0	0
Total	*182,451*	*22,751*	*5,606*

(All numbers given in oven-dry tonnes.)

Very little residual biomass is available in the Dakota Tipi area from the forestry industry.

Table 6: Forestry Biomass Available Within 30km Radius of Dakota Tipi[21]

straw & stovers	*annual average*
Hardwood roadside harvest residue	0
Softwood roadside harvest residue	27
Hardwood mill residue	0
Softwood mill residue	0
Urban wood waste	0
Total	*27*

(Oven-dry tonnes)

4.a.3 UNREALIZED BIOMASS IN DAKOTA TIPI AREA

The most promising type of unrealized biomass for Dakota Tipi would be from cattails, which grow abundantly along roadway ditches all around Dakota Tipi, and also proliferate in the marches south of Lake Manitoba.

4.b Sagkeeng Biomass

The area around Sagkeeng is mixed forest and farmland, with forest predominating, especially to the east.

The farmland is used for spring wheat and other cereal grains, oil seeds and hay crops. The forested areas support commercial pulpwood extraction and local sawlog forestry. There is also some significant growth of cattails and sedges in the area, although not as extensive as the area around Dakota Tipi.

[21] *Ibid.*

4.b.1 COMMERCIAL BIOMASS IN SAGKEENG AREA

It appears that no biomass fuel is produced in the agricultural sector in the Sagkeeng area so, when considering commercially-available biomass forestry biomass is more likely to be practical.

- *Forestry Management Units*

  Sagkeeng straddles FMU 31 and FMU 24.

  It is important to note that five other First Nations communities also have reserve lands within these two Forest Management Units:

  - Brokenhead Ojibway First Nation, Shoal Lake First Nation, and Buffalo Point First Nation are within FMU 24,
  - Black River First Nation and Hollow Water First Nation are also within in FMU 31.

  Harvesting of timber from either of these FMUs would require an agreement with the other First Nations communities within those FMUs, in addition to the agreement with the Province of Manitoba Forest Branch.

- *Provincial Forests*

  It is also important to note that there are three Provincial Forests within FMU 24:

  - Brightstone Sand Hills Provincial Forest begins immediately south of Sagkeeng reserve land.
  - Belair Provincial Forest begins immediately to the west of Sagkeeng reserve land.
  - Agassiz Provincial Forest begins approximately 30 km south.

  Negotiating sustainable harvesting from any one of these Provincial Forests could generate more than enough biomass for Sagkeeng's needs.

- *Burn Areas*

  An alternative that may be worth exploring for Sagkeeng is the harvest of burn areas. With rare exceptions, wood from these areas cannot be used for commercial purposes, but can often be suitable for biomass fuel.

Figure 12. Burn Areas Relevant to Sagkeeng[22]

Table 7: Burn Areas Relevant to Sagkeeng[23]

year	*fire name*	*fire size*	*approximate distance from community*
2010	-	-	85 km
2011	EA132	18,870 ha	70 km
2011	EA134	15,111 ha	125 km
2012	EA028	5,958 ha	150 km
2012	EA126	6,385 ha	95 km

These burn areas are considerably further away from the Sagkeeng community than the two nearest Provincial Forests are. Discussions with

[22] Manitoba Conservation. "Fire Mapping (Archived Data)." Government of Manitoba. http://www.gov.mb.ca/conservation/fire/Fire-Maps/index.html accessed October 2, 2016.

[23] The names and sizes of fires prior to 2011 are not archived online.

the Forestry Branch would be necessary to weigh the alternatives of harvesting from burn areas compared to harvesting from Provincial forests.

4.b.2 RESIDUAL BIOMASS IN SAGKEENG AREA

Like the Dakota Tipi area, there is significant residual biomass available in the Sagkeeng area. However, the residual biomass mix between agriculture and forestry is significantly different between the two areas.

BIMAT data indicates that there is some residual agricultural biomass available.

Table 8: Agricultural Biomass Available Within 30km Radius of Sagkeeng[24]

straw & stovers	*annual average*	*1-in-10 year low*	*1-in-20 year low*
Barley	2,062	326	174
Wheat	9,193	799	0
Flaxseed	638	85	55
Oats	3,201	333	177
Corn	0	0	0
Total	*15,095*	*1,543*	*406*
			(Oven-dry tonnes)

Although these numbers may, at first glance, seem quite large, they are less than 10% of the residual agricultural biomass available in the 30km radius around Dakota Tipi.

On the other hand, while BIMAT indicated that Dakota Tipi had only 27 tonnes of residual forestry biomass available nearby, it indicates that Sagkeeng has 10,000 tonnes available nearby.

Table 9: Forestry Biomass Available Within 30km Radius of Sagkeeng[25]

straw & stovers	*annual average*
Hardwood roadside harvest residue	0
Softwood roadside harvest residue	10,327
Hardwood mill residue	0
Softwood mill residue	0
Urban wood waste	0
Total	*10,327*
	(Oven-dry tonnes)

There is also significant residual forestry biomass being created by Manitoba Hydro as it clears wooded areas near Sagkeeng.

[24] *Ibid.*

[25] *Ibid.*

4.b.3 UNREALIZED BIOMASS IN SAGKEENG AREA

There is some unrealized biomass from cattails and sedges in the area, although not as much as around Dakota Tipi.

4.c St. Theresa Point Biomass

4.c.1 COMMERCIAL BIOMASS IN ST THERESA POINT AREA

There is no commercial biomass produced by the agricultural sector, suitable for heating, in the St Theresa Point area.

- *Forestry Management Units*

  St Theresa Point reserve land lies within FMU 37 (Mukwa Narrows), FMU 90 (primary reserve land at St Theresa Point) and FMU 91 (Cantin Lake).

  Although there is no commercial logging activity in these FMUs, there is more than enough forest biomass that could be sustainably harvested to meet the needs of St Theresa Point.

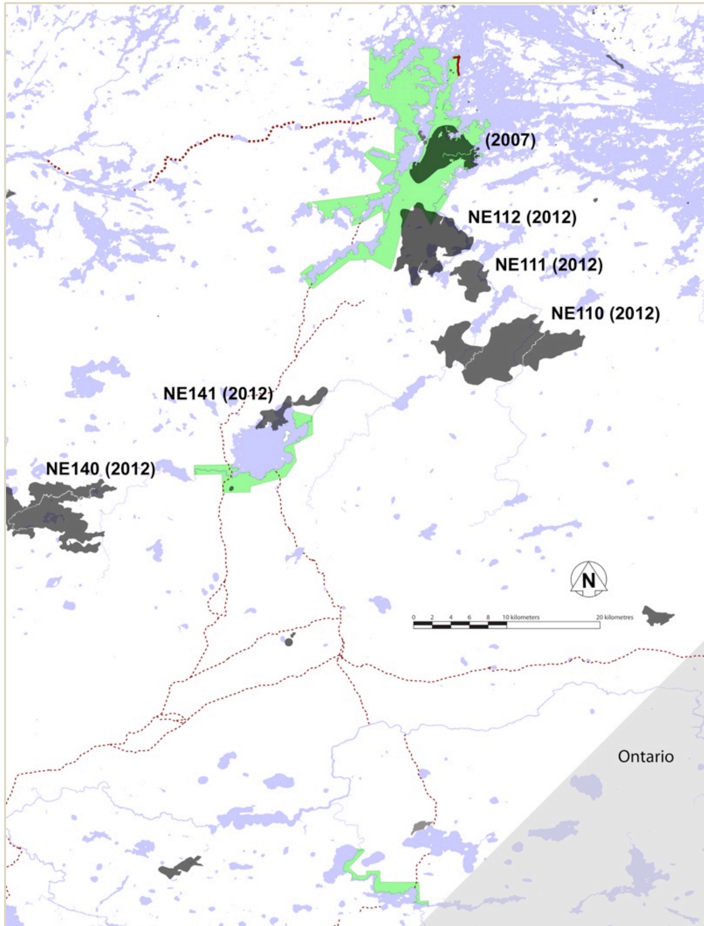
  As with Sagkeeng, it is important to note that two nearby First Nations communities also have reserve lands within two of the Forest Management Units relevant to St Theresa Point: Wasagamack First Nation and Garden Hill First Nation have reserve land within FMU 90. Wasagamack also has land on the south shore of Bigstone Lake within FMU 91.

  As with Sagkeeng, harvesting of timber from these FMUs would require an agreement with these two communities, in addition to the agreement with the Province of Manitoba Forest Branch.

- *Burn Areas*

  The most viable forestry materials for biomass in the St Theresa Point area are burn areas left behind from nearby forest fires. There have been many forest fires in the St Theresa Point area, including one in 2007 on St Theresa Point's primary reserve land (but south of the area where most people live), and a series of fires that occurred in 2012, to the south of St Theresa Point.

Figure 13. Burn Areas Relevant to St Theresa Point[26]



These burn areas are much closer to the St Theresa Point community than the burn areas near Sagkeeng are to the Sagkeeng community.

Table 10: Burn Areas Relevant to St Theresa Point[27]

year	*fire name*	*fire size*	*approximate distance from community*
2007	-	-	8 km
2012	NE112	3,933 ha	16 km
2012	NE111	1,121 ha	22 km
2012	NE110	6,228 ha	30 km

Harvesting from burnt areas would leave unburnt forests available for other potential uses. These four areas—more than 10,000 hectares all within 30 km of the St Theresa Point community—could provide abundant harvestable biomass for the community.

[26] Manitoba Conservation. *Ibid*.

[27] The names and sizes of fires prior to 2011 are not archived online.

4.c.2 RESIDUAL BIOMASS IN ST THERESA POINT AREA

The BIMAT indicates that neither agricultural biomass nor forestry biomass residues are available in the St Theresa Point area.

This does NOT mean that there is no biomass in the area.

Although the forests in the St Theresa Point area could support a properly-managed forestry harvesting, because of distance and access constraints, a commercial forestry industry does not exist in this area. Because the BIMAT calculates only commercial residue, and there is no commercial forestry in the area, it reports that there is no residue.

While there is also some potential for commercial agriculture in the area, there is currently none and, therefore, no agricultural residue.

4.c.3 UNREALIZED BIOMASS IN ST THERESA POINT AREA

There are no large, harvestable growth of cattails or sedges in the St Theresa Point area.

5 BUILDINGS CONSIDERED

One of the questions this study was tasked with answering was:

- How much electrical heat is being consumed in buildings that are clustered close enough to each other to be viable candidates for a district heating system?

In order to answer this question, it was not appropriate to examine every building—including residences—in each community. Instead, the study looked at clusters of buildings, and especially clusters of larger buildings, currently using electricity for heat.

These represent the bulk of the electricity consumed for heat in the community. Converting them to biomass heating will produce the quickest and most significant reduction in electricity consumed for heat.

As well, implementing solutions for these larger, clustered buildings to be heated with biomass creates a system that can, in later phases, be used to heat other buildings in the community—including residences—with biomass.

This second stage of heating conversion can be done either through:

- Adding additional buildings to the district heating loop(s) created for the first set of buildings, or
- Using the biomass-gathering and processing systems created to supply fuel to the set of larger buildings to provide fuel for other heating systems in the community.

  So, for example, if a system for wood harvesting is created to produce wood chips for the main buildings, some of the wood can be split and provided to smaller residential-sized heating systems.

To find out the potential for biomass heating of the larger, clustered buildings, a variety of buildings and their heating systems were examined in each community.

5.a Dakota Tipi

Of the three communities reviewed, Dakota Tipi has the fewest community buildings (four) that could be readily converted to biomass heat. Although this is a low number compared to the other reviewed communities, those four buildings include virtually all the non-residential buildings in the community.

Figure 14. Buildings Considered at Dakota Tipi

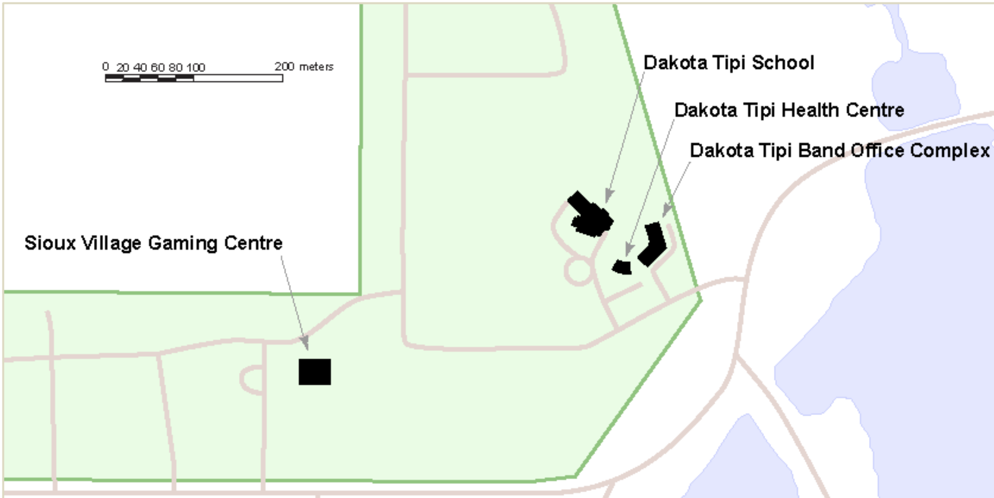


Figure 15. Dakota Tipi First Nation School

Figure 16. Dakota Tipi Health Centre

Figure 17. Dakota Tipi Band Office Complex

Figure 18. Sioux Village Gaming Centre

Table 11: Dakota Tipi – Buildings Considered – Identification[28]

	location	
building	*latitude*	*longitude*
Dakota Tipi First Nation School	49.9485	-98.3415
Dakota Tipi Health Centre	49.9478	-98.3410
Dakota Tipi Band Office Complex	49.9482	-98.3406
Sioux Village Gaming Centre	49.9468	-98.3460

Table 12: Dakota Tipi – Buildings Considered – Building Footprints[29]

	ft²	*m²*
Dakota Tipi First Nation School	13,420	1,247
Dakota Tipi Health Centre	2,304	214
Dakota Tipi Band Office Complex	7,892	733
Sioux Village Gaming Centre	10,829	1,006
totals:	*10,829*	*1,006*

Table 13: Dakota Tipi – Buildings Considered – Energy Consumed Annually for Heat

	%	
	electricity	*natural gas*
Dakota Tipi First Nation School	0%	100%
Dakota Tipi Health Centre	9%	91%
Dakota Tipi Band Office Complex	45%	55%
Sioux Village Gaming Centre	100%	0%
totals:	*33%*	*67%*

[28] Building names are derived from on-site signage and online sources. These may vary from the names assigned in Manitoba Hydro records. For example, the building designated here as "Sioux Village Gaming Centre" is designated as "Casino" in Manitoba Hydro billing records. Customer numbers and premise numbers are derived from confidential Manitoba Hydro billing records which Dakota Tipi First Nation gave permission to be shared with Aki Energy for the purposes of writing this report. This information was used to inform this report but, because it is confidential, is not included in this document. The latitude and longitude numbers are also available through Manitoba Hydro records. However, because they all verified through Google Maps, that data need not be considered confidential.

[29] Building footprint dimensions were calculated by first going on location and measuring the exterior dimensions of each building. Those numbers were checked against images from Google Earth, which were analyzed using Adobe Illustrator's measurement capabilities. Square footage—usually calculated by measuring the interior dimensions of each room—will be less. The amount by which it is less will depend on building construction and configuration, but will always be at least 10% less.

5.b Sagkeeng

Sagkeeng has more buildings than Dakota Tipi that could be heated with biomass. Fourteen were considered.

Figure 19. Buildings Considered at Sagkeeng

Figure 20. Sagkeeng Anicinabe Community School (on South Shore)

Figure 21. Water Treatment Plant

Figure 22. Office Building

Figure 23. Fort Alexander Pharmacy & Health Offices

Figure 24. Sagkeeng Gaming Centre and Band Hall

Figure 25. Sagkeeng Mino Pimatiziwin Family Treatment Centre

Figure 26. Sagkeeng Health Centre

Figure 27. Public Works Building

Figure 28. Band Office

Figure 29. St. Alexandre Catholic Church

Figure 30. Sagkeeng First Nation Arena Multiplex

Figure 31. Sagkeeng Superstore

Figure 32. Former Anicinabe Community School (on North Shore)

Figure 33. Sagkeeng Anicinabe High School (on North Shore)

Table 14: Sagkeeng – Buildings Considered – Identification[30]

	location	
building	*latitude*	*longitude*
Sagkeeng Anicinabe Community School	50.6185	-96.3628
Water Treatment Plant	50.6179	-96.3096
Office Building	50.6167	-96.3090
Fort Alexander Pharmacy & Health Offices	50.6148	-96.3101
Sagkeeng Gaming Centre and Band Hall	50.6148	-96.3119
Sagkeeng Mino Pimatiziwin Family Treatment Centre	50.6113	-96.3095
Sagkeeng Health Centre	50.6117	-96.3074
Public Works Building	50.6177	-96.3083
Band Office	50.6171	-96.3069
St. Alexandre Catholic Church	50.6157	-96.3069
Sagkeeng First Nation Arena Multiplex	50.6097	-96.2964
Sagkeeng Superstore	50.6087	-96.2955
Former Anicinabe Community School	50.6046	-96.2595
Sagkeeng Anicinabe High School	50.5991	-96.2543

[30] Building names are derived from on-site signage, the Sagkeeng Anicinabe First Nation website (http://www.sagkeeng.ca), and other online sources. These names may vary from the names assigned in Manitoba Hydro records. For example, the building designated here as "Sagkeeng Mino Pimatiziwin Family Treatment Centre" is designated as "Sagkeeng Family Treatment Centre" in Manitoba Hydro billing records. Customer numbers and premise numbers are derived from confidential Manitoba Hydro billing records which Sagkeeng Anicinabe First Nation gave permission to be shared with Aki Energy for the purposes of writing this report. This information was used to inform this report but, because they are confidential, are not included in this document. The latitude and longitude numbers are also available through Manitoba Hydro records. However, because they all verified through Google Maps, that data need not be considered confidential.

Table 15: Sagkeeng – Buildings Considered – Building Footprints[31]

	ft^2	*m^2*
Sagkeeng Anicinabe Community School	52,817	4,907
Water Treatment Plant	5,568	517
Office Building	2,987	278
Fort Alexander Pharmacy & Health Offices	6,442	598
Sagkeeng Gaming Centre and Band Hall	17,220	1,600
Sagkeeng Mino Pimatiziwin Family Treatment Centre	38,559	3,582
Sagkeeng Health Centre	14,270	1,326
Public Works Building	5,065	471
Band Office	5,472	508
St. Alexandre Catholic Church	6,557	609
Sagkeeng First Nation Arena Multiplex	42,014	3,903
Sagkeeng Superstore	2,465	229
Former Anicinabe Community School	29,494	2,740
Sagkeeng Anicinabe High School	36,495	3,391
totals:	*265,426*	*24,659*

Table 16: Sagkeeng – Estimated Energy Consumed Annually for Heat[32]

	kWh/yr	*data/estimate source*
Sagkeeng Anicinabe Community School	1,030,444	estimate
Water Treatment Plant	[confidential]	MB Hydro
Office Building	58,280	estimate
Fort Alexander Pharmacy & Health Offices	125,679	estimate
Sagkeeng Gaming Centre and Band Hall	[confidential]	MB Hydro
Sagkeeng Mino Pimatiziwin Family Treatment Centre	[confidential]	MB Hydro
Sagkeeng Health Centre	[confidential]	MB Hydro
Public Works Building	[confidential]	MB Hydro
Band Office	[confidential]	MB Hydro
St. Alexandre Catholic Church	127,923	estimate
Sagkeeng First Nation Arena Multiplex	[confidential]	MB Hydro
Sagkeeng Superstore	[confidential]	MB Hydro
Former Anicinabe Community School	575,424	estimate
Sagkeeng Anicinabe High School	712,010	estimate
total:	*4,926,325*	

[31] Building footprint dimensions were calculated by first going on location and measuring the exterior dimensions of each building. Those numbers were checked against images from Google Earth, which were analyzed using Adobe Illustrator's measurement capabilities. Square footage—usually calculated by measuring the interior dimensions of each room—will be less. The amount by which it is less will depend on building construction and configuration, but will always be at least 10% less.

[32] Confidential data from Manitoba Hydro was secured and is used to calculated total estimated energy consumption but, because this data is confidential, it is not shown here. As noted in the table, an estimate is

5.c St. Theresa Point

St Theresa Point has the largest number of community buildings that could be heated by biomass—at least two dozen.

However, because these buildings are not clustered together as tightly as they are in Dakota Tipi and Sagkeeng, creating district heating loops represents more of a challenge.

Figure 34. Buildings Considered at St. Theresa Point

There are many more non-residential buildings in St Theresa Point that could be considered for conversion to biomass than at either Dakota Tipi or Sagkeeng. What follows are photographs of a representative sample.

used when Manitoba Hydro data is not available. Based on the Heating Degree Days data, it is estimated as 210 kWh/m^2.

Figure 35. St. Theresa Point Airport

Figure 36. St. Theresa Point Airport Garage (1 of 2)

Figure 37. St. Mary Island Store (left) and Store Garage (right)

Figure 38. St. Theresa Catholic Church

Figure 39. Youth Centre

Figure 40. St. Theresa Point Little Eagles Day Care

Figure 41. Island Lake First Nations Family Services

Figure 42. Attaway Leasing Offices And Northern Store

Figure 43. RCMP

Figure 44. St. Theresa Point Ansininew Government House

Figure 45. Office Buildings (Beside Government House)

Figure 46. Adelaide McDougall Memorial Health Centre

Figure 47. Equipment Garage (Left) And Fire Hall (Right)

Figure 48. Water Truck Garage (Left) & Sewage Truck Garage (Right)

Figure 49. St. Theresa Point First Nation Water Treatment Plant

Figure 50. St. Theresa Point High School and Elementary School

Figure 51. St. Theresa Point Middle School

Figure 52. St. Theresa Point Teacherages

Table 17: St Theresa Point – Buildings Considered – Identification[33]

	location	
building	*latitude*	*longitude*
St. Theresa Point Airport	53.8440	-94.8524
St. Theresa Point Airport Garages	53.8448	-94.8512
St. Mary Island Store	53.8416	-94.8552
Store Garage	53.8419	-94.8553
St. Theresa Catholic Church	53.8333	-94.8486
Youth Centre	53.8319	-94.8496
Attaway Leasing Offices And Northern Store	53.8295	-94.8523
RCMP	53.8290	-94.8520
St. Theresa Point Little Eagles Day Care	53.8304	-94.8535
Island Lake First Nations Family Services	53.8303	-94.8541
Band Police	53.8290	-94.8542
University College of the North	53.8286	-94.8550
Community Centre	53.8285	-94.8539
Nurses' Residence	53.8173	-94.8524
Adelaide McDougall Memorial Health Centre	53.8175	-94.8511
St. Theresa Point Ansininew Government House	53.8162	-94.8517
Office Buildings	53.8158	-94.8521
Fire Hall	53.8135	-94.8549
Equipment Garage	53.8134	-94.8552
Sewage Truck Garage	53.8132	-94.8554
Water Truck Garage	53.8131	-94.8555
Sewage Treatment Plant	53.8073	-94.8581
St. Theresa Point First Nation Water Treatment Plant	53.8046	-94.8625
Teacherages	53.7830	-94.8789
St. Theresa Point High School and Elementary School	53.7801	-94.8822
St. Theresa Point Middle School	53.7801	-94.8822

[33] Building names are derived from on-site signage, the St. Theresa Point First Nation website (http://www.stpfirstnation.com), and other online sources. These names may vary from the names assigned in Manitoba Hydro records. For example, the building designated here as "Adelaide McDougall Memorial Health Centre" is designated as "Nursing Station" in Manitoba Hydro billing records. Customer numbers and premise numbers are derived from confidential Manitoba Hydro billing records which St. Theresa Point First Nation gave permission to be shared with Aki Energy for the purposes of writing this report. This information was used to inform this report but, because it is confidential, is not included in this document. The latitude and longitude numbers are also available through Manitoba Hydro records. However, because they all verified through Google Maps, that data need not be considered confidential.

Table 18: St. Theresa Point – Building Footprints[34]

	ft²	*m²*
St. Theresa Point Airport	5,672	527
St. Theresa Point Airport Garages	3,810	354
St. Mary Island Store	3,886	361
Store Garage	9,635	895
St. Theresa Catholic Church	7,814	726
Youth Centre	4,029	374
Attaway Leasing Offices And Northern Store	27,161	2,523
RCMP	1,110	103
St. Theresa Point Little Eagles Day Care	5,935	551
Island Lake First Nations Family Services	8,350	776
Band Police	5,167	480
University College of the North	3,521	327
Community Centre	3,983	370
Nurses' Residence	13,993	1300
Adelaide McDougall Memorial Health Centre	17,545	1630
St. Theresa Point Ansininew Government House	8,503	790
Office Buildings	3,018	280
Fire Hall	2,299	214
Equipment Garage	1,527	142
Sewage Truck Garage	1,906	177
Water Truck Garage	699	65
Sewage Treatment Plant	6,588	612
St. Theresa Point First Nation Water Treatment Plant	4,835	449
Teacherages[35]	11,267	1,047
St. Theresa Point High School and Elementary School	57,049	5,300
St. Theresa Point Middle School	31,215	2,900
totals:	*250,516*	*23,274*

[34] Building footprint dimensions were calculated by first going on location and measuring the exterior dimensions of each building. Those numbers were checked against images from Google Earth, which were analyzed using Adobe Illustrator's measurement capabilities. Square footage—usually calculated by measuring the interior dimensions of each room—will be less. The amount by which it is less will depend on building construction and configuration, but will always be at least 10% less.

[35] The teacherages as estimated, collectively, as 14 houses at 800 ft^2 each.

Table 19: St. Theresa Point – Estimated Energy Consumed Annually for Heat[36]

	kWh/yr	*data/estimate source*
St. Theresa Point Airport	126,459	estimate
St. Theresa Point Airport Garages	84,955	estimate
St. Mary Island Store	86,647	estimate
Store Garage	214,824	estimate
St. Theresa Catholic Church	174,220	estimate
Youth Centre	[confidential]	Mb Hydro
Attaway Leasing Offices And Northern Store	[confidential]	Mb Hydro
RCMP	24,752	estimate
St. Theresa Point Little Eagles Day Care	132,336	estimate
Island Lake First Nations Family Services	186,168	estimate
Band Police	71,160	Mb Hydro
University College of the North	78,505	estimate
Community Centre	88,800	estimate
Nurses' Residence	[confidential]	Mb Hydro
Adelaide McDougall Memorial Health Centre	[confidential]	Mb Hydro
St. Theresa Point Ansininew Government House	[confidential]	Mb Hydro
Office Buildings	67,290	estimate
Fire Hall	[confidential]	Mb Hydro
Equipment Garage	34,039	estimate
Sewage Truck Garage	[confidential]	Mb Hydro
Water Truck Garage	[confidential]	Mb Hydro
Sewage Treatment Plant	[confidential]	Mb Hydro
St. Theresa Point First Nation Water Treatment Plant	[confidential]	Mb Hydro
Teacherages	249,723	estimate
St. Theresa Point High School and Elementary School	[confidential]	Mb Hydro
St. Theresa Point Middle School	[confidential]	Mb Hydro
totals:	*4,951,335*	

[36] Confidential data from Manitoba Hydro was secured and is used to calculated total estimated energy consumption but, because this data is confidential, it is not shown here. As noted in the table, an estimate is used when Mb Hydro data is not available. Based on the Heating Degree Days data, it is estimated as 210 kWh/m^2.

6 BUILDINGS SCREENED OUT AFTER INITIAL CONSIDERATION

While all of the buildings listed in all three communities *could* be heated by biomass, some are significantly easier to convert to biomass than others.

Because some have alternative heating options available, or because they are more isolated than others, including them in biomass-based district heating loops is not recommended *at this time*. Once one or more biomass heating loops are established in a community, extending biomass heating to other buildings becomes easier.

What follows, then, is a listing of buildings considered in an initial review, and the reasons they are screened out from further consideration *at this time*.

6.a Dakota Tipi

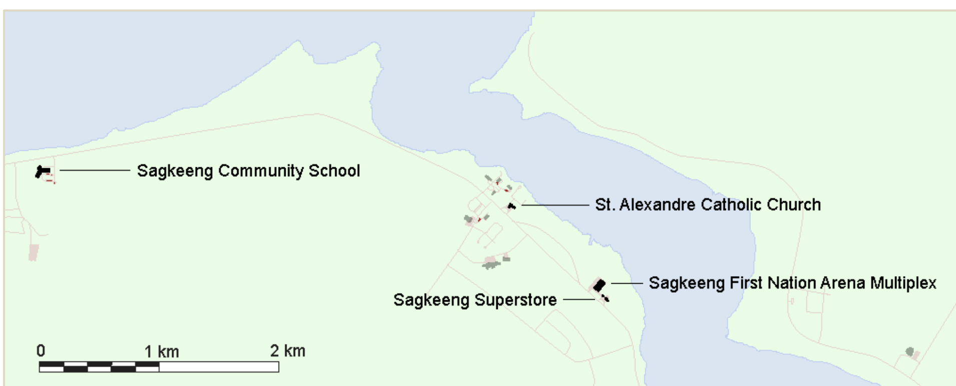
None of the four buildings at Dakota Tipi are screened out; they are all viable candidates for biomass heat and are considered in more detail in the remainder of this report.

6.b Sagkeeng

Four Sagkeeng buildings were screened out from further consideration at this time:

- Sagkeeng Community School
- St. Alexandre Catholic Church
- Sagkeeng First Nation Arena Multiplex
- Sagkeeng Superstore

Figure 53. Sagkeeng Buildings Screened Out



6.b.1 SAGKEENG COMMUNITY SCHOOL

Located on Highway 11 in the southwest area of Sagkeeng, the Sagkeeng Community School was screened out of further consideration for two reasons.

First, this School is nearly 4 km from other community buildings that could be on a biomass district loop.

Second, this School is already under active consideration by Manitoba Hydro for heating conversion.

6.b.2 ST. ALEXANDRE CATHOLIC CHURCH

St. Alexandre Catholic Church is located near a number of community buildings that could be heated on a biomass district loop and, therefore, could be included within that loop.

However, because the church is not owned by the Band, heating information for the Church was not covered under the non-disclosure agreement used for this study, and so data was not available from Manitoba Hydro.

If a biomass district loop is developed for Sagkeeng, the owner of the Church (the Archdiocese of St. Boniface) should be approached to see if they are interested in being included in the loop. They could be either a partner in the entity which owns the district heating loop (and therefore contribute a proportional share of the capital and operating costs of the system) or a customer of that entity (and therefore purchase heat from it).

6.b.3 SAGKEENG SUPERSTORE AND SAGKEENG ARENA MULTIPLEX

These two buildings were screened out of further consideration primarily because alternative heating options are available for them that should be considered first.

These two buildings both have ongoing, predictable cooling requirements—the Multiplex needs to keep its ice at a constant temperature and the Superstore needs to keep food refrigerated.

The Multiplex also has a restaurant, which will be generating recyclable heat if there is a stove hood required for the cooking area.

Both buildings will also have significant heating needs, as well as some air conditioning needs in the summer months.

Therefore, the feasibility of a heating transference system, integrating the heating and cooling production and needs of the two buildings, should be explored before biomass heating is considered.

It is plausible that a system transferring heat and cooling (perhaps supplemented with a geothermal system for heating and cooling storage to balance out seasonal needs) within and between these two buildings will meet the temperature control and air handling needs, without any need for supplemental heat.

A secondary consideration is distance. These buildings are 1 km away from other community buildings that could be on a biomass district loop. While district loops of this length are feasible, their requirements for piping insulation and pump size makes them very expensive.

6.c St. Theresa Point

A number of St. Theresa Point buildings were screened out from further consideration *at this time*:

- St. Theresa Point Airport terminal and Airport Garages
- St. Mary Island Store and Store Garage
- St. Theresa Catholic Church
- Youth Centre
- St. Theresa Point First Nation Water Treatment Plant
- St. Theresa Point Teacherages

6.c.1 ST. THERESA POINT AIRPORT TERMINAL AND AIRPORT GARAGES

The Airport complex (located just north of the reserve on St. Mary Island) was screened out of further consideration primarily because the Band does not own it. The airport complex is owned and operated by the Government of Manitoba.

The logistics of setting up a biomass district heating loop on St. Mary Island are not technically challenging, if at least one biomass district heating loop—and an entity for supplying the needed fuel—is already in operation in the St. Theresa Point community.

A loop just for St Mary Island could be quite feasible. It could take in only the airport's needs, or it could be extended to include the store (see below). Fuel sufficient for a year's needs (with a suitable allowance for a reserve) could be brought over to the island on the winter road. This fuel could be supplemented with the slash created when the brush around the landing strip is cut down.

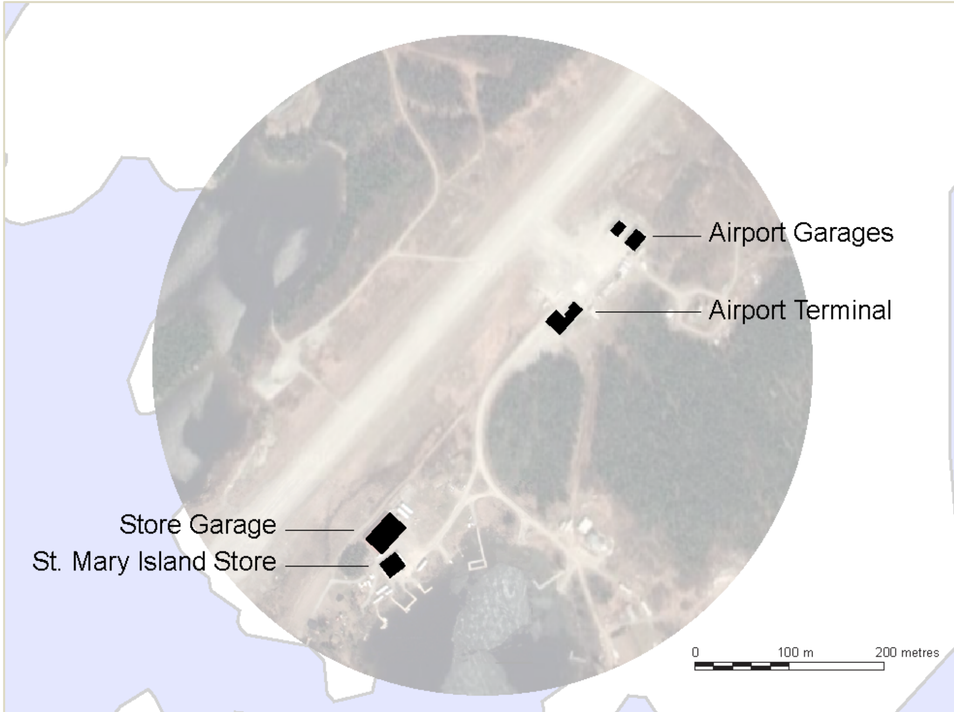
If a biomass district heating system is installed and operational in the community, the Band should begin discussions with the Government of Manitoba and propose supplying heat to the Airport buildings. An ideal time for those discussions would be when the Airport's existing electric furnace system is coming near the end of its operational life. At that point, the option of having heat supplied locally may be both logistically and financially attractive.

6.c.2 ST. MARY ISLAND STORE AND STORE GARAGE

Adding the Store (and, if desired) the Store Garage to a district-heating loop on the Island would not be difficult, provided it was done at the same time as the district loop for the airport was installed.

The terminal and the store are approximately 320 metres apart. If the biomass boiler were installed half way between them, supplying heat to both sets of buildings would be fairly straightforward.

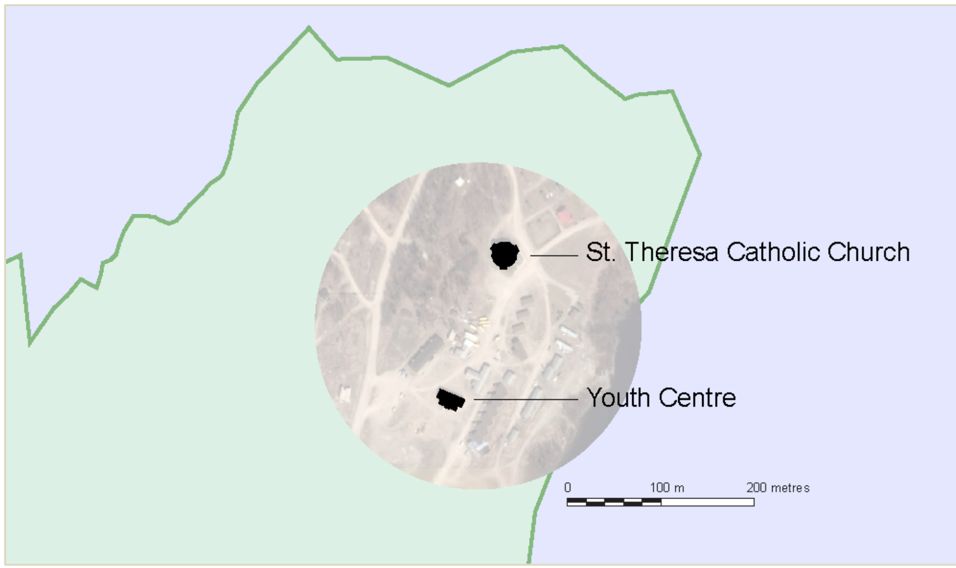
Figure 54. Screened-Out Buildings on St. Mary Island



6.c.3 ST. THERESA CATHOLIC CHURCH AND YOUTH CENTRE

St. Theresa Catholic Church was screened out because the Church (and it's Rectory) were retrofitted with geothermal heat pumps in 1999. The most recent check of these heat pumps in 2013, indicated that they were still operating well.[37]

Figure 55. Screened-Out Buildings on North Tip of Community



The Youth Centre is approximately 150 metres away from the Church. The first option for retrofitting the Youth Centre's heating system would be to consider integrating it with the Church's heating and cooling system and, if necessary, expanding the Church's geothermal field.

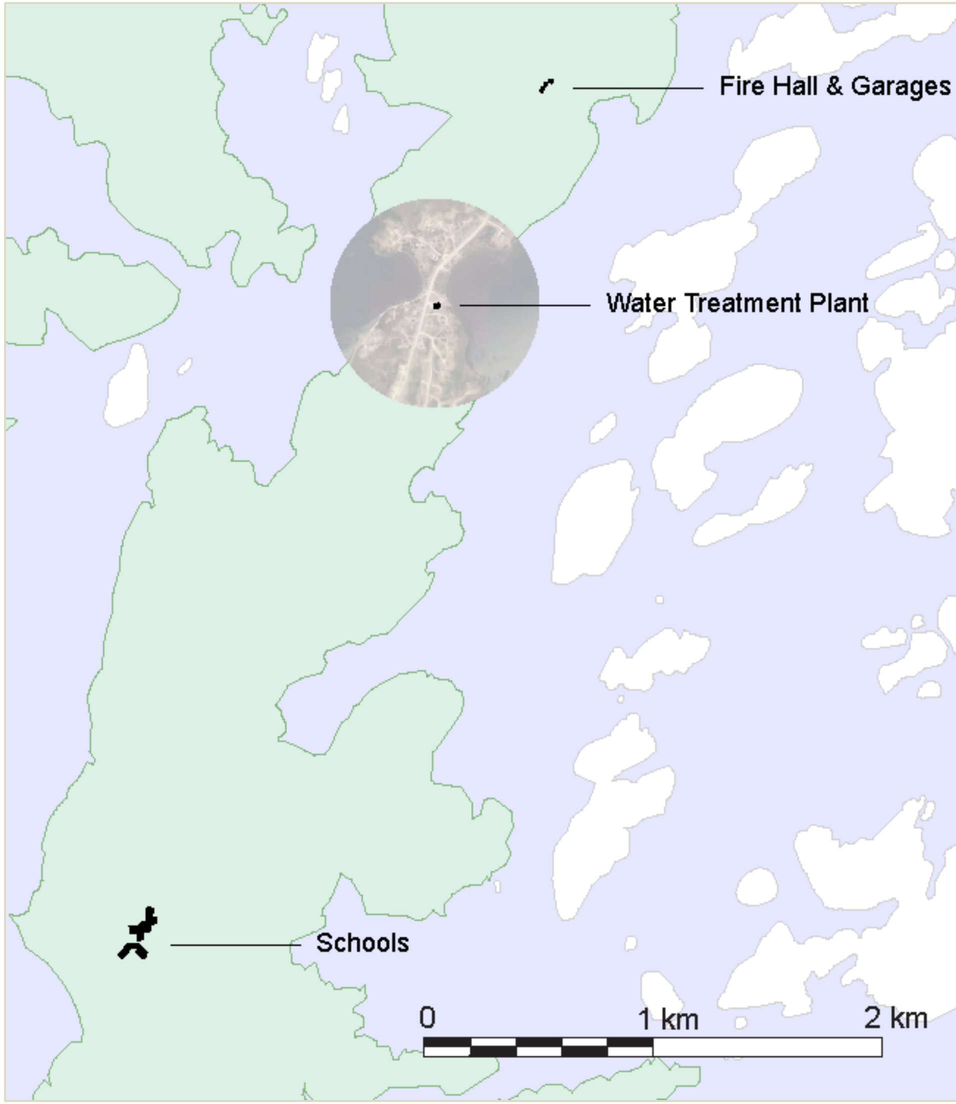
Alternatively, there are a number of buildings that have been recently moved to the area immediately around the Youth Centre, and there is multiplex housing less than 100 metres to the east of the Youth Centre. Once other biomass systems are established in the community, it may be appropriate to consider a heating system that integrates biomass and geothermal, and meets the needs of both residential and non-residential buildings in this area.

6.c.4 ST. THERESA POINT FIRST NATION WATER TREATMENT PLANT

The Water Treatment Plant was screened out because it is too far away from other community buildings to be realistically considered for a biomass heating loop. The nearest cluster of buildings—the fire hall and garages—is approximately 1 kilometre away.

[37] Manitoba Geothermal Energy Alliance. "St. Theresa Point." https://www.mgea.ca/lead_project/st-theresa-point/ accessed January 3, 2017.

Figure 56. Water Treatment Plant (Screened Out)



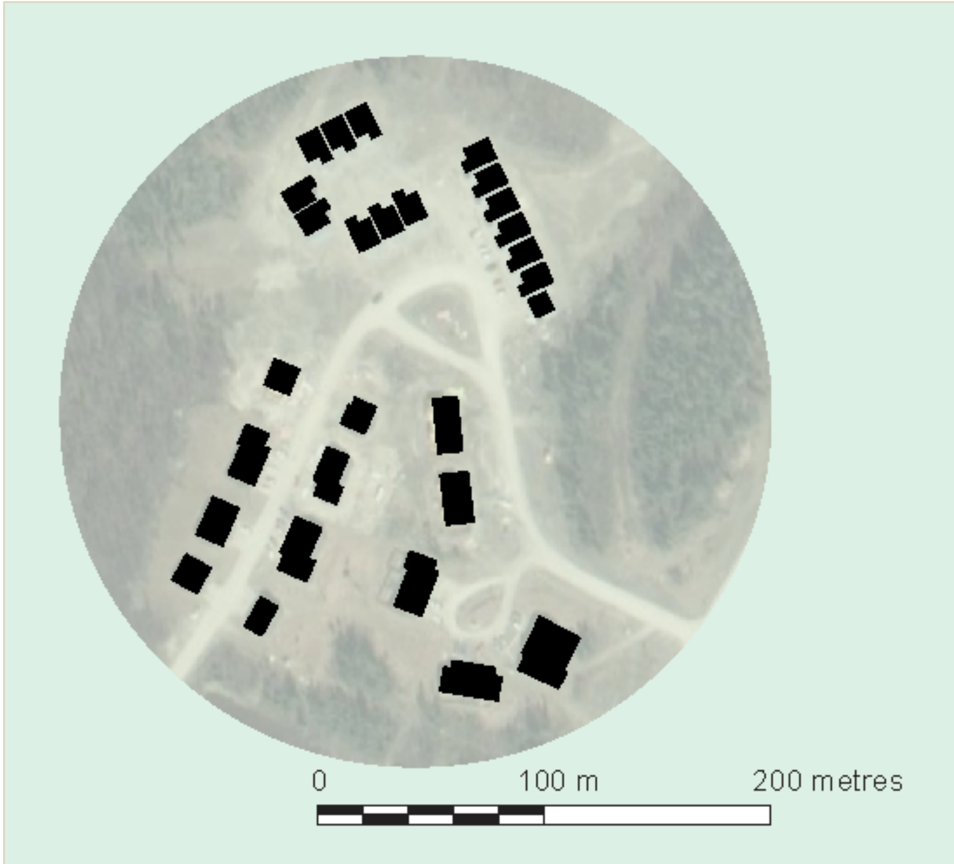
The Water Treatment Plant may be a good candidate for a geothermal system. Alternatively, once a biomass system is in operation in the community, a small, standalone boiler may be feasible for this building.

6.c.5 TEACHERAGES

The teacherages are located near the schools. If a biomass heating loop system is put in place for the schools, adding the Teacherages may best be considered as an add-on at a future stage.

In order to accommodate this potential add-on, the proposed biomass system for the Schools (below) has the potential for expansion built in.

Figure 57. Teacherages (Screened Out)



7 BUILDINGS RECOMMENDED FOR BIOMASS HEATING

7.a Dakota Tipi

All four community buildings reviewed at Dakota Tipi could be converted to biomass heating.

Table 20: Dakota Tipi – Buildings Recommended for Biomass Heating

	ft^2	*m^2*
Dakota Tipi First Nation School	13,420	1,247
Dakota Tipi Health Centre	2,304	214
Dakota Tipi Band Office Complex	7,892	733
Sioux Village Gaming Centre	10,829	1,006
totals:	*10,829*	*1,006*

The next section will detail the Biomass District Loops proposed for these buildings.

7.b Sagkeeng

Ten of the 14 community buildings reviewed at Sagkeeng are recommended for potential conversion to biomass heating. Together, these buildings represent 60% of the total footprint of the Sagkeeng Anicinabe First Nation buildings considered.

Table 21: Sagkeeng – Buildings Recommended for Biomass Heating

	ft^2	*m^2*
Water Treatment Plant	5,568	517
Office Building	2,987	278
Fort Alexander Pharmacy & Health Offices	6,442	598
Sagkeeng Gaming Centre and Band Hall	17,220	1,600
Sagkeeng Mino Pimatiziwin Family Treatment Centre	38,559	3,582
Sagkeeng Health Centre	14,270	1,326
Public Works Building	5,065	471
Band Office	5,472	508
Former Anicinabe Community School	29,494	2,740
Sagkeeng Anicinabe High School	36,495	3,391
totals:	*161,573*	*15,011*

As noted in the previous section, the four buildings not recommended for conversion to Biomass District Heating Systems at this time could be converted to biomass heating at a later date.

The next section will detail the two Biomass District Loops proposed for these buildings. Not all of these buildings would need to be (or should be) converted at once.

7.c St. Theresa Point

Seventeen community buildings reviewed at Sagkeeng are recommended for conversion to biomass heating. Together, these buildings represent just over 75% of the total footprint of the St. Theresa Point First Nation buildings considered.

Table 22: St. Theresa Point – Buildings Recommended for Biomass Heating

	ft^2	*m^2*
Attaway Leasing Offices And Northern Store	27,161	2,523
RCMP	1,110	103
St. Theresa Point Little Eagles Day Care	5,935	551
Island Lake First Nations Family Services	8,350	776
Band Police	5,167	480
University College of the North	3,521	327
Community Centre	3,983	370
Nurses' Residence	13,993	1,300
Adelaide McDougall Memorial Health Centre	17,545	1,630
St. Theresa Point Ansininew Government House	8,503	790
Office Buildings	3,018	280
Fire Hall	2,299	214
Equipment Garage	1,527	142
Sewage Truck Garage	1,906	177
Water Truck Garage	699	65
St. Theresa Point High School and Elementary School	57,049	5,300
St. Theresa Point Middle School	31,215	2,900
totals:	*192,981*	*17,929*

As noted in the previous section, most (if not all) of the buildings not recommended for conversion to Biomass District Heating Systems at this time could be converted to biomass heating at a later date.

The next section will detail the four Biomass District Loops proposed for these buildings. Not all of these buildings would need to be (or should be) converted at once.

8 BIOMASS DISTRICT HEATING SYSTEMS RECOMMENDED

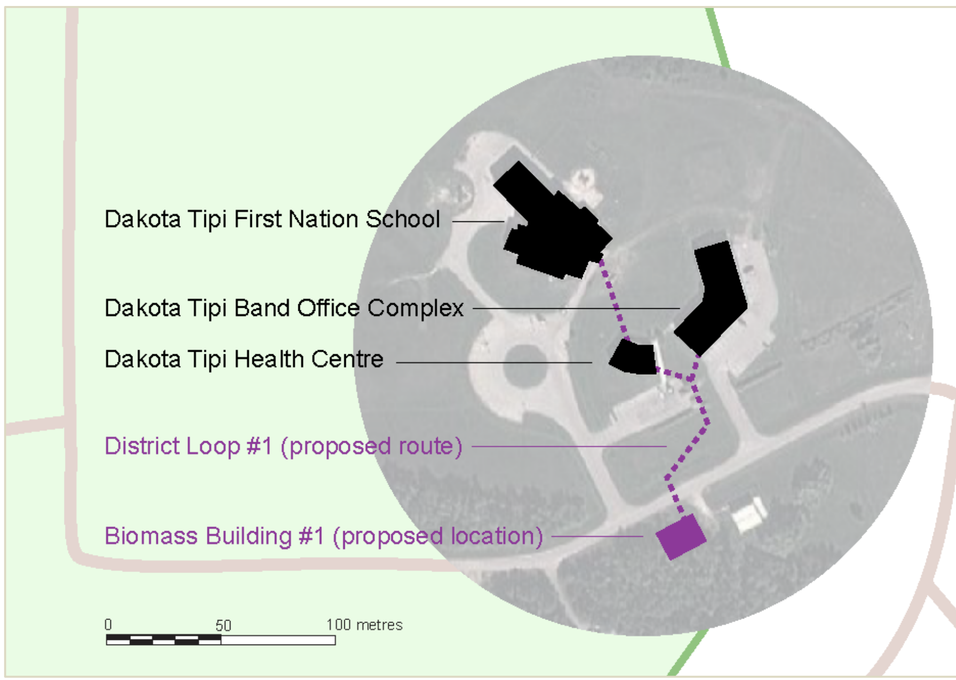
8.a Dakota Tipi

Two Biomass District Systems are proposed to serve the heating needs of the four community buildings at Dakota Tipi.

8.a.1 DAKOTA TIPI PROPOSED BIOMASS DISTRICT SYSTEM #1

The first would heat the School, Band Office Complex, and Health Centre.

Figure 58. Proposed Biomass Building #1 & District Loop #1



Biomass Building #1 would be located immediately adjacent to the existing Water Treatment Plant (the white building immediately to the right of Biomass Building #1 indicated in the figure above). The Biomass Building would be able to take advantage of the access road already in place for the Water Treatment Plant and would be accessible by Dakota St.

The proposed route for District Loop #1 would be entirely underground—travelling under Dakota St, branching to the Health Centre and Office Complex, and continuing on to the School. (Note that there are two pipes required for the all loops—a send and a return pipe—and both would be laid in the same trench.)

Table 23: Dakota Tipi District System #1 Heating Requirements

	kWh/yr
Dakota Tipi First Nation School	226,361
Dakota Tipi Health Centre	139,601
Dakota Tipi Band Office Complex	36,896
total:	*402,857*

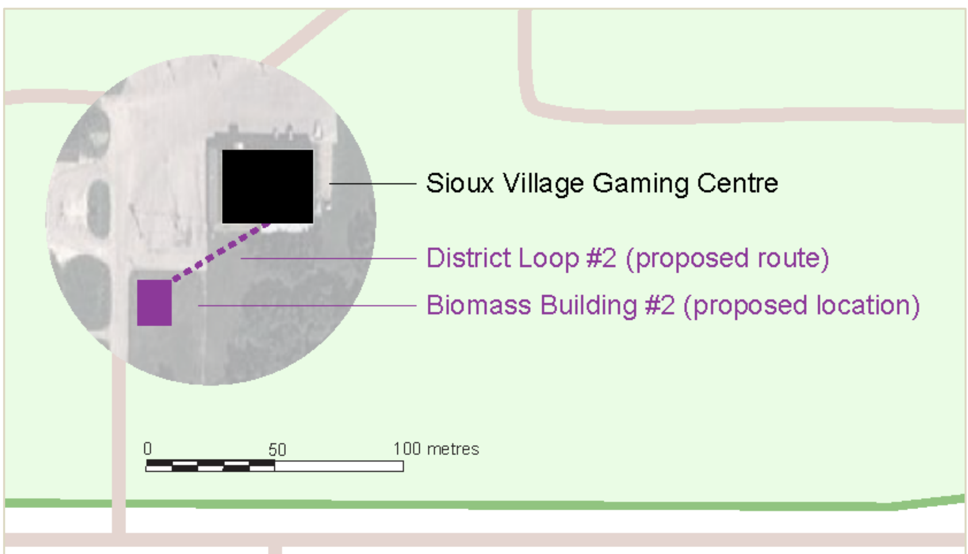
Table 24: Dakota Tipi District System #1 Loop Lengths[38]

	loop distance[39]
Dakota Tipi First Nation School	140 m
Dakota Tipi Band Office Complex	90 m
Dakota Tipi Health Centre	80 m
total loop length:	*210 m*

8.a.2 DAKOTA TIPI PROPOSED BIOMASS DISTRICT SYSTEM #2

The second biomass system would heat the Gaming Centre.

Figure 59. Proposed Biomass Building #2[40] & District Loop #2



[38] These are the estimated distances between the Biomass Boiler in Biomass Building #1 and the furnace rooms in each of the buildings. As noted earlier, because a loop requires a send and a return pipe, the total amount of underground pipe required would be approximately twice these amounts.

[39] All distances are rounded up to the nearest 10 metres.

[40] Note that neither of the Biomass Buildings are drawn to scale; they are drawn to denote location. Biomass Building #2, for example, would be significantly smaller than Biomass Building #1, because it would be heating a significantly smaller building area.

Biomass Building #2 would be located immediately adjacent to Gamblers Rd, which is accessible from Yellowquill Trail (Provincial Road 64N).

Table 25: Dakota Tipi System #2 Heating Requirements

	kWh/yr
Sioux Village Gaming Centre	154,000

Table 26: Dakota Tipi System #2 Loop Lengths

building	*loop distance*
Sioux Village Gaming Centre	60 m

This district loop could be made shorter by locating Biomass Building #2 closer to the Gambling Centre. This is not recommended because of a number of disadvantages:

- More difficulty in accessing the Biomass Building to refuel, particularly in winter, or if the Gambling Centre's parking lot is full.
- Potential concerns from the Fire Commissioner's Office (FCO) or from insurance carriers. Although biomass boilers are manufactured to strict fire standards, and the danger of fire from a biomass heating system is, if anything, less than the danger of fire from a natural gas heating system, because they are not as common in North America as they are in Europe, the FCO or an insurance carrier may express concerns about locating biomass boilers very near buildings. A distance of 50 metres between the boiler and the building should be more than sufficient to address any concerns.

8.a.3 DAKOTA TIPI BIOMASS DISTRICT SYSTEM ALTERNATIVE

Because the Dakota Tipi community is quite compact, the Gaming Centre is not that far from the proposed Biomass Building #1. It is feasible to extend Biomass District System #1 to heat the Gaming Centre as well.

Figure 60. Dakota Tipi Biomass District System Alternative

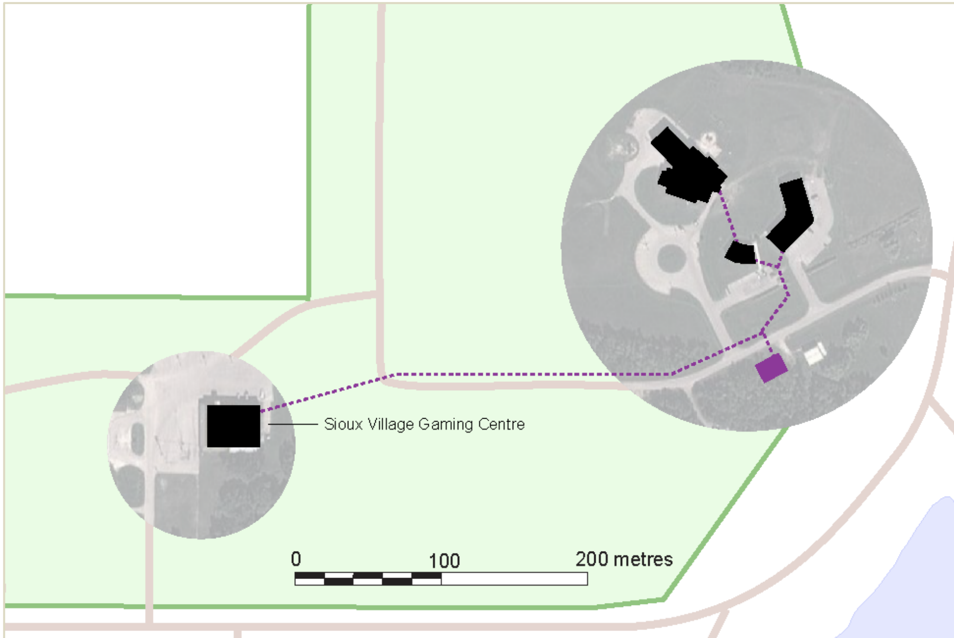


Table 27: Dakota Tipi Alternative District System Heating Requirements

	kWh/yr
Dakota Tipi First Nation School	226,361
Dakota Tipi Health Centre	139,601
Dakota Tipi Band Office Complex	36,896
Sioux Village Gaming Centre	154,000
total:	*556,857*

Table 28: Dakota Tipi Alternative District System Loop Lengths

building	*loop distance*
Dakota Tipi First Nation School	140 m
Dakota Tipi Band Office Complex	90 m
Dakota Tipi Health Centre	80 m
Sioux Village Gaming Centre	320 m
Total Loop Length:	*530 m*

While this alternative is feasible, it is not recommended at this time.

Instead, if Dakota Tipi is were to install biomass heating, it is recommended that they begin with Biomass District System #1 as proposed first, but sizing Boiler #1 to be able to accommodate the potential addition of the Gaming Centre.

After System #1 is installed and operational, Dakota Tipi could weigh the pros and cons of either adding System #2, or extending System #1. (See Proposal Section, below.)

8.b Sagkeeng

Two sets of buildings in Sagkeeng should be heated by biomass.

The first is a cluster of eight buildings in the centre of the south shore community. The second is the High School and, if it is redeveloped, the former school on the north shore.

8.b.1 PROPOSED CENTRAL SAGKEENG COMMUNITY BIOMASS SYSTEM

Figure 61. Central Sagkeeng Buildings Potentially on Biomass System

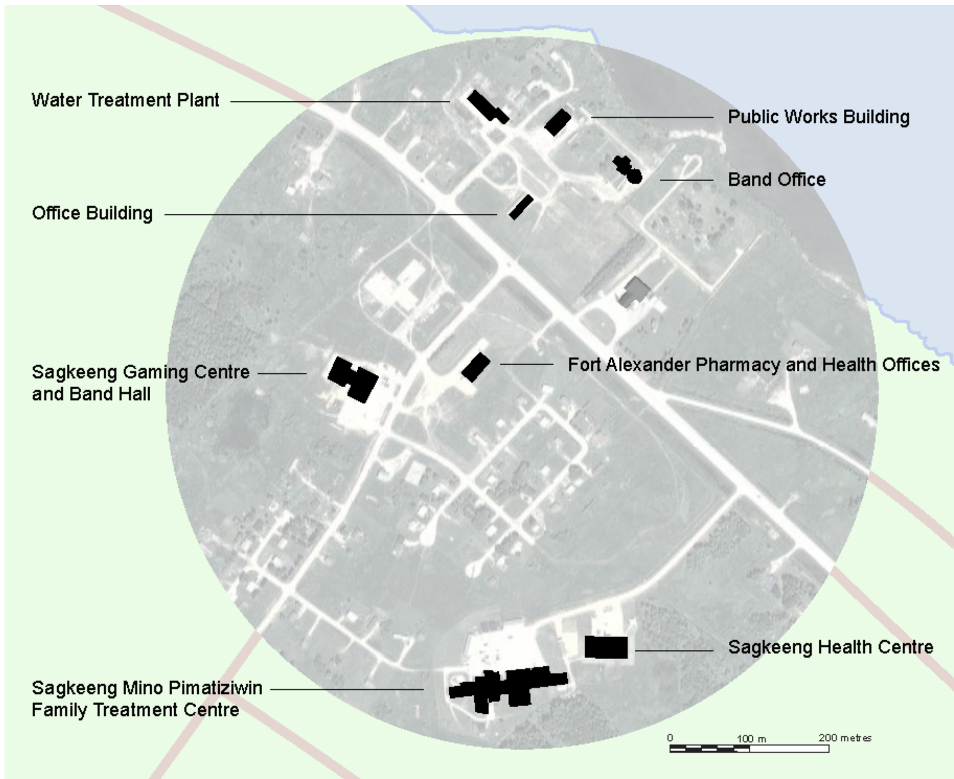
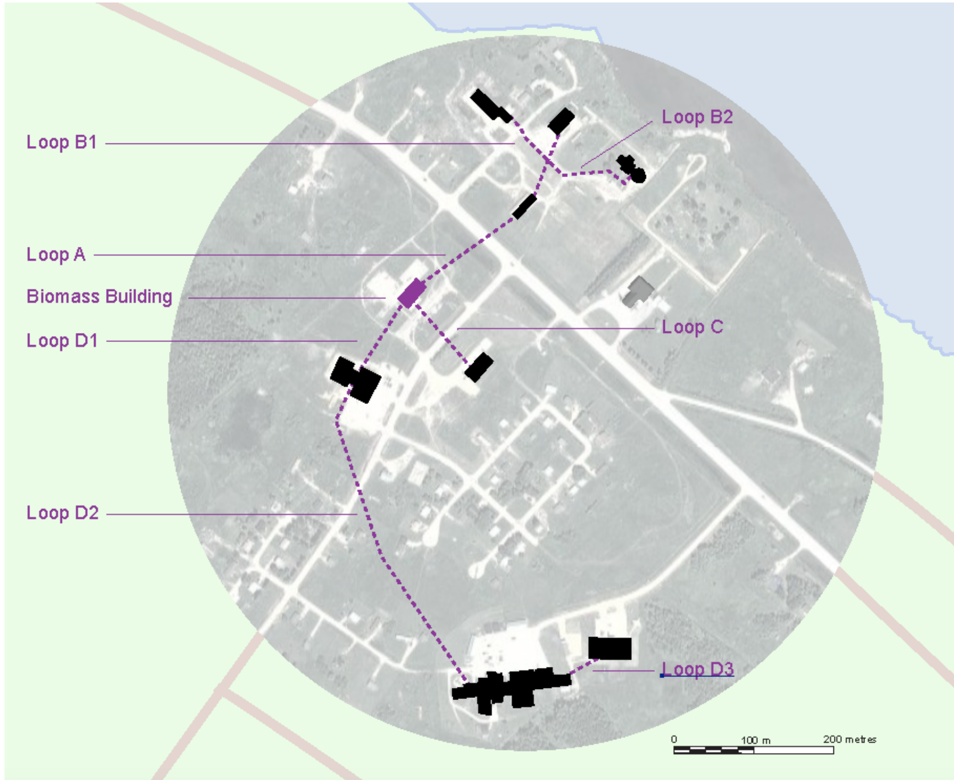


Figure 62. Proposed Central Sagkeeng Community Biomass System



All of these buildings could be served from a single Biomass Building, which would house the boiler(s), the pumps, and a supply of fuel.

Table 29: Central Sagkeeng Community District System Heating Requirements

	kWh/yr
Office Building	58,280
Public Works Building	145,480
Water Treatment Plant	246,320
Band Office	64,920
Fort Alexander Pharmacy & Health Offices	125,679
Sagkeeng Gaming Centre and Band Hall	123,714
Sagkeeng Mino Pimatiziwin Family Treatment Centre	712,827
Sagkeeng Health Centre	265,080
total:	1,742,300

It is recommended that the Biomass Building be located in the empty lot just south of Highway 11. This area has already been cleared, has good road access, and is currently unused.

Not all of the District Loops would need to be built at once. It is proposed that:

- Loop A would go under Highway 11 to the older Office Building immediately north of the Highway, and then on to the Public Works Building.

- Loop B branch off from Loop A to the Water Treatment Plant and the Band Office. Loop B could be built at the same time Loop A or could be added later.

- Loop C would go southeast under the road and connect to the Pharmacy and Health Offices building.

- Loop D would go southeast to the Gaming Centre (D1) and then on to the Treatment Centre (D2) and the Health Centre (D3). This loop could be built in stages; for example, D1 could be completed first, then D2 and then, later, D3.

Table 30: Central Sagkeeng Community District System Loops

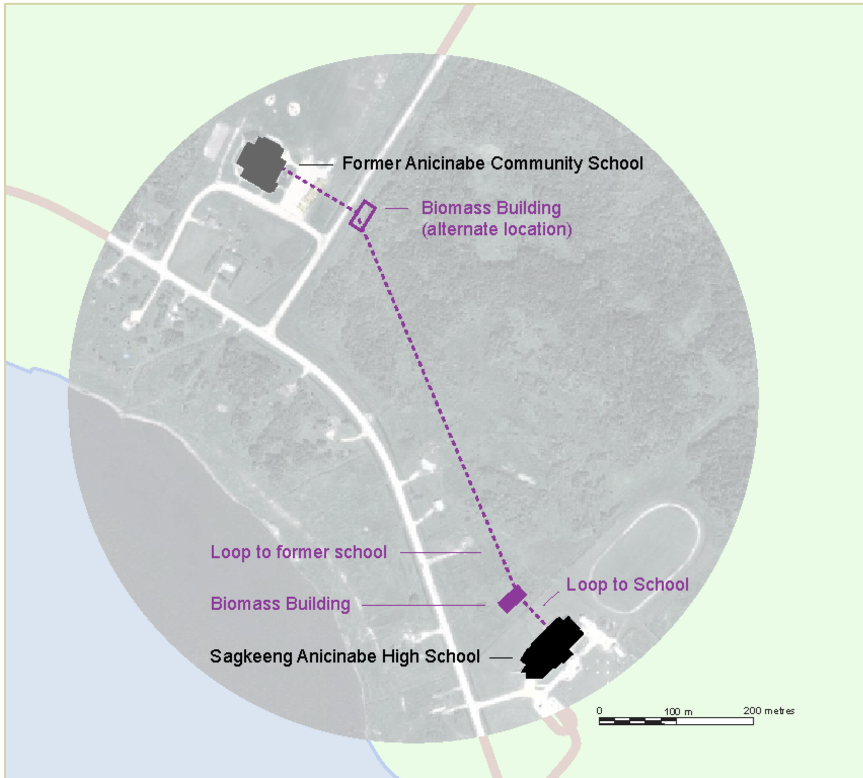
	loop		
	label	*length*[41]	*distance to boiler*[42]
Office Building	A1	170 m	170 m
Public Works Building	A2	100 m	270 m
Water Treatment Plant	B1	70 m	340 m
Band Office	B2	130 m	400 m
Fort Alexander Pharmacy & Health Offices	C	130 m	130 m
Sagkeeng Gaming Centre and Band Hall	D1	120 m	120 m
Sagkeeng Mino Pimatiziwin Family Treatment Centre	D2	500 m	720 m
Sagkeeng Health Centre	D3	140 m	860 m
total loop length:		*1,360 m*	

[41] All lengths are rounded up to the nearest 10 metres.

[42] These are the estimated distances between the Biomass Boiler in the Biomass Building and the furnace rooms in each of the buildings. As noted earlier, because a loop requires a send and a return pipe, the total amount of underground pipe required would be approximately twice these amounts.

8.b.2 PROPOSED NORTH SHORE SCHOOL BIOMASS SYSTEM

Figure 63. Potential North Shore Biomass System



This would be a much simpler biomass system to install than the one proposed for the south shore community. Perhaps it's greatest attraction is the fact that the High School is currently heated by propane. Heating it with biomass would greatly reduce (or perhaps eliminate) the reliance on propane.

Table 31: Sagkeeng North Shore District System Heating Requirements

	kWh/yr
Sagkeeng Anicinabe High School	712,010
Former Anicinabe Community School	575,424
total:	*1,287,434*

Table 32: Sagkeeng North Shore District System Loop

	loop distance
Sagkeeng Anicinabe High School	90 m[43]
Former Anicinabe Community School	680 m
total loop length:	*770 m*

Installing a Biomass System by the High School also creates the potential for heating the former Anicinabe Community School, should it be developed for use again.

One potential issue to be aware of for this Biomass System would be road access for fuel delivery. A short road (approximately 100 metres) would have to be built (and kept clear during the winter), either from the School's current roadway, or off the Northshore Road.

If this Biomass System is developed at the same time that the former Anicinabe Community School is developed, consideration should be given to locate the Biomass Building on alternate location shown in the Figure above. It would not change the total loop distances, but would simplify road access.

[43] The Biomass Building is shown set back from the School by 50 metres. As noted in the Dakota Tipi section, a setback of this distance would allay any concerns the Office of the Fire Commissioner or an insurance carrier might have. (Although, again, it's important to note that biomass is significantly less flammable than propane.) The distance from the Biomass Building's Boiler to the High School's furnace room is estimated at 90 metres, in part due to rounding up (to the nearest 10 m) and due to the fact that School's furnace room is not located on the northwest side of the building.

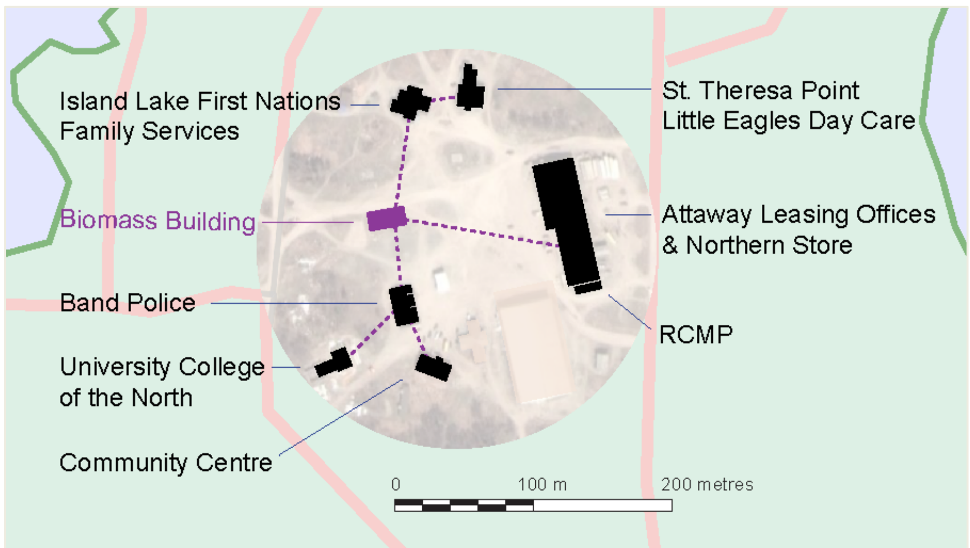
8.c St. Theresa Point

Four Biomass Systems are recommended for St. Theresa Point:

1. North Community Cluster
2. Medical & Governance Cluster
3. Fire Hall & Garages Cluster
4. Schools Cluster

8.c.1 NORTH COMMUNITY CLUSTER

Figure 64. Proposed North Community District Heating System



This Biomass System would have three underground district heating loops branching out of the Biomass Building. The North branch would go to the Family Services and Day Care buildings. The East branch would go to the Attaway building, to the Northern Store's heating and refrigeration equipment, and to the RCMP building. The South branch would go to the Band Police Building, the University College of the North, and the Community Centre.

Table 33: North Community District System Heating Requirements

	kWh/yr
Island Land First Nations Family Services	186,168
St. Theresa Point Little Eagles Day Care	132,336
Attaway Leasing Offices	94,680
Northern Store	
RCMP	24,752
Band Office	71,160
University College of the North	78,505
Community Centre	88,800
total:	*676,401*

Table 34: North Community District System Loops

	loop		
	branch	*length*[44]	*distance to boiler*[45]
Island Land First Nations Family Services	North	90 m	90 m
St. Theresa Point Little Eagles Day Care		50 m	140 m
Attaway Leasing Offices	East	140 m	140 m
Northern Store		60 m	200 m
RCMP		30 m	170 m
Band Office	South	70 m	70 m
University College of the North		60 m	130 m
Community Centre		50 m	120 m
	total loop length:	*550 m*	

This entire system could be built together, each branch could be built at a different time, and even each extension of each could branch could be built at different times.

So, for example, the East branch could initially go only to the Attaway Leasing Offices. If and when the First Nation (or an entity the First Nation owned) negotiated an agreement with the Northern Store to sell them heat and refrigeration services, that portion of the East branch could be added. Similarly, if and when an agreement was reached with the RCMP to provide them with heat, that portion of the East branch could be added.

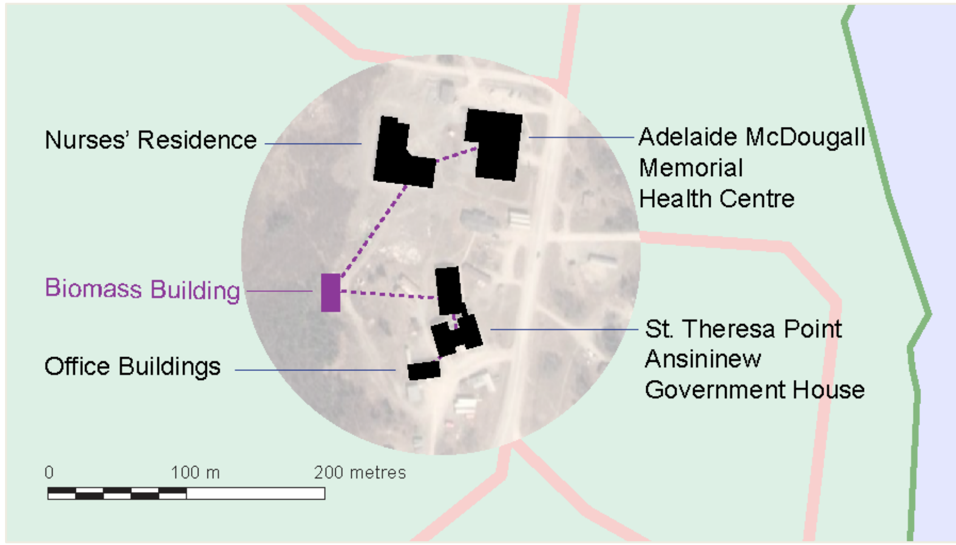
In order for this sort of step-by-step installation to occur, the biomass boiler, pumps, and piping all need to be sized to meet the needs of all of these buildings.

[44] All lengths are rounded up to the nearest 10 metres.

[45] These are the estimated distances between the Biomass Boiler in the Biomass Building and the furnace rooms in each of the buildings. As noted earlier, because a loop requires a send and a return pipe, the total amount of underground pipe required would be approximately twice these amounts.

8.c.2 MEDICAL & GOVERNANCE CLUSTER

Figure 65. Proposed Medical & Governance District Heating System



This Biomass System would have two underground district heating loops branching out of the Biomass Building. The North branch would go to the Nurses' Residence and Adelaide McDougall Memorial Health Centre. The East branch would go to the St. Theresa Point Ansininew Government House and to the Office Buildings immediately south of them.

Table 35: Medical & Governance District System Heating Requirements

	kWh/yr
Nurses' Residence	120,720
Adelaide McDougall Memorial Health Centre	330,240
St. Theresa Point Ansininew Government House	260,880
Office Buildings	67,290
total:	*779,130*

Table 36: Medical & Governance District System Loops

	loop		
	branch	*length*	*distance to boiler*
Nurses' Residence	North	110 m	110 m
Adelaide McDougall Memorial Health Centre		70 m	180 m
St. Theresa Point Ansininew Government House	East	120 m	120 m
Office Buildings		40 m	160 m
total loop length:		*340 m*	

As with the North Community District System, the entire system could be built together, or each branch could be built at a different time, or even each extension of each could branch could be built at different times.

So, for example, it may be preferable to build the East branch (to Government House and the Office Buildings) first, and then to negotiate selling heat to the Nurses' Residence and the Health Centre.

8.c.3 FIRE HALL & GARAGES CLUSTER

Figure 66. Proposed Fire Hall & Garages District Heating System

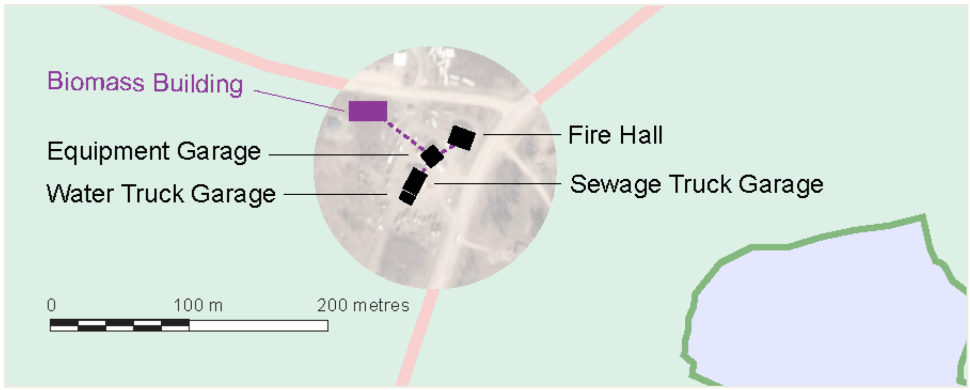


Table 37: Fire Hall & Garages District System Heating Requirements

	kWh/yr
Equipment Garage	34,039
Sewage Truck Garage	123,920
Water Truck Garage	110,400
Fire Hall	114,817
total:	*383,176*

This District System would have a single underground heating loop coming from the Biomass Building to the Equipment Garage. The loop would then branch to the other garages and the Fire Hall.

Table 38: Fire Hall & Garages District System Loop

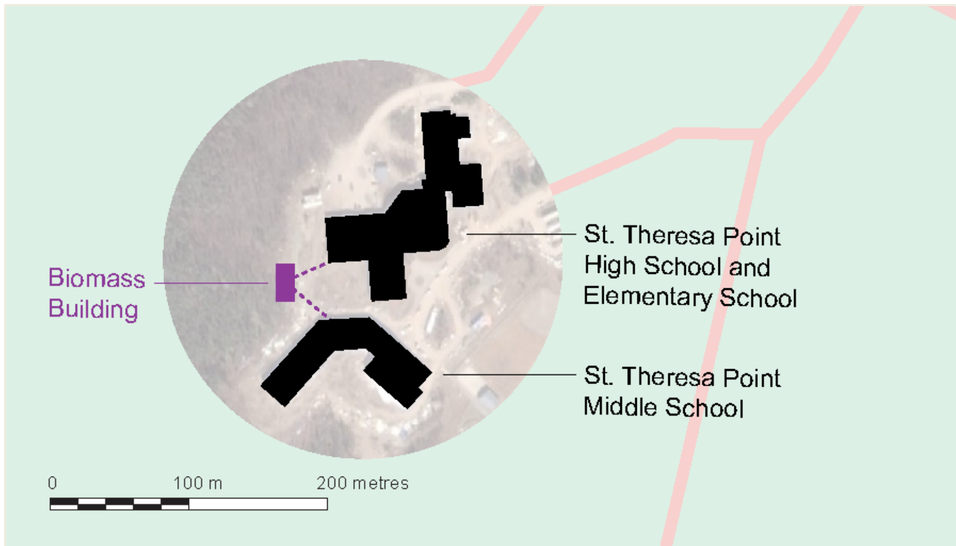
	loop	
	length	*distance to boiler*
Equipment Garage	50 m	50 m
Sewage Truck Garage	20 m	70 m
Water Truck Garage	20 m	90 m
Fire Hall	30 m	80 m
total loop length:	*120 m*	

The Fire Hall has a used-oil heater in it so, if there is sufficient used oil in the community to meet this building's heating needs there may not be much benefit to adding the branch to the Fire Hall to this District System. If, on the other hand, there is not sufficient used oil, having the District System go to this building will be crucial for community safety, as the Fire Trucks need to be thawed and dried in winter after they attend a fire.

Consideration should also be given to combining this system with the Medical & Governance District System noted above. The closest building in this cluster (the Fire Hall) is 320 metres south of the Biomass Building proposed for that cluster.

8.c.4 SCHOOLS CLUSTER

Figure 67. Proposed Schools District Heating System



The location shown above has the shortest loop requirements—approximately 50 metres to each building and a maximum of 100 metres to each building's furnace room.

If this location for the Biomass Building proves to be a problem (or if the teacherages are to be included in the Schools District Heating System) a location just to the north of the High School on the service road behind the schools may be more practical. This will not change the length of the loop to the High School and Elementary School's furnace heating systems, but will increase the distance to the Middle School by approximately 100 metres.

Table 39: Schools District System Heating Requirements

	kWh/yr
St. Theresa Point High School and Elementary School	1,213,729
St. Theresa Point Middle School	538,200
total:	*1,751,929*

Table 40: Schools District System Loops

	loop	
	length	*distance to boiler*
St. Theresa Point High School and Elementary School	100 m	100 m
St. Theresa Point Middle School	100 m	100 m
total loop length:	*200 m*	

9 RETSCREEN ANALYSES

A RETScreen analysis was done on every District System proposed in this study—2 for Dakota Tipi, 2 for Sagkeeng, and 4 for St. Theresa Point.

The heating energy required (calculated in W/m2) was entered for each building in each system to match the measured or estimated heating requirements (in kWh/year) for that building, as estimated in the previous section.

This analysis generated estimates on the required capacity of each Biomass Boiler and District System, as well as an estimate on the projected annual fuel consumption for each System.

A summary of those estimates is listed below. Appendices showing the results of the RETScreen analyses for each District System is included as appendices to this report.

9.a Dakota Tipi

Table 41: Dakota Tipi - RETScreen Results

	Heating Requirements	*Recommended Minimum System Capacity*	*RETScreen Estimated Fuel Consumption*	*Appendix*
System #1 (School & Offices)	403 mWh/yr	330 kW	98 tonnes/yr	5
System #2 (Gaming Centre)	155 mWh/yr	140 kW	38 tonnes/yr	6
total:	*558 mWh/yr*	*470 kW*	*136 tonnes/yr*	

9.a.1 ASSESSMENT OF RETSCREEN RESULTS

The RETScreen analysis for Dakota Tipi System #1 may not provide entirely accurate estimates.

This is not the fault of the RETScreen calculations; the available energy use data may be inaccurate. The primary concern is the energy data available for the School may well be low—particularly the capacity requirement estimate.

A secondary concern is the heating load estimate for the Medical Centre seems very high—257 W/m^2, while the heating load estimate for the Band Office Complex seems low—20 W/m^2. The concerns regarding Medical Centre and Band Office estimates are not as serious as those for the School, for two reasons. First, they can be expected to offset each other. Second, they are a smaller portion of the heating load on System #1 than the School.

If System #1 proceeds to a feasibility stage, a review of the original engineering plans for the School's heating system, as well as a multi-year review of natural gas consumption by the School will be required.

The estimates given in the next section round off and add 70% to the RETScreen estimates for System #1 to account for this uncertainty.

The results for System #2 contain less uncertainty than that for System #1. The estimates given in the next section round off and add 20% to the RETScreen analysis, primarily because estimating high has fewer design, capital and operational cost consequences than estimating low. [46]

9.b Sagkeeng

Table 42: Sagkeeng - RETScreen Results

	Heating Requirements	*Recommended Minimum System Capacity*	*RETScreen Estimated Fuel Consumption*	*Appendix*
Community Centre System	1,742 mWh/yr	1,300 kW	423 tonnes/yr	7
Schools System	1,287 mWh/yr	900 kW	313 tonnes/yr	8
total:	*3,029 mWh/yr*	*2,200 kW*	*736 tonnes/yr*	

9.b.1 ASSESSMENT OF RETSCREEN RESULTS

The RETScreen results for these two systems can be considered moderately accurate.

The data for energy use for individual buildings on the Community Centre System may be somewhat problematic. For example, the Water Treatment Plant heating load estimate appears to be high (177 W/m^2) while that for the Gaming Centre is unusually low (28 W/m^2). However, the aggregate estimate can be expected to be more accurate than the estimates for individual buildings, as the heating loads average out when they are combined. Nonetheless, uncertainty remains.

The estimates given in the next section round off and add 30% to the RETScreen estimates to account for this uncertainty.

The results for the Schools System contains significant unavoidable uncertainty, because we do not know at this time if the former Community School will be rebuilt. The estimates given in the next section round off and add 50% to the RETScreen estimates to account for this uncertainty.

[46] If 20% less fuel is used than estimated, for example, there are few concerns. If 20% more fuel is used than estimated, the storage bins may have been sized too small, and more frequent deliveries are required, driving up costs. More importantly, if the boiler and piping equipment is 20% oversized, the capital costs will not be as significant as if they are 20% undersized. In the worst case scenario, undersized equipment will have to be replaced. Oversizing also builds in a buffer for adding buildings to a District System without having to rebuild the system.

9.c St. Theresa Point

Table 43: St. Theresa Point - RETScreen Results

	Heating Requirements	*Recommended Minimum System Capacity*	*RETScreen Estimated Fuel Consumption*	*Appendix*
North Community System	676 mWh/yr	600 kW	164 tonnes/yr	9
Medical & Governance System	779 mWh/yr	630 kW	191 tonnes/yr	10
Fire Hall & Garages System	383 mWh/yr	300 kW	93 tonnes/yr	11
Schools System	1,752 mWh/yr	1,300 kW	426 tonnes/yr	12
total:	3,591 *mWh/yr*	*2,830 kW*	*874 tonnes/yr*	

9.c.1 ASSESSMENT OF RETSCREEN RESULTS

The RETScreen results for these systems can be considered to be moderately accurate. Because every District System proposed has multiple buildings, inaccuracies in individual building estimates can be expected to average out.

The estimates given in the next section round off and add 20% to the RETScreen analysis for three of the Systems proposed for St. Theresa Point, primarily because estimating high has fewer design, capital and operational cost consequences than estimating low. The estimate given in the next section adds 30% for the fourth System (the Schools System) to enable ease of expansion of the System to the teacherages. [47]

[47] If 20% less fuel is used than estimated, for example, there are few concerns. If 20% more fuel is used than estimated, fuel storage may have been sized too small, and more frequent deliveries are required, driving up costs. More importantly, if the boiler and piping equipment is 20% oversized, the capital costs will not be as significant as if they are 20% undersized. In the worst case scenario, undersized equipment will have to be replaced. Oversizing also builds in a buffer for adding buildings to a District System without having to rebuild the system.

10 ESTIMATED HEATING, SYSTEM & FUEL REQUIREMENTS & RECOMMENDATIONS

10.a Dakota Tipi

Table 44: Dakota Tipi – System Estimates & Recommendations

	Estimated Heating Requirements	*Recommended Minimum System Capacity*	*Estimated Fuel Consumption*
System #1 (School & Offices)	690 mWh/yr	560 kW	170 tonnes/yr
System #2 (Gaming Centre)	190 mWh/yr	170 kW	50 tonnes/yr
total:	880 mWh/yr	730 kW	220 *tonnes/yr*

10.b Sagkeeng

Table 45: Sagkeeng – System Estimates & Recommendations

	Estimated Heating Requirements	*Recommended Minimum System Capacity*	*Estimated Fuel Consumption*
Community Centre System	2,300 mWh/yr	1,700 kW	500 tonnes/yr
Schools System	1,900 mWh/yr	1,400 kW	500 tonnes/yr
total:	*4,200 mWh/yr*	*3,100 kW*	*1,000 tonnes/yr*

10.c St. Theresa Point

Table 46: St. Theresa Point – System Estimates & Recommendations

	Estimated Heating Requirements	*Recommended Minimum System Capacity*	*Estimated Fuel Consumption*
North Community System	800 mWh/yr	700 kW	200 tonnes/yr
Medical & Governance System	900 mWh/yr	800 kW	200 tonnes/yr
Fire Hall & Garages System	500 mWh/yr	400 kW	100 tonnes/yr
Schools System	2,300 mWh/yr	1,700 kW	600 tonnes/yr
total:	*4,500 mWh/yr*	*3,600 kW*	*1,100 tonnes/yr*

11 TYPICAL BIOMASS DISTRICT HEATING SYSTEM LAYOUT

Most Biomass District Heating Systems have similar layouts:

- A biomass boiler housed in a Biomass Building. The boiler burns the biomass and heats the water/glycol fluid.
- A system for storing and handling the fuel—usually either a walking floor within the Biomass Building or bins right beside it.
- In some cases, a buffer tank to store the heated water/glycol fluid to maintain even burn temperatures.
- Underground, insulated piping that transports the heated fluid from the Biomass Building to the buildings to be heated (“send” lines), paired with piping that transports the fluid back to the Biomass Building to be heated up again (“return”) lines.
- Either:
  - Radiators within the buildings to distribute the heat from the fluid throughout the buildings, or
  - Tie-ins from the District Heating System piping into buildings’ existing heating systems.
- Thermostats and monitoring systems to ensure that all the equipment is operating properly, and the heat in the buildings is the temperature its occupants want it to be.

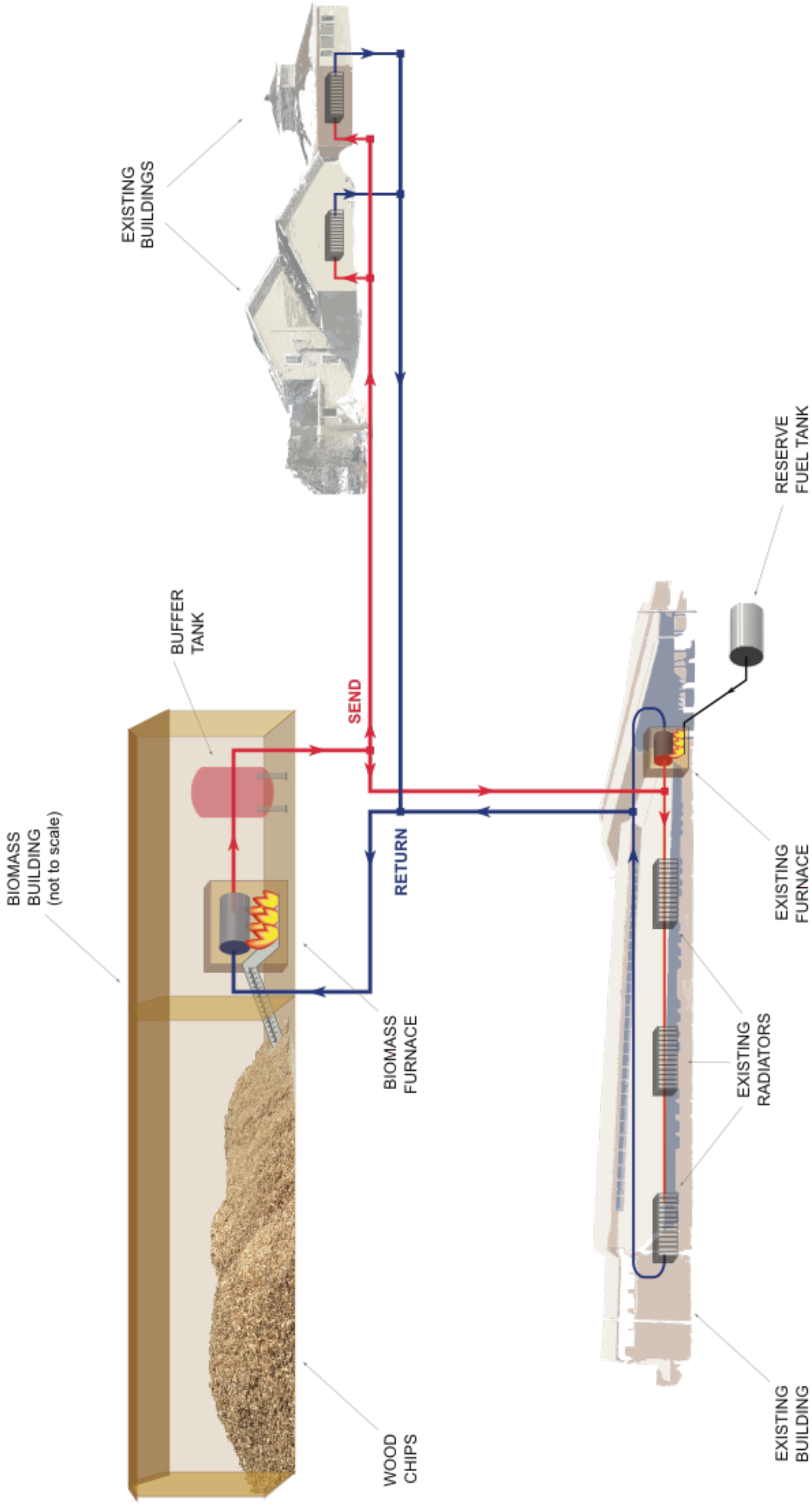
The following figure shows a typical layout to heat two building clusters. As many buildings as required can be added to a system like this.

The figure shows wood chips stored on a walking floor inside the biomass building, and fed into the biomass boiler using an auger system. This is a typical arrangement for larger systems, and for systems using wood chips. Systems using pellets typically have bins for storage.

The building on the right has the District Heating System heating the building directly.

The building at the bottom has the District Heating System tied into the building’s existing heating system. In this arrangement, the building’s current heating system remains in place as a backup.

Figure 68. Biomass District Heating System Schematic – Typical Components



12 TYPICAL EQUIPMENT

There is a broad range of choices of biomass equipment available for the Biomass District Heating Systems recommended in this Study.[48]

12.a Biomass Boilers

At the heart of each District System is a biomass boiler. It burns the biomass and heats the water that circulates through the underground piping to each building.

The boilers shown below are *not* specific recommendations for each First Nation or each District System. Instead, they are shown to give a sense of the types of equipment available to meet the capacity requirements.

Even though more than one manufacturer's product is shown for each First Nation, it is *not* recommended that a First Nation use more than one manufacturer's products. Using the same manufacturer for all the biomass systems in a single First Nation reduces training, operating and maintenance costs.

[48] Inclusion of a manufacturer or product in this section does *not* mean Aki Energy, Boke Consulting or DLF Consulting is endorsing that manufacturer or product. Similarly, omission of a manufacturer or product in this section does *not* mean Aki Energy, Boke Consulting, or DLF Consulting has concerns regarding that manufacturer or product.

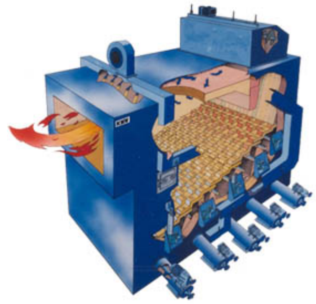
Table 47: Sample Biomass Boiler Options for Dakota Tipi District Systems

	Recommended Minimum System Capacity	*Potential Systems*
System #1 (School & Offices)	560 kW	 Hoval STU[49]
System #2 (Gaming Centre)	170 kW	 Veissmann Vitoflex KRT-220[50]

[49] http://www.hoval.co.uk/products/

[50] http://www.viessmann.ca/en/commercial/biomass-boilers/wood-boilers/vitoflex_300-rf.html

Table 48: Sample Biomass Boiler Options for Sagkeeng District Systems

	Recommended Minimum System Capacity	*Potential Systems*
Community Centre System	1,700 kW	 KMW Systems[51]  Wellons FEI[52]
Schools System	1,400 kW	 Blue Flame Stoker [53]

[51] http://www.kmwsystems.com/solutions/how-it-works/index.html

[52] http://www.wellonsfei.ca/en/wood-fired-boiler-burning-chip.aspx

[53] http://blueflamestoker.com/products/

Table 49: Sample Biomass Boiler Options for St. Theresa Point District Systems

	Recommended Minimum System Capacity	*Potential Systems*
North Community System	700 kW	 Froling Lambdamat 750[54]
Medical & Governance System	800 kW	 SIM Enterprises[55]
Fire Hall & Garages System	400 kW	 ETA HACK VR 333 - 500[56]
Schools System	1,700 kW	 Kohlbach[57]

[54] http://www.froeling.com/fileadmin/content/produkte/downloads/EN/EN_Prospekt_Lambdamat.pdf

[55] http://www.simenterprisesltd.com/products/industrial/index.html

[56] http://strefa.lt/en/granulinis-katilas-eta-hack-vr-333-350-kw-5/

12.b Fuel Storage and Handling

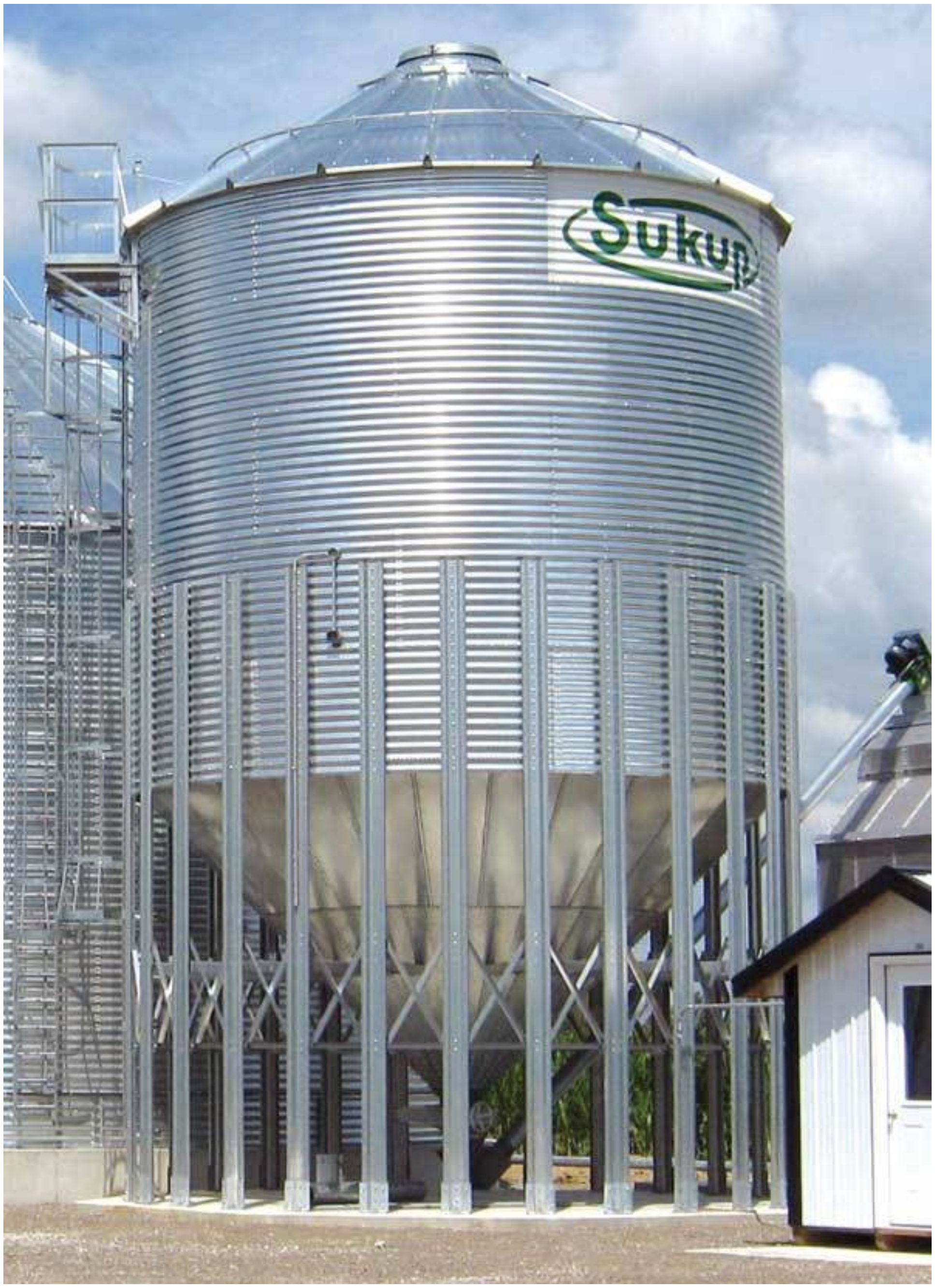
As noted above, there are two broad types of biomass fuel storage and handling. If pellets are used, a bin system is usually preferable. If wood chips are used, a walking floor is usually recommended.

Figure 69. Typical Pellet Bin for Smaller Biomass System[58]

[57] http://www.kohlbach.at/en/cetest-firstpage0/produkte/#en/cetest-firstpage0/produkte/kesselsysteme/warm-heisswasserkessel/

[58] http://www.get-renewables.com/wood-pellet-storage/4564934984

Figure 70. Pellet Bin for Larger Biomass System[59]



[59] http://biomassmagazine.com/articles/12312/putting-pellets-away

Figure 71. Wood Chips on a Walking Floor

Figure 72. Pistons & Start of Auger System at Front of Walking Floor

Figure 73. Auger Sending Fuel Into Boiler

12.c Buffer Tanks

Figure 74. Indoor Buffer Tanks

Figure 75. Outdoor Buffer Tank

12.d District System Piping

Figure 76. Pumps Sending Water/Glycol Fluid Through Piping

Figure 77. Pipes Going Underground

Figure 78. Installing Underground Piping

Figure 79. Close-up of Typical Insulated Underground Piping Connections[60]

[60] http://www.insulatedpipe.co.uk/insulated-pipe

12.e Options for Heating Buildings On Biomass District Systems

Figure 80. Typical Tie-In to Existing Heating System

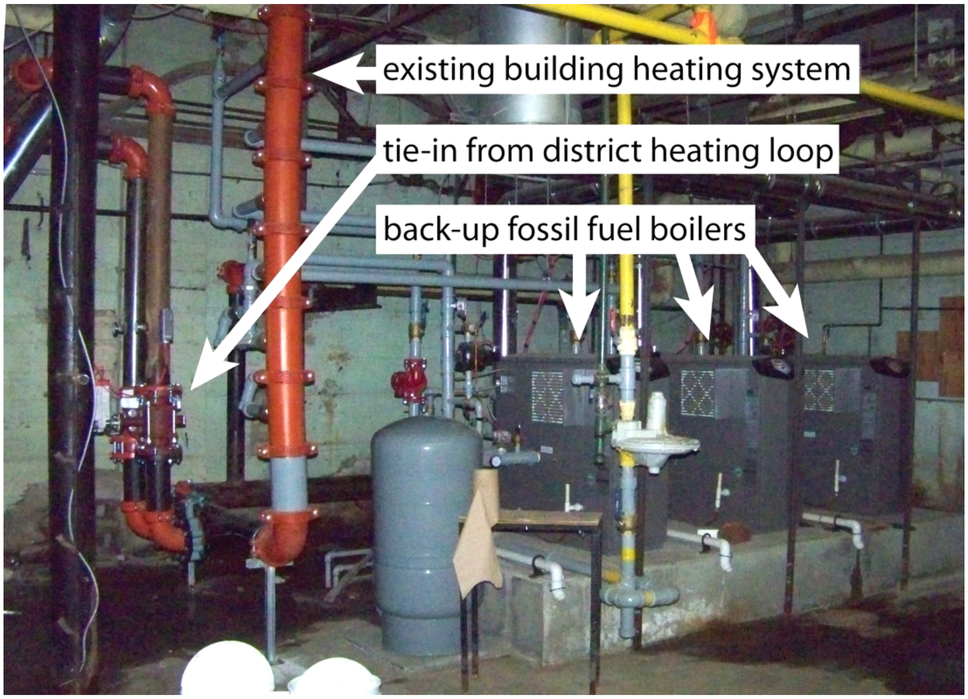


Figure 81. Radiator Coil – Heats Air Directly In Air Handling Systems & Ducts[61]

[61] http://www.ecoheatsolutions.com/heatingsolutions/woodpelletboilers/

Figure 82. Fan Coil Room Heaters[62]

Figure 83. In-Floor Heating[63]

[62] http://www.simplybiomass.co.uk/gizex-boilers-for-the-uk/

[63] http://www.ecosmart-energy.co.uk/Underfloor_Heating.html

12.f Chipping Equipment

If wood chips are used as fuel, the First Nation will usually have the option of chipping logs themselves. Given that non-chipped forest slash typically sells for about $50/tonne in Manitoba, and wood chips sell for about $90/tonne,[64] the First Nation may prefer to purchase and operate a chipper, employing local people to do the chipping and, therefore, keeping the revenue from chipping in their community.

A small limb-chipper (the kind typically owned by municipalities for light duty brush cleanup) is not robust enough for the volume of chipping usually required for a biomass system.

Suitable commercial chippers are available.

Figure 84. Disc Commercial Wood Chipper[65]

[64] Wood chips vary in price based on moisture content, what the raw wood source is, how many tonnes are being purchased, how far they have to be transported, and whether or not the buyer is willing to contract for multiple purchases.

[65] http://stumpcutters.com/wood-chippers/disk-style/2012-2512-series-12-in/

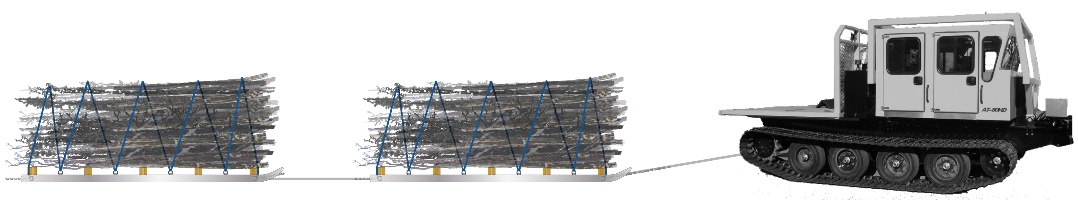
Figure 85. Drum Commercial Wood Chipper[66]

Because the chipper will be largely stationary, if an electric motor is feasible, it would be preferable to a diesel engine. The cost of fuel would be less if the First Nation is on the main Manitoba grid, the maintenance and servicing cost can be expected to be less for an electric motor than for a diesel engine, and the GHG emissions would be significantly reduced.

12.g Harvesting Equipment

If the First Nation chooses to harvest their own logs, significant investment and training will be required to buy the harvesting and hauling equipment. The First Nation may already have suitable hauling equipment—tractors, flatbed trucks—or may need to lease or purchase the equipment.

Figure 86. Log Sleds & Tracked Hauling Vehicle



[66] http://www.stbpallet.com/natural-wood-mulch-and-bio-mass-boiler-fuel

12.h Log Handling Equipment

The best equipment for moving small logs is probably a skid-steer with a log grappler.

Figure 87. Tracked Skid Steer With Log Grappler.

If a First Nation decides to work with logs (rather than buying chips), there is significant potential for spin-off revenues from selling firewood. In that case, a log splitter could also be a profitable investment.

Figure 88. Electric Log Splitter

Electric log splitters are capable of doing the work required and will help to reduce the consumption of fossil fuel in the biomass operation.

13 FINANCIAL PROJECTIONS - OPERATING

There is a market for biomass in Manitoba, but that market is small and still in development. As a result, prices are not as firm or predictable as they are in mature markets. (Examples of mature markets would include Europe or north-eastern United States.)

13.a Factors Affecting Biomass Pricing

The price of biomass fuel varies by source, form, purpose, moisture content, grade, volume, order commitment, season, and transportation distance.[67]

- Source:
    - In general, agriculturally-sourced biomass tends to be less expensive than biomass sourced from forestry.
- Form:
    - Pellets are usually more expensive than chips, primarily because they require more processing to make.
- Purpose:
    - Fuel suitable for Combined Heat and Power (CHP) systems is usually more expensive than fuel suitable for heating systems such as the ones proposed in this Study. CHP systems operate at higher temperatures.
- Moisture Content
    - The less moisture the biomass contains, the higher the price. Buying high-moisture biomass because the price is low is rarely economical, as a significant portion of the energy produced in burning is being “wasted” in evaporating the moisture.
- Grade
    - Biomass pellets are graded, in part by the percentage of “fines” (broken particles and dust) the delivered material contains; the fewer fines, the higher the price.

[67] Despite these variations, it’s worth noting that, over time, biomass fuel does not vary in price as much as fossil fuel.

- Volume:
    - Biomass purchased by the tonne is less expensive than by the bag. When it is purchased by the truckload, it is less expensive than when purchased by the tonne.
- Order Commitment
    - In general, buying biomass one transaction at a time can be expected to cost more per tonne than entering a contract for a year or for multiple years. Sellers prefer to have steady, predictable demand.
- Season
    - Prices tend to be higher in fall and winter than in spring or summer, primarily because demand is higher. This variation can be offset by entering into a contract.
- Transportation Distance
    - Because biomass is bulky compared to fossil fuels, the further it travels, the more expensive it is.
    - As a rule of thumb, to keep costs low—and minimize greenhouse gas emissions—biomass should be harvested within 50 km of where it is used for fuel.

13.b Estimating Biomass Fuel Cost

Given all the variables affecting biomass pricing noted above, an estimate of the cost of biomass for each community is just that—an estimate. Factoring all of these variables together, we estimate the following costs for biomass for each community.

Table 50: Estimated Biomass Fuel Rates

	cost per tonne
Dakota Tipi	$150
Sagkeeng	$170
St. Theresa Point	$200

Given the estimates of fuel required for each community, if all the District Heating Systems recommended were built, we can estimate total annual fuel costs.

- Table 51: Estimated Annual Biomass Fuel Cost

	tonnes per year	*cost per tonne*	*cost per year*
Dakota Tipi	220	$150	$33,000
Sagkeeng	1,000	$170	$170,000
St. Theresa Point	1,100	$200	$220,000

13.a Estimating Operating Expenditures

If each community supplied all this fuel itself—doing all the harvesting, transportation, and processing itself—the cost of fuel would be retained as earned revenue by the community, and spent locally.

A community that produced its own fuel would be creating permanent, local jobs. However, it must be remembered that not all of the earned revenue noted above would go to salaries.

Expenses for operations, equipment and system maintenance, and an equipment replacement reserve will be needed. We project that 60% of the revenues would go to salaries and the remaining 40% would be divided:

- 20% on operating expenses
- 10% on equipment and system maintenance
- 10% to an equipment replacement reserve

Table 52: Projected Expenditures

	salaries		**non-salary expenditures**		
	total	*FTE*[68]	*operating*	*equipment & system maintenance*	*equipment replacement reserve*
Dakota Tipi	$19,800	0.6	$6,600	$3,300	$3,300
Sagkeeng	$102,000	2.9	$34,000	$17,000	$17,000
St. Theresa Point	$132,000	3.8	$44,000	$22,000	$22,000

Our projections, then, show that these Biomass District Heating Systems would create one full-time job in Dakota Tipi, three in Sagkeeng and four in St. Theresa Point. If, as seems likely, harvesting is done seasonally rather than year round, the number of seasonal jobs would be larger.

It should also be noted that, if a community did not harvest and process the biomass itself—for example, buying pellets or wood chips from a commercial supplier—less than the above amounts would remain in these communities.

[68] FTE: Full-Time Equivalent jobs, based on a salary of $35,000 per person per year.

13.b Comparing Biomass Costs to Other Heating Fuel Options

Comparing the costs of heating with different fuels is, inevitably, filled with uncertainty. To make matters more complicated, the cost of a fuel is more than just its price.

The level of uncertainty is, however, acceptable if the purpose is to make general comparisons between fuels.

13.b.1 ESTIMATING GHG EMISSIONS

In addition to the money that is paid to the supplier, there are GHG (Green House Gas) emission costs. Depending on the fuel, GHG emissions can occur when fuel is extracted, when it is transported and stored, and when it is burnt for heat. Only some of these costs are included in the price paid to the supplier. To add to the complexity, different fuels produce different mixtures of GHG emissions.

There are also significant contamination cleanup costs, especially for diesel, when it is spilled.

And, also in keeping with standard practice, the GHG emissions estimates here *only* consider emissions from fuel combustion. They do not count the GHG emissions incurred in extracting, refining, transporting, or storing the fuel. They do also not count the GHG emissions incurred in decontamination operations after a fuel spill.

Table 53: Estimated GHG Emissions by Fuel Unit[69]

	CO_2e/unit of fuel	
diesel[70]	2.7	kg/litre
propane	1.5	kg/litre
natural gas	1.9	kg/m^3
biomass[71]	0.0	kg/kg

[69] In keeping with international practice, GHG emissions are given in CO2 equivalents (CO2e). These estimates are derived from the British Columbia Ministry of the Environment's publication "2014 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions, Including Guidance for Public Sector Organizations, Local Governments and Community Emissions", https://www.toolkit.bc.ca/sites/default/files/2014_best_practices_methodology_for_quantifying_greenhouse_gas_emissions%20%281%29.pdf.

[70] The actual GHG emissions generated by diesel combustion varies, in part, with the grade of diesel. The number used here is based on the middle grade diesel commonly used for fuel oil in northern Manitoba.

[71] Because biomass is a renewable resource, and the CO_2 that is returned to the air during combustion was only recently extracted from the air, industry practice is to consider biomass to have no net effect on GHGs.

Table 54: Energy Potential by Fuel[72]

	kWh/unit of fuel	
diesel	10.6	kWh/litre
propane	7.0	kWh/litre
natural gas	10.4	kWh/m^3
biomass[73]	3.5	kWh/kg

Table 54 estimates heat production in an "ideal" combustion system—in which 100% of the potential energy of the fuel is turned into heat. Of course, actual energy systems are not 100% efficient. To estimate the useable heat generated, we need to estimate the efficiency of the furnace or other heating system.

To make matters slightly more complicated, diesel is used in two different ways to make heat. In the first method ("in diesel furnace") the diesel is burnt and directly turned into heat. In the second method ("through diesel-electric system") the diesel is used to make electricity, and that electricity is turned into heat through a resistance heat system—usually a baseboard heater or small, free-standing electric heater.

In this report, for ease of comparison, heating systems are estimated to be 70% efficient. The actual efficiency will by equipment manufacturer, by equipment age, and by how well (or poorly) it is serviced.

Table 55: Estimated Heat Energy Produced by Various Fuels & Systems

kWh/unit of fuel		*fuel system*	*estimated system efficiency*	*estimated heat energy produced*	
10.6	kWh/litre	diesel - in furnace	75%	8.0	kWh/litre
		diesel - through diesel/electric system	40%	4.3	kWh/litre
7.0	kWh/litre	propane	75%	5.3	kWh/litre
10.4	kWh/m^3	natural gas	75%	7.8	kWh/m^3
3.5	kWh/kg	biomass	75%	2.6	kWh/kg

[72] Sources: National Energy Board (https://apps.neb-one.gc.ca/Conversion/conversion-tables.aspx?GoCTemplateCulture=en-CA#2-3), NRCan (http://www.nrcan.gc.ca/energy/natural-gas/5641), and British Columbia Ministry of the Environment (https://www.toolkit.bc.ca/sites/default/files/2014_best_practices_methodology_for_quantifying_greenhouse_gas_emissions%20%281%29.pdf).

[73] This is an estimate based on typical woody biomass harvested in Manitoba. Depending on the tree species and the moisture content of the wood, the actual number could be higher or lower. This is, however, a reasonable estimate for a pre-feasibility study.

The Biomass Energy Centre (http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,20041&_dad=portal) gives its estimate as 3.5 kWh/kg, and 1 kWh/kg = 1 mWh/tonne.

Wood Energy (http://woodenergy.ie/woodasafuel/listandvaluesofwoodfuelparameters-part1/) and the Biomass Energy Resource Centre (http://www.biomasscenter.org/pdfs/Wood-Chip-Heating-Guide.pdf) both give ranges for their estimates, consistent with the estimate given here.

To make a realistic comparison of GHG emissions from various fuels and heating systems, we need to estimate the CO_2e per unit of heat actually produced.

Table 56: Estimated GHG Emissions by Heat Unit[74]

fuel & system	*estimated heat energy produced*		*estimated CO_2e/heat unit*	
diesel - in furnace	8.0	kWh/litre	0.34	kg/kWh
electric heat from diesel-electric system	4.3	kWh/litre of diesel	0.63	kg/kWh
electric heat from hydro generation[75]			0	kg/kWh
propane	5.3	kWh/litre	0.29	kg/kWh
natural gas	7.8	kWh/m^3	0.25	kg/kWh
biomass	2.6	kWh/kg	0	kg/kWh

13.b.2 ESTIMATING DOLLAR COSTS

The actual cost of fuel will vary, in part, by how remote the community is where the fuel is consumed. With the exception of electricity, actual prices for these fuels in the communities studied are not available. For comparison, the average retail prices for fuels for December 2017 in relevant locations were:

Table 57: Current Costs of Comparable Fuels in Relevant Locations[76]

	Canada	*Winnipeg*	*Brandon*	*Labrador City*	*Thunder Bay*	*Whitehorse*	*Yellowknife*	*unit*
diesel	$1.22	$1.17	$1.17	$1.41	$1.31	$1.23	$1.24	/litre
furnace oil	$1.07				$1.28			/litre
propane	$0.82	$0.78	$1.25		$0.91	$0.93		/litre

[74] As noted above, these estimates do not include GHG emissions incurred during extraction, transportation, storage, or spill cleanup and decontamination.

[75] Electric heat systems powered from the main electric heat system in Manitoba derive their power from hydro-electric systems (primarily dams). In keeping with industry practice, these systems are calculated here to produce no GHG emissions (0.0 CO_2e/kWh of heat produced).

[76] As of December 2017. Source: *Natural Resources Canada*, "Energy Sources, Average Retail Prices in Canada". http://www.nrcan.gc.ca/energy/fuel-prices/4593/ A blank in a cell means that data was not available.

Table 58: Current Cost of Fuels

	Dakota Tipi	*Sagkeeng*	*St. Theresa Point*	*unit*	*estimate or actual?*
electricity[77]	$0.08	$0.08	$0.08	/kWh	actual
diesel[78]	$1.17	$1.23	$1.52	/litre	estimated
propane[79]	$1.02	$1.07	$1.32	/litre	estimated
natural gas[80]	$0.23	n/a[81]	n/a	/m³	actual
biomass[82]	$150	$170	$200	/tonne	estimated

To compare the cost of heating by different fuels, we need to combine these costs of fuels with the estimated amount of heat produced per unit of fuel.

Table 59: Estimated Current Costs of Heat

	estimated fuel cost				**estimated heat produced per unit of fuel**		**estimated heat cost**			
	Dakota Tipi	*Sag-keeng*	*St. Theresa Point*				*Dakota Tipi*	*Sag-keeng*	*St. Theresa Point*	
electricity	$0.08	$0.08	$0.08	/kWh	1	kWh	$0.08	$0.08	$0.08	/kWh
diesel	$1.17	$1.23	$1.52	/litre	8.0	kWh/litre	$0.15	$0.15	$0.19	/kWh
propane	$1.02	$1.07	$1.32	/litre	5.3	kWh/litre	$0.19	$0.20	$0.25	/kWh
natural gas	$0.23	n/a	n/a	/m³	7.8	kWh/m³	$0.03			/kWh
biomass	$150	$170	$200	/tonne	2.6	kWh/kg	$0.06	$0.06	$0.08	/kWh

Of course, fuel prices will not remain at their current level. Price changes will be driven by market forces, by decisions of the Manitoba Public Utility Board, and by the Carbon Levy.

Table 60: Estimated Annual Rates of Increase, Without Carbon Levy

electricity	4%
diesel	2%
propane	2%
natural gas	2%
biomass	2%

[77] Based on current Manitoba Hydro residential rates.

[78] Estimated cost of diesel in Dakota Tipi is the average of the actual costs in Winnipeg and Brandon. The cost of diesel in Sagkeeng was estimated to be 5% higher than the cost in Dakota Tipi. The cost of diesel in St. Theresa Point was estimated to be 30% higher than in Dakota Tipi.

[79] Estimated cost of propane in Dakota Tipi is the average of the actual costs in Winnipeg and Brandon. The cost of propane in Sagkeeng was estimated to be 5% higher than the cost in Dakota Tipi. The cost of propane in St. Theresa Point was estimated to be 30% higher than in Dakota Tipi.

[80] Based on current Manitoba Hydro residential rates.

[81] "N/A" means this fuel is not available at this location.

[82] Estimated cost of biomass is based on the cost of wood chips, delivered, to communities in similar locations.

Table 61: Estimated Dakota Tipi Fuel Price with Annual Increases Factored In, but Without Carbon Levy

	2018	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*2027*	
electricity	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	/kWh
diesel	$1.19	$1.22	$1.24	$1.27	$1.29	$1.32	$1.34	$1.37	$1.40	$1.43	/litre
propane	$1.04	$1.06	$1.08	$1.10	$1.12	$1.14	$1.17	$1.19	$1.21	$1.24	/litre
natural gas	$0.23	$0.24	$0.24	$0.25	$0.25	$0.26	$0.26	$0.27	$0.27	$0.28	/m^3
biomass	$153.00	$156.06	$159.18	$162.36	$165.61	$168.92	$172.30	$175.75	$179.26	$182.85	/tonne

Table 62: Estimated Sagkeeng Fuel Price with Annual Increases Factored In, but Without Carbon Levy

	2018	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*2027*	
electricity	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	/kWh
diesel	$1.25	$1.28	$1.30	$1.33	$1.36	$1.38	$1.41	$1.44	$1.47	$1.50	/litre
propane	$1.09	$1.11	$1.13	$1.15	$1.18	$1.20	$1.22	$1.25	$1.27	$1.30	/litre
biomass	$173.40	$176.87	$180.41	$184.01	$187.69	$191.45	$195.28	$199.18	$203.17	$207.23	/tonne

Table 63: Estimated St. Theresa Point Fuel Price with Annual Increases Factored In, but Without Carbon Levy

	2018	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*2027*	
electricity	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	/kWh
diesel	$1.55	$1.58	$1.61	$1.65	$1.68	$1.71	$1.75	$1.78	$1.82	$1.85	/litre
propane	$1.35	$1.37	$1.40	$1.43	$1.46	$1.49	$1.52	$1.55	$1.58	$1.61	/litre
biomass	$204.00	$208.08	$212.24	$216.49	$220.82	$225.23	$229.74	$234.33	$239.02	$243.80	/tonne

Table 64: Carbon Levy by Fuel[83]

	at $10/tonne CO2e	
electricity	$0.0000	/kWh
diesel	$0.0274	/litre
propane	$0.0155	/litre
natural gas	$0.0196	/m^3
biomass	$0.0000	/tonne

Table 65: Estimated Carbon Levy for the Next 10 Years

2018	$10	/tonne CO_2e
2019	$20	
2020	$30	
2021	$40	
2022	$50	
2023	$50	
2024	$50	
2025	$50	
2026	$50	
2027	$50	

[83] Source: Government of Canada. "Technical paper: federal carbon pricing backstop." https://www.canada.ca/en/services/environment/weather/climatechange/technical-paper-federal-carbon-pricing-backstop.html.

Table 66: Estimated Carbon Levy by Fuel

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
electricity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	/kWh
diesel	$0.03	$0.05	$0.08	$0.11	$0.14	$0.14	$0.14	$0.14	$0.14	$0.14	/litre
propane	$0.02	$0.03	$0.05	$0.06	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	/litre
natural gas	$0.02	$0.04	$0.06	$0.08	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	/m^3
biomass	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	/tonne

Table 67: Estimated Dakota Tipi Fuel Prices with Annual Increases and Projected Carbon Levies Factored In

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
electricity	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	/kWh
diesel	$1.22	$1.27	$1.32	$1.38	$1.43	$1.45	$1.48	$1.51	$1.54	$1.56	/litre
propane	$1.05	$1.09	$1.12	$1.16	$1.20	$1.22	$1.24	$1.27	$1.29	$1.31	/litre
natural gas	$0.25	$0.28	$0.30	$0.33	$0.35	$0.35	$0.36	$0.36	$0.37	$0.38	/m^3
biomass	$153.00	$156.06	$159.18	$162.36	$165.61	$168.92	$172.30	$175.75	$179.26	$182.85	/tonne

Table 68: Estimated Sagkeeng Fuel Prices with Annual Increases and Projected Carbon Levies Factored In

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
electricity	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	/kWh
diesel	$1.28	$1.33	$1.39	$1.44	$1.49	$1.52	$1.55	$1.58	$1.61	$1.63	/litre
propane	$1.10	$1.14	$1.18	$1.22	$1.25	$1.28	$1.30	$1.33	$1.35	$1.38	/litre
biomass	$173.40	$176.87	$180.41	$184.01	$187.69	$191.45	$195.28	$199.18	$203.17	$207.23	/tonne

Table 69: Estimated St. Theresa Point Fuel Prices with Annual Increases and Projected Carbon Levies Factored In

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
electricity	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	/kWh
diesel	$1.58	$1.64	$1.70	$1.76	$1.82	$1.85	$1.88	$1.92	$1.95	$1.99	/litre
propane	$1.36	$1.40	$1.45	$1.49	$1.53	$1.56	$1.59	$1.62	$1.65	$1.69	/litre
biomass	$204.00	$208.08	$212.24	$216.49	$220.82	$225.23	$229.74	$234.33	$239.02	$243.80	/tonne

Table 70: Estimated Dakota Tipi Heat Prices

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
electricity	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	/kWh
diesel	$0.15	$0.16	$0.17	$0.17	$0.18	$0.18	$0.19	$0.19	$0.19	$0.20	/kWh
propane	$0.20	$0.21	$0.21	$0.22	$0.23	$0.23	$0.24	$0.24	$0.24	$0.25	/kWh
natural gas	$0.03	$0.04	$0.04	$0.04	$0.04	$0.05	$0.05	$0.05	$0.05	$0.05	/kWh
biomass	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	/kWh

Table 71: Estimated Sagkeeng Heat Prices

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
electricity	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	/kWh
diesel	$0.16	$0.17	$0.17	$0.18	$0.19	$0.19	$0.19	$0.20	$0.20	$0.20	/kWh
propane	$0.21	$0.22	$0.22	$0.23	$0.24	$0.24	$0.25	$0.25	$0.26	$0.26	/kWh
biomass	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	/kWh

Table 72: Estimated St. Theresa Point Heat Prices

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
electricity	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	/kWh
diesel	$0.20	$0.21	$0.21	$0.22	$0.23	$0.23	$0.24	$0.24	$0.24	$0.25	/kWh
propane	$0.26	$0.27	$0.27	$0.28	$0.29	$0.30	$0.30	$0.31	$0.31	$0.32	/kWh
biomass	$0.08	$0.08	$0.08	$0.08	$0.08	$0.09	$0.09	$0.09	$0.09	$0.09	/kWh

Figure 89. Estimated Dakota Tipi Heat Prices

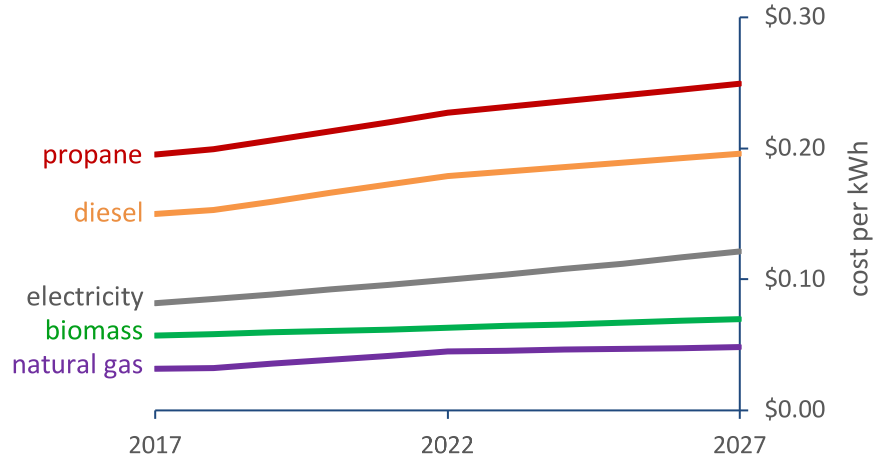


Figure 90. Estimated Sagkeeng Heat Prices

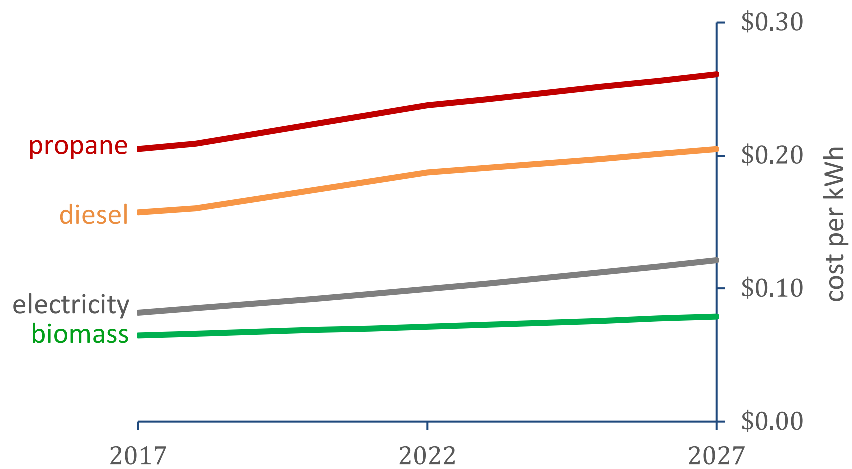
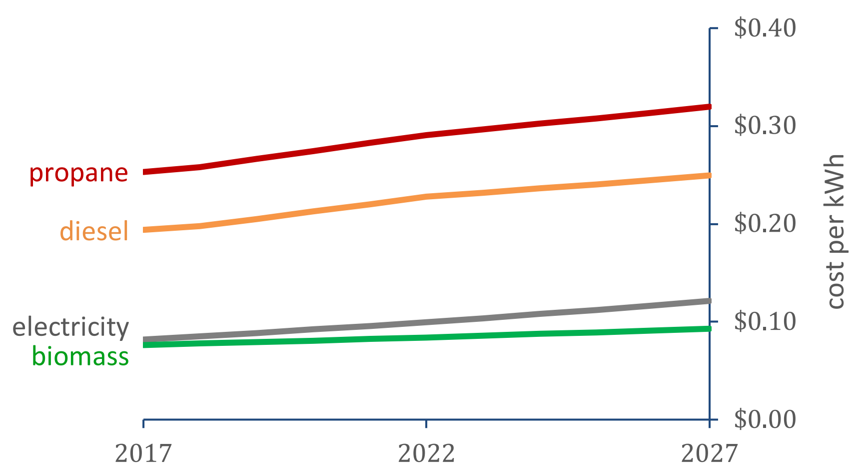


Figure 91. Estimated St. Theresa Point Heat Prices



13.b.3 CONCLUSIONS FROM COMPARING BIOMASS COSTS TO OTHER HEATING FUEL OPTIONS

All of these data, estimates and calculations can easily become overwhelming. There are, however, a number of conclusions that can be drawn, even at this pre-feasibility stage:

- GHG emissions from heating with hydro-based electricity and biomass are much less than emissions from heating with diesel, propane or natural gas.
- Heating with biomass is *currently* comparable in cost to heating with electricity, if grid-based electricity is available.
    - Because geothermal heat is more efficient than resistance heat, heating with geothermal can be expected to cost less than heating with biomass.
- Heating with biomass can be expected to cost *less* than heating with grid-electricity over the next decade.
    - Because the cost of electricity can be expected to rise faster than the cost of biomass, the gap in costs between geothermal heating and biomass heating will shrink over the next decade.
- Heating with biomass in these communities costs *much* less than heating with propane or diesel—roughly 2 to 3 times less.
- Where it is available[84] heating with natural gas currently costs less than heating with biomass.
    - As the carbon levy grows over the next five years, the gap between heating with natural gas and heating with biomass will shrink.
    - If the carbon levy does not go above $50/tonne, this gap may not disappear.

[84] Of the three communities studied, natural gas is available in Dakota Tipi only.

14 GREENHOUSES

14.a Precedents

There have been numerous attempts to set up and operate greenhouses in First Nations communities and in remote communities in Canada.

Perhaps the most inspiring is the Inuvik Community Greenhouse[85], which has been in operation since 2000. The Iqaluit Community Greenhouse Society[86] is another significant success story, operating a greenhouse since 2007. Both require intensive community volunteer and fundraising input to break even.

The Arctic Farmer Nursery[87] operates a greenhouse in Yellowknife. Its funding model is completely different from the Inuvik and Iqaluit greenhouse models. It is part of a larger commercial operation, selling farm and gardening supplies, as well as landscaping services, to people in and around Yellowknife.

The work at T'Sou-Ke First Nation in BC also suggests models that could be considered.[88]

As attractive as these successes are, they must considered alongside the many attempts at greenhouses that have not proved as successful.

14.b The Greenhouse Industry

There are, of course, numerous greenhouses all over Canada. Some are commercial operations; others are community- or privately-operated.

One of the better sources of data for larger, commercial greenhouse operations is "The Economics of Production and Marketing of Greenhouse Crops in Alberta"[89]. The average size of greenhouse operation considered in this study is 4,000 m^2. Roughly 45% of the space in these greenhouses is used for food plants, 45% is used for ornamental plants, and

[85] See inuvikgreenhouse.com/

[86] See iqaluitgreenhouse.com/

[87] See http://arcticfarmer.com/

[88] See http://tsoukenation.com/ladybug-garden-greenhouse/ and tsoukenation.com/tsou-ke-going-green-really-green/

[89] Available at www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex4369/$file/821-59.pdf?OpenElement

10% is used to grow tree seedlings. On average, one of these greenhouses will have 5 full-time and 10 part-time employees.

The average investment cost for these operations (roughly equivalent to the capital cost) ranged between \$118 and \$300/m^2, with the variation depending primarily on the product being grown.

The average cost of production (roughly equivalent to the operations and maintenance cost) was approximately \$100/m^2, while the average revenue was approximately \$125/m^2. This means that, on average, commercial greenhouses have a small, positive profit margin.

This does *not* mean that a greenhouse in any of the three communities studied would necessarily be economically viable. That will depend on many factors, including:

- What crops are grown.
- How the facilities are operated.
- What model of operation (for profit, community, private, *etc*.) is chosen.
- Who the crops are given or sold to, and for how much.

But it *does* mean that the greenhouse industry is not, on average, a money-losing industry.

14.c Energy and Commercial Greenhouses

With very few exceptions—Vanderveen's greenhouse in Carman[90] being a notable example—these commercial greenhouse operations are not heated with biomass. Most are heated with natural gas. If they are year-round operations, the cost of heat can be a significant portion of the budget, and produce a significant amount of greenhouse gases.

There is no technical reason why these larger, commercial greenhouses use fossil fuels rather than biomass for heat. Even with the current low cost of natural gas, the heating costs of biomass and natural gas are roughly equal.

If a biomass-based District Heating System was already installed, the capital and operating costs of heating a greenhouse with biomass can be expected to be equal to (or, in some circumstances even lower) than the cost of heating with natural gas.

One of the less-recognized advantages of a District Heating Loop for a greenhouse operation is the potential to cool the greenhouse during the day in the summer, if the District Heating Loop was connected to another facility that needed heat during the day.

So, for example, if a community had a kiln-drying operation (which it would need if it was harvesting green wood and wanted that wood to be suitable for housing and building construction), on warmer days, the District Heating Loop could transfer heat from the greenhouse to the kiln, reducing the cost of operation in both. A heat sink (something as simple as a large, insulated water tank, like the one pictured in Figure 7—Outdoor Buffer Tank—earlier in this report) could smooth out the production and demand schedules of

[90] See vanderveensgreenhouses.com/

that heat, enabling the kiln to operated even when cooling wasn't required in the greenhouse.

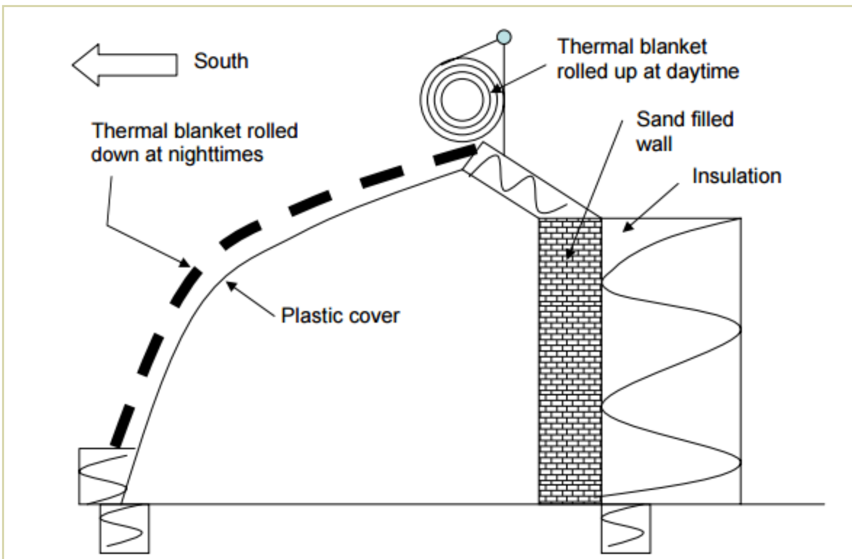
14.d Energy and Smaller Greenhouses

A number of smaller greenhouse operators in Manitoba are using non-fossil-fuel energy technologies, including biomass, in their greenhouses.

If one or more of the communities studied in this report wanted to investigate the feasibility of a greenhouse in their community, these operations have a great deal to offer as examples. None of the technologies they are using are experimental.

Perhaps the simplest, established technology is the use of heat sinks and thermal blankets to manage the heat.

Figure 92. Simplified Schematic of Solar Energy Greenhouse – Side View[91]



Smaller greenhouses are also more likely than large commercial operations to use biomass for heat, although this is not because biomass technology is more suitable for smaller

[91] The sand filled wall acts as a heat sink, absorbing heat during the day and returning it to the greenhouse at night. A thick concrete wall (min. 20 cm) or a water-filled container system can substitute for the sand filled wall.

greenhouses. One of the larger greenhouse operations in Manitoba—Pineland Forest Nursery in Hadashville heats its 30,000 m^2 greenhouse almost entirely with biomass.[92]

14.e Relevant Examples of Greenhouses

Five relevant examples of greenhouses were examined for this report:

1. Wenkai Greenhouses in Elie
2. Blue Lagoon Greenhouse St. Francis Xavier
3. Room to Grow Greenhouse
4. Jeannie's Greenhouse
5. The Farm-in-a-Box initiative at Garden Hill First Nation

All five are at a scale that could be adopted in each of the three communities and use technologies that would be particularly relevant as examples.

The first four are particularly relevant in that they use biomass at least from supplemental heat. The fifth is relevant because it provides an example of integrating a greenhouse with a broader food initiative on a First Nation.

14.e.1 WENKAI GREENHOUSES

Wenkai has been growing vegetables in Elie, Manitoba, for over ten years.

He grew up in a rice farming village in China and moved to Canada in the 1990s to complete his Masters in Agronomy. Wenkai then completed a PhD in Plant Genetics and took a job as a soil researcher before deciding to start growing vegetables.

Wenkai has been a vendor at St. Norbert Farmer's Market since he began growing vegetables and enjoys connecting with regular customers there. He also sells his vegetables to Crampton's Market, Superstore and Vic's Fruit Market.

Wenkai's solar energy greenhouse can be a useful model for an energy-efficient greenhouse.[93]

Figure 93. Wenkai Greenhouse Exterior in Winter

[92] See http://pinelandforestnursery.com/bio-energy/ for more information on the use of biomass in Pineland's operations.

[93] See more at wksolarenergygreenhouse.com/ and directfarmmanitoba.ca/farms/219/wenkai-oriential-vegetables.

Figure 94. Wenkai Greenhouse Interior

14.e.2 BLUE LAGOON GREENHOUSE

Blue Lagoon Organics in St. Francis Xavier uses primarily wood pellets for heat in its greenhouse.

They also use a small amount of electricity to start plants with hog farrowing mats placed under the flats to keep the roots warm in early spring.

Lori Anne Regnier reports that, while their wood pellet stove provides enough heat, they do not operate in the coldest months. By not heating the greenhouse in these months, everything in the greenhouse freezes thoroughly. This reduces the pesticides and herbicides required.

Summer presents more energy challenges than winter; they spend more energy keeping the greenhouse cool in summer than heating it in winter. This is done primarily through fans pulling air in and out.[94]

[94] See more at bluelagoonorganics.com, smallfarmsmanitoba.com/farms/72/blue-lagoon-organics, and cog.ca/documents/07FAFlorascape.pdf.

Figure 95. Blue Lagoon Organics Greenhouse Exterior

Figure 96. Blue Lagoon Organics Interior – View 1

Figure 97. Blue Lagoon Organics Interior – View 2

14.e.3 ROOM TO GROW GREENHOUSE

Room to Grow is a guesthouse, greenhouse and garden on the north slope of Turtle Mountain in southwest Manitoba.[95] It specializes in bedding plants, herbs and open-pollinated vegetables. It also grows annual flowers, and native and general perennials.

The greenhouse is heated primarily by sunlight, with supplemental heat from a wood-fired boiler.

The greenhouse features 2x6 spruce rafters that support the plastic covering. The rear wall is insulated to R-50 with stacked straw bales sandwiched between layers of stucco. Sheets of roofing tin form an inner wall, 4" from the stucco, to hold gravel that stores heat during the day and releases it at night. A small fan circulates air between double sheets of poly covering the front part of the greenhouse.

[95] See http://www.roomtogrowinfo.ca

Figure 98. Room To Grow Greenhouse Exterior

Figure 99. Room To Grow Greenhouse Interior

14.e.4 JEANNIE'S GREENHOUSE

Jeannie's Greenhouse (and Garden Centre) in Ashern grows tomatoes, cucumbers and hanging baskets.[96]

The solar greenhouse occupies 200 m^2 (23 feet by 100 feet).

The greenhouse is constructed much like the Wenkai greenhouse described above.

This greenhouse has wood stove just inside the greenhouse entrance, to supplement heat from the solar wall and keep temperatures up early in the season.

A furnace fan distributes heated air from around the stove by blowing the air through a poly duct strung along the base of the rear wall.

14.e.5 GARDEN HILL GREENHOUSE

The Garden Hill greenhouse is particularly relevant for two reasons—it is in operation less than 15 km from St. Theresa Point, and it is an excellent example of integrating a greenhouse with a broader, healthy-food initiative.

Figure 100. Garden Hill Greenhouse Exterior (Shown Under Construction)

[96] See facebook.com/jeanniesgreenhouse/ and http://greenhousecanada.com/energy/alternative-fuels/solar-greenhouse-interest-heating-up-in-manitoba-927.

Figure 101. Garden Hill Greenhouse Interior (with Chicks)

The Garden Hill greenhouse is the smallest of the examples shown here—roughly 50 m^2—but even at that small size, it serves multiple purposes:

- A place to grow vegetables.
- A site for hands-on education.
- A way to offer tips and support to local community members wanting to start their own greenhouses.
- A demonstration site showing the feasibility of a larger greenhouse operation.

It also provides a safe place for the chicks to grow.

14.e.6 ADDITIONAL, POTENTIALLY-RELEVANT, GREENHOUSES

Additional greenhouses, that were not examined for this report, but could be relevant as examples in a feasibility study, include:

1. Vanderveens Greenhouse in Carman (mentioned earlier)[97]
2. Pineland Forest Nursery in Hadashville (mentioned earlier)
3. Solomon's Home Garden Gift greenhouse[98] (in Portage La Prairie, 3 km from Dakota Tipi)
4. OurFarm.biz[99] (12 km east of Dakota Tipi)
5. Vanstone Nurseries[100] (15 km north of Dakota Tipi)
6. Chevrefils Greenhouse (4 km east of Sagkeeng)
7. Margie's Greenhouse[101] (35 km southeast of Sagkeeng)
8. Lynn's Plants and Things in Lynn Lake[102] (located in a climate with some things in common with St. Theresa Point's climate).

14.f Decisions Required Prior to Conducting a Greenhouse Feasibility Study

A number of decisions need to be made by a community *before* it commissions a feasibility study of adding a greenhouse to a biomass-based district heating loop.

It may be tempting to leave these decisions to the feasibility stage. However, doing so only hands the responsibility for choosing what type of greenhouse—if any—a community wants over to a consultant.

Some of the specific questions that need to be answered prior to the feasibility study include:

14.f.1 WHO IS PASSIONATE ABOUT DOING LEADING THE WORK?

Every small greenhouse operator interviewed for this report made a point of emphasizing how much work a greenhouse is.

They wanted anyone considering starting a greenhouse to know that the amount of time required to make a greenhouse successful was far beyond what they had initially imagined.

[97] See http://www.vanderveensgreenhouses.com.

[98] See https://www.solomonshomegardengift.ca/the-greenhouse.

[99] See http://ourfarm.biz/index.html.

[100] See http://www.vanstonenurseries.com.

[101] See http://www.margiesgreenhouse.com.

[102] See https://www.facebook.com/lynnsplantsandthingsgreenhouse.

If the main people involved see it primarily as a job, and expect that job to have limited, predictable hours, the greenhouse project will not last.

14.f.2 WHAT ARE THE PRIORITIES OF THE GREENHOUSE PROJECT?

Advocates of a greenhouse project will have many different reasons for supporting a project—jobs, economic diversification, healthy local food, organic food, greenhouse gas reduction, supporting healthy-living initiatives, supporting local community members to start their own gardens and greenhouses, education.

All of these are worthy reasons to operate a greenhouse. However, if they are all of equal priority, it is unlikely that the greenhouse will meet any of them very well or for very long.

A greenhouse primarily focused on jobs and economic diversification may not produce any food at all designed for local consumption. A greenhouse focused on healthy-living initiatives and education may not sell any of its produce. A greenhouse designed to support local gardeners may not produce any finished food at all.

Carefully and thoroughly setting priorities—and agreeing on which goals matter most and which matter least—will be essential for guiding the feasibility study.

14.f.3 HOW LARGE SHOULD THE GREENHOUSE BE?

The exact size will be determined in the feasibility study, but the rough size needs to be decided before.

A greenhouse beside the school—perhaps constructed along the south side of the building—can be as small as 2 m^2 and still serve as a valuable educational tool.

A 20 m^2 greenhouse can, if integrated into a larger gardening initiative, supply virtually all the seedlings a community needs to grow food in cold frames and garden plots beside their own homes.

A 200 m^2 greenhouse can provide a significant portion of a community's vegetable needs.

A 2000 m^2 greenhouse can, depending on the crops grown, be a significant source of employment in a community, and generate revenue from sales to people and companies beyond the First Nation itself.

14.f.4 HOW MANY MONTHS PER YEAR WILL THE GREENHOUSE OPERATE?

This report recommends designing the greenhouse to operate no more than 11 months per year.

Having a period of at least one month (and, ideally, three) when the greenhouse is permitted to freeze completely is likely to be crucial in ensuring the long-term viability of a greenhouse operated in one of these three communities.

Greenhouse projects—particularly in northern or remote communities—are often begun with the intention of having fresh produce all winter. With enough heat, artificial light, and nutrients put into a greenhouse, crops can grow anywhere, any time.

Unfortunately, after the first year or so of success, it is quite common for 12-month greenhouse to develop infestations of bugs, mold, or micro-organisms.

Conditions of continuous high humidity and warmth virtually guarantee that these infestations will occur. These infestations can sometimes kill all the plants in a greenhouse.

Experienced professional greenhouse operators who run year-round greenhouses are usually able to manage these infestations, but usually need to use high levels of herbicides and pesticides to do so.

Once an infestation has occurred, restoring the greenhouse to health can be a long, difficult process. It may even be more economical, depending on the type of infestation, to abandon the greenhouse completely and build a new one.

Allowing the greenhouse and all its components to freeze avoids this problem. The greenhouse must be designed to withstand this type of solid freezing, and care needs to be taken before the freeze period to ensure that the greenhouse and its equipment is properly prepared.

Having a freeze period every year also means the greenhouse will only draw energy from the District Heating System in "shoulder seasons"—spring and fall—rather than during the peak heating demand months. This means that quite a large greenhouse can be included in a biomass district system without having to increase the peak capacity of the biomass boiler(s) at the heart of the system.

15 CONCLUSIONS

Biomass heating is a viable option for the community buildings in each of the First Nations considered.

A greenhouse can be a viable addition to the biomass District Heating Loop proposed for any of the three First Nations considered.

Given that these three communities are located in three different ecological zones in Manitoba, it is likely that most (if not all) First Nations communities could use biomass to heat their community buildings as well. There is biomass virtually everywhere in Manitoba.

While this study shows that biomass heating is viable, it has not yet answered the question of whether or not biomass heating is the *best* option for each of these community buildings.

15.a Comparing Heating Systems

15.a.1 BIOMASS HEATING VS. FOSSIL FUELS

Biomass heating offers a number of advantages over fossil fuels:

- Biomass fuel is not a net contributor to greenhouse gas emissions.
- Biomass heating almost always creates local jobs. Because biomass is available virtually everywhere in Manitoba, and biomass fuel has significant transportation costs, the most cost-effective biomass fuel is likely to be local fuel.
- Over time, biomass fuel tends to vary less in price than fossil fuels.
- Feasible in remote communities.
- Minimal soil or water contamination concerns.

Heating with fossil fuels does have some advantages over biomass heating:

- Higher energy density (measured in kWh/tonne or cubic metre).
- More mature fuel delivery infrastructure.
- Fuel is standardized.

15.a.2 BIOMASS HEATING VS. ELECTRIC RESISTANCE HEATING

Biomass heating offers at least one significant advantage over electric resistance heating:

- Electricity not used for heating can be put to more valuable uses.

Biomass's primary disadvantages compared to electric resistance heat are:

- If the community is on the primary Manitoba Hydro electric grid, providing biomass fuel requires more effort than providing electricity.

- Fuel is standardized.

15.a.3 BIOMASS HEATING VS. GEOTHERMAL

Biomass has some advantages over geothermal:

- Lower electricity consumption per unit of heat produced.
- Permanent jobs created harvesting fuel.
- Better suited to heating hot water for domestic and medical centre use.
- Better suited for integrating into existing high-temperature water/glycol heating systems.

However, geothermal systems have some advantages over biomass systems:

- With geothermal systems, cooling is as easy as heating.
- No effort required to supply fuel.

15.b Comparing Heating Systems for Each of These Three Communities

Deciding how the pros and cons of each heating option balance out in each of these communities cannot be decided in the abstract. They must be considered for each community.

15.b.1 DAKOTA TIPI

Dakota Tipi has two special circumstances that must be considered in comparing the merits of heating systems:

- It is one of the few First Nations on Manitoba's natural gas pipeline system.
- It has little access to biomass that it can harvest.

The most likely biomass fuel for Dakota Tipi is pellets—either pellets from the agricultural industry (available for purchase in Portage La Prairie) or forestry-based pellets (available from commercial producers and at least one Hutterite colony).

Purchasing biomass fuel can be expected to cost roughly as much as purchasing natural gas. And buying biomass fuel will not create jobs for Dakota Tipi members.

If reducing greenhouse gases is a primary goal for Dakota Tipi, then installing one or more Biomass District Heating Systems and purchasing biomass pellets should be pursued.

If creating local jobs is the primary goal, installing a Biomass District Heating is not likely to achieve that goal, unless Dakota Tipi can negotiate with Forestry Manitoba to harvest wood in a nearby Forestry Management Unit (FMU).

Given the climate of Dakota Tipi, and the lack of readily-available self-harvesting biomass, Geothermal District Systems may be more attractive to this community than Biomass District Systems.

15.b.2 SAGKEENG

The most significant issue for Sagkeeng in considering its heating options is the dependency of the High School on propane. Sagkeeng is not on Manitoba's natural gas pipeline system, and is not likely to be on that system in the foreseeable future.

Nearly as important in considering its options is Sagkeeng's easy access to forestry-based "waste" wood. They have access to it at a low-cost from Manitoba Hydro's line clearing work in the area, and to Forestry Management Units (FMUs) that used to be used for commercial harvesting but are no longer considered commercially viable.

15.b.3 ST. THERESA POINT

The availability of significant volumes of burnt wood in the St. Theresa Point region is perhaps the most significant issue in considering heating options for this community.

A close second is the experience of the community in "harvesting" derelict vehicles. The equipment used collected derelict vehicles is likely to be adaptable to biomass harvesting. Many of the skills developed by the community members to did this collection are directly applicable to harvesting, transporting and handling biomass.

It is also significant that this community began an initiative to set up a sawmill.

16 RECOMMENDED NEXT STEPS

16.a Dakota Tipi

In addition to the actions outlined below, Dakota Tipi should begin discussions with Forestry Manitoba to determine the availability of forestry harvesting licenses for approximately 250 tonnes per year—ideally within 50 km of the reserve.

A Council and community discussion is also required to determine the relative importance of the following goals:

- Ease of operation of heating systems
- Reduction of greenhouse gas (GHG) emissions
- Integration of air conditioning into the heating system
- Creation of jobs for community members

Understanding which of these goals are more and less important will help guide the choice of heating systems.

16.a.1 DISTRICT SYSTEM #1 (SCHOOL & OFFICES)

Action on this District System is not recommended until longer-term plans are in place for the use of the School.

Once those plans are in place, a full natural gas consumption history of this building is required. This should be paired with a review of the original design parameters of this building, to determine if the building is operating at maximum efficiency. A review is also needed to determine if the two existing Air Handling Units should be updated with Heat Recovery Ventilation capabilities. Finally, the expected life span of the current HVAC system and furnaces is needed, to understand when (and if) system replacement is required.

16.a.2 DISTRICT SYSTEM #2 (GAMING CENTRE)

It is recommended that a feasibility study of integrating a geothermal system into this building's HVAC systems be conducted before a feasibility study of a biomass system.

16.a.3 DAKOTA TIPI GREENHOUSE

Dakota Tipi's location means that it could operate a commercially-viable greenhouse.

It could also set up and operate a greenhouse associated with the school to promote healthy living and to enrich the educational experience.

16.b Sagkeeng

Sagkeeng should immediately enter into discussions with Manitoba Hydro to determine how much line-clearing biomass material is likely to be available over the next decade in the Sagkeeng region, and if Manitoba Hydro is interested in entering into a long-term contract with Sagkeeng to harvest this material.

Sagkeeng should also begin discussions with Forestry Manitoba to determine the availability of forestry harvesting licenses for approximately 1,000 tonnes per year in areas within 50 km of the community. Among other options, harvesting wood from EA132 (the 2011 forest fire approximately 50 km NE of the community) should be explored with Forestry Manitoba.

16.b.1 NORTH SHORE SCHOOLS SYSTEM

It is recommended that this System be prioritized over the Central Community System.

Both the Schools and the Community Systems have merit, but the possibility of reducing or eliminating propane for School heating is particularly attractive. As well, the opportunity to create a new heating system of the unused former Community School should not be missed.

It is also recommended that the current functioning of the HVAC system in the School be reviewed and, if necessary, re-commissioned. Staff report significant problems with uneven heat in different areas of the building. This review needs to be conducted before (or simultaneously with a full biomass feasibility study for this building).

16.b.2 CENTRAL COMMUNITY SYSTEM

It is recommended that a feasibility study of creating a Biomass District Heating System be conducted for the central community's buildings, as a second priority after the north shore Schools system.

Within the Central Community System, it is recommended that this system be constructed in three phases:

Phase 1: Connect some or all of:

- Office Building
- Public Works Building
- Water Treatment Plant
- Band Office
- Fort Alexander Pharmacy & Health Offices
- Sagkeeng Gaming Centre and Band Hall

Phase 2: Add:

- Sagkeeng Mino Pimatiziwin Family Treatment Centre

Phase 3: Add:

- Sagkeeng Health Centre

The phased-in approach is recommended for a number of reasons:

- The Treatment Centre and the Health Centre are both large buildings.
- The Treatment Centre's heating system is fairly complicated, and will not be as easy to retrofit as the buildings of Phase 1.
- The Medical Centre's heating system is very new. Adding another heating system to it at this time may be disruptive.

16.b.3 SAGKEENG GREENHOUSE

Sagkeeng is too far away from Winnipeg to operate a commercially-focused greenhouse, primarily designed to sell produce outside its community, that can compete successfully in the open market.

Other greenhouses are located much closer to Winnipeg, and they will inevitably have lower transportation costs to bring their goods to market to the province's main market.

However, Sagkeeng could operate a greenhouse that was designed primarily to provide food for community members, and to support local gardening and healthy living initiatives.

If Sagkeeng operated a greenhouse of this sort, attached to a District Heating System, they could also operate it in conjunction with a wood kiln dryer.

16.c St. Theresa Point

St. Theresa Point should immediately enter into discussions with Manitoba Hydro to determine how much line-clearing biomass material is likely to be available over the next decade in and around St. Theresa Point, and if Manitoba Hydro is interested in entering into a long-term contract with St. Theresa Point to harvest this material.

A similar discussion should be started with the Government of Manitoba's Department of Infrastructure regarding harvesting brush at the Airport.

St. Theresa Point should also begin discussions with Forestry Manitoba to determine the availability of forestry harvesting licenses for approximately 1,100 tonnes per year in areas within 20 km of the community. Priority in those discussions should be given to harvesting burnt wood from the 2007 fire just south of the community (on reserve land) as well as NE112 (the 2012 fire just south of the community).

All four of the Biomass District Heating Systems could be constructed. It may be best to prioritize the Medical and Governance System, followed by the Fire Hall & Garages System. Installing these Systems would be relatively straightforward. Starting with one (or two) Systems (rather than all four at once) is likely to increase the chances of long-term success.

16.c.1 ST. THERESA POINT GREENHOUSE

If St. Theresa Point were to undertake a greenhouse initiative again, like Sagkeeng, it would not be viable to grow food primarily for “export” to the larger commercial market.

However, it is possible that it could provide food to the local market at a cost competitive to the Northern Store.

Perhaps even more valuable, it to serve as an education venue for the school, and a source for seedlings and support to people wanting to start their own cold-frame gardens.

Unlike in Sagkeeng or Dakota Tipi, cold-frame systems will be crucial in extending growing seasons for many vegetables.

Figure 102. A Small Cold-Frame Garden

17 APPENDICES

17.a Appendix 1: RETScreen Analysis – Dakota Tipi System #1

RETScreen Load & Network Design - Heating project

Heating project	Unit		Building clusters 1	2	3
Base case heating system	Multiple buildings - space heating				
See technical note on heating network design					
Heated floor area per building cluster	m²	2,194	1,247	214	733
Number of buildings in building cluster	building	4	1	2	1
Fuel type			Biomass	Biomass	Biomass
Seasonal efficiency	%	-	75%	75%	75%
Heating load calculation					
Heating load for building cluster	W/m²	-	72	257	20
Domestic hot water heating base demand	%	15%			
Total heating	MWh	403	227	139	37
Total peak heating load	kW	159	90	55	15
Fuel consumption - unit		-	t	t	t
Fuel consumption - annual		-	55	34	9
Fuel rate - unit		-	$/t	$/t	$/t
Fuel rate		-	150.000	150.000	150.000
Fuel cost	$	14,700	$ 8,278	$ 5,071	$ 1,352
Proposed case energy efficiency measures					
End-use energy efficiency measures	%	0%			
Net peak heating load	kW	159	90	55	15
Net heating	MWh	403	227	139	37

RETScreen Energy Model - Heating project

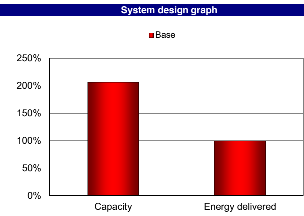
☐ Show alternative units

Proposed case heating system			
System selection	Base load system		
Base load heating system			
Technology	Biomass system		
Fuel selection method	Single fuel		
Fuel type	Biomass		
Fuel rate	$/t	150.000	
Biomass system			
Capacity	kW	330.0	207.0%
Heating delivered	MWh	403	100.0%
Manufacturer			
Model			
Seasonal efficiency	%	75%	
Boiler type		Hot water	
Fuel required	GJ/h	1.6	

See product database

Proposed case system characteristics	Unit	Estimate	%
Heating			
Base load heating system			
Technology		Biomass system	
Capacity	kW	330.0	207.0%
Heating delivered	MWh	403	100.0%
Peak load heating system			
Technology		Boiler	
Fuel type		Natural gas - m³	
Fuel rate	$/m³		
Suggested capacity	kW	0.0	
Capacity	kW		0.0%
Heating delivered	MWh	0.0	0.0%
Manufacturer			See PDB
Model			
Seasonal efficiency	%		
Back-up heating system (optional)		Peak system not required	
Technology			
Capacity	kW		

System design graph



Proposed case system summary	Fuel type	Fuel consumption - unit	Fuel consumption	Capacity (kW)	Energy delivered (MWh)
Heating					
Base load	Biomass	t	98	330	403
Peak load	Natural gas	m³	0	0	0
			Total	330	403

17.b Appendix 2: RETScreen Analysis – Dakota Tipi System #2

RETScreen Load & Network Design - Heating project

Heating project	Unit	
Base case heating system	Single building - space heating	
Heated floor area for building	m²	1,006
Fuel type		Biomass
Seasonal efficiency	%	75%
Heating load calculation		
Heating load for building	W/m²	67.0
Domestic hot water heating base demand	%	5%
Total heating	MWh	155
Total peak heating load	kW	67.4
Fuel consumption - annual	t	38
Fuel rate	$/t	150.000
Fuel cost		$ 5,648
Proposed case energy efficiency measures		
End-use energy efficiency measures	%	
Net peak heating load	kW	67.4
Net heating	MWh	155

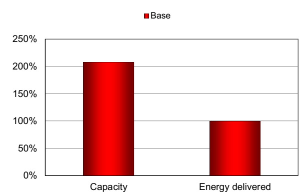
RETScreen Energy Model - Heating project

☐ Show alternative units

Proposed case heating system				
System selection	Base load system			
Base load heating system				
Technology	Biomass system			
Fuel selection method	Single fuel			
Fuel type	Biomass			
Fuel rate	$/t	150.000		
Biomass system				
Capacity	kW	140.0	207.7%	See product database
Heating delivered	MWh	155	100.0%	
Manufacturer				
Model				
Seasonal efficiency	%	75%		
Boiler type		Hot water		
Fuel required	GJ/h	0.7		

Proposed case system characteristics	Unit	Estimate	%	
Heating				
Base load heating system				
Technology		Biomass system		
Capacity	kW	140.0	207.7%	
Heating delivered	MWh	155	100.0%	
Peak load heating system				
Technology		Boiler		
Fuel type		Biomass		
Fuel rate	$/t	150.000		
Suggested capacity	kW	0.0		
Capacity	kW	0	0.0%	
Heating delivered	MWh	0.0	0.0%	
Manufacturer			See PDB	
Model				
Seasonal efficiency	%			
Back-up heating system (optional)		Peak system not required		
Technology				
Capacity	kW			

System design graph



Proposed case system summary	Fuel type	Fuel consumption - unit	Fuel consumption	Capacity (kW)	Energy delivered (MWh)
Heating					
Base load	Biomass	t	38	140	155
Peak load	Biomass	t	0	0	0
			Total	**140**	**155**

17.c Appendix 3: RETScreen Analysis – Sagkeeng Central Community System

RETScreen Load & Network Design - Heating project

Heating project	Unit			1	2	3	4	5	6	7	8
Base case heating system	Multiple buildings - space heating										
See technical note on heating network design			Building clusters								
Heated floor area per building cluster	m²	8,880		278	471	517	508	598	1,600	3,582	1,326
Number of buildings in building cluster	building	8		1	1	1	1	1	1	1	1
Fuel type				Biomass	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass
Seasonal efficiency	%	-		75%	75%	75%	75%	75%	75%	75%	75%
Heating load calculation											
Heating load for building cluster	W/m²	-		78	114	177	48	77	28	74	75
Domestic hot water heating base demand	%	3%									
Total heating	MWh	1,742		58	145	246	66	124	121	714	268
Total peak heating load	kW	647		22	54	92	24	46	45	265	99
Fuel consumption - unit		-		t	t	t	t	t	t	t	t
Fuel consumption - annual		-		14	35	60	16	30	29	173	65
Fuel rate - unit		-		$/t	$/t	$/t	$/t	$/t	$/t	$/t	$/t
Fuel rate		-		150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000
Fuel cost	$	63,468		$ 2,128	$ 5,270	$ 8,982	$ 2,393	$ 4,519	$ 4,397	$ 26,017	$ 9,761
Proposed case energy efficiency measures											
End-use energy efficiency measures	%	0%									
Net peak heating load	kW	647		22	54	92	24	46	45	265	99
Net heating	MWh	1,742		58	145	246	66	124	121	714	268

RETScreen Energy Model - Heating project

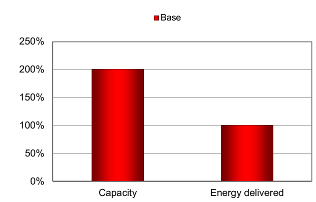
☐ Show alternative units

Proposed case heating system			
System selection	Base load system		
Base load heating system			
Technology	Biomass system		
Fuel selection method	Single fuel		
Fuel type	Biomass		
Fuel rate	$/t	150.000	
Biomass system			
Capacity	kW	1,300.0	201.0%
Heating delivered	MWh	1,742	100.0%
Manufacturer			
Model			
Seasonal efficiency	%	75%	
Boiler type		Hot water	
Fuel required	GJ/h	6.2	

See product database

Proposed case system characteristics	Unit	Estimate	%
Heating			
Base load heating system			
Technology		Biomass system	
Capacity	kW	1,300.0	201.0%
Heating delivered	MWh	1,742	100.0%
Peak load heating system			
Technology		Boiler	
Fuel type		Biomass	
Fuel rate	$/t		
Suggested capacity	kW	0.0	
Capacity	kW		0.0%
Heating delivered	MWh	0.0	0.0%
Manufacturer			*See PDB*
Model			
Seasonal efficiency	%	Peak system not required	
Back-up heating system (optional)			
Technology			
Capacity	kW		

System design graph



Proposed case system summary	Fuel type	Fuel consumption - unit	Fuel consumption	Capacity (kW)	Energy delivered (MWh)
Heating					
Base load	Biomass	t	423	1,300	1,742
Peak load	Biomass	t	0	0	0
			Total	1,300	1,742

17.d Appendix 4: RETScreen Analysis – Sagkeeng Schools System

RETScreen Load & Network Design - Heating project

Heating project	Unit			Building clusters 1	2
Base case heating system	Multiple buildings - space heating				
See technical note on heating network design				1	2
Heated floor area per building cluster	m²	6,131		3,391	2,740
Number of buildings in building cluster	building	2		1	1
Fuel type				Biomass	Biomass
Seasonal efficiency	%	-		75%	75%
Heating load calculation					
Heating load for building cluster	W/m²	-		73.1	73.1
Domestic hot water heating base demand	%	10%			
Total heating	MWh	1,288		713	576
Total peak heating load	kW	448		248	200
Fuel consumption - unit		-		t	t
Fuel consumption - annual		-		173	140
Fuel rate - unit		-		$/t	$/t
Fuel rate		-		150.000	150.000
Fuel cost		$	46,941	$ 25,963	$ 20,978
Proposed case energy efficiency measures					
End-use energy efficiency measures	%	0%			
Net peak heating load	kW	448		248	200
Net heating	MWh	1,288		713	576

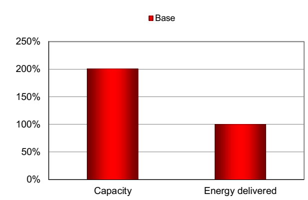
RETScreen Energy Model - Heating project

☐ Show alternative units

Proposed case heating system				
System selection	Base load system			
Base load heating system				
Technology	Biomass system			
Fuel selection method	Single fuel			
Fuel type	Biomass			
Fuel rate	$/t	150.000		
Biomass system				
Capacity	kW	900.0	200.8%	*See product database*
Heating delivered	MWh	1,288	100.0%	
Manufacturer				
Model				
Seasonal efficiency	%	75%		
Boiler type		Hot water		
Fuel required	GJ/h	4.3		

Proposed case system characteristics	Unit	Estimate	%
Heating			
Base load heating system			
Technology		Biomass system	
Capacity	kW	900.0	200.8%
Heating delivered	MWh	1,288	100.0%
Peak load heating system			
Technology		Boiler	
Fuel type		Biomass	
Fuel rate	$/t		
Suggested capacity	kW	0.0	
Capacity	kW		0.0%
Heating delivered	MWh	0.0	0.0%
Manufacturer			*See PDB*
Model			
Seasonal efficiency	%		
Back-up heating system (optional)		Peak system not required	
Technology			
Capacity	kW		

System design graph



Proposed case system summary	Fuel type	Fuel consumption - unit	Fuel consumption	Capacity (kW)	Energy delivered (MWh)
Heating					
Base load	Biomass	t	313	900	1,288
Peak load	Biomass	t	0	0	0
			Total	**900**	**1,288**

17.e Appendix 5: RETScreen Analysis – St. Theresa Point North Community System

RETScreen Load & Network Design - Heating project

Heating project	Unit			1	2	3	4	5	6	7
Base case heating system	Multiple buildings - space heating									
See technical note on heating network design				**Building clusters**						
Heated floor area per building cluster	m²	5,130		776	551	2,523	103	480	327	370
Number of buildings in building cluster	building	7		1	1	1	1	1	1	1
Fuel type				Biomass	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass
Seasonal efficiency	%	-		75%	75%	75%	75%	75%	75%	75%
Heating load calculation										
Heating load for building cluster	W/m²	-		101	101	16.5	101	63	101	101
Domestic hot water heating base demand	%									
Total heating	MWh	676		185	131	98	25	71	78	88
Total peak heating load	kW	287		78	56	42	10	30	33	37
Fuel consumption - unit		-		t	t	t	t	t	t	t
Fuel consumption - annual		-		45	32	24	6	17	19	21
Fuel rate - unit		-		$/t	$/t	$/t	$/t	$/t	$/t	$/t
Fuel rate		-		200.000	200.000	200.000	200.000	200.000	200.000	200.000
Fuel cost		$	32,836	$ 8,977	$ 6,374	$ 4,768	$ 1,191	$ 3,463	$ 3,783	$ 4,280
Proposed case energy efficiency measures										
End-use energy efficiency measures	%	0%								
Net peak heating load	kW	287		78	56	42	10	30	33	37
Net heating	MWh	676		185	131	98	25	71	78	88

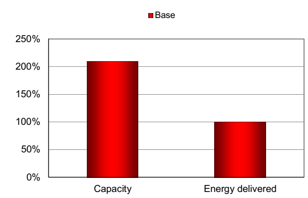
RETScreen Energy Model - Heating project

☐ Show alternative units

Proposed case heating system				
System selection	Base load system			
Base load heating system				
Technology	Biomass system			
Fuel selection method	Single fuel			
Fuel type	Biomass			
Fuel rate	$/t	200.000		
Biomass system				
Capacity	kW	600.0	209.3%	*See product database*
Heating delivered	MWh	676	100.0%	
Manufacturer				
Model				
Seasonal efficiency	%	75%		
Boiler type		Hot water		
Fuel required	GJ/h	2.9		

Proposed case system characteristics	Unit	Estimate	%
Heating			
Base load heating system			
Technology		Biomass system	
Capacity	kW	600.0	209.3%
Heating delivered	MWh	676	100.0%
Peak load heating system			
Technology		Boiler	
Fuel type		Biomass	
Fuel rate	$/t		
Suggested capacity	kW	0.0	
Capacity	kW		0.0%
Heating delivered	MWh	0.0	0.0%
Manufacturer			*See PDB*
Model			
Seasonal efficiency	%		
Back-up heating system (optional)		Peak system not required	
Technology			
Capacity	kW		

System design graph



Proposed case system summary	Fuel type	Fuel consumption - unit	Fuel consumption	Capacity (kW)	Energy delivered (MWh)
Heating					
Base load	Biomass	t	164	600	676
Peak load	Biomass	t	0	0	0
			Total	**600**	**676**

17.f Appendix 6: RETScreen Analysis – St. Theresa Point Medical and Governance System

RETScreen Load & Network Design - Heating project

Heating project	Unit		1	2	3	4
Base case heating system	Multiple buildings - space heating					
See technical note on heating network design			**Building clusters**			
Heated floor area per building cluster	m²	4,000	1,300	1,630	790	280
Number of buildings in building cluster	building	4	1	1	1	1
Fuel type			Biomass	Biomass	Biomass	Biomass
Seasonal efficiency	%	-	75%	75%	75%	75%
Heating load calculation						
Heating load for building cluster	W/m²	-	36.3	79.2	130	93
Domestic hot water heating base demand	%	10%				
Total heating	MWh	787	122	333	265	67
Total peak heating load	kW	305	47	129	103	26
Fuel consumption - unit		-	t	t	t	t
Fuel consumption - annual		-	30	81	64	16
Fuel rate - unit		-	$/t	$/t	$/t	$/t
Fuel rate		-	200.000	200.000	200.000	200.000
Fuel cost		$ 38,233	$ 5,915	$ 16,181	$ 12,873	$ 3,264
Proposed case energy efficiency measures						
End-use energy efficiency measures	%	0%				
Net peak heating load	kW	305	47	129	103	26
Net heating	MWh	787	122	333	265	67

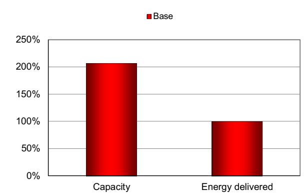
RETScreen Energy Model - Heating project

☐ Show alternative units

Proposed case heating system				
System selection	Base load system			
Base load heating system				
Technology	Biomass system			
Fuel selection method	Single fuel			
Fuel type	Biomass			
Fuel rate	$/t	200.000		
Biomass system				
Capacity	kW	630.0	206.5%	*See product database*
Heating delivered	MWh	787	100.0%	
Manufacturer				
Model				
Seasonal efficiency	%	75%		
Boiler type		Hot water		
Fuel required	GJ/h	3.0		

Proposed case system characteristics	Unit	Estimate	%
Heating			
Base load heating system			
Technology		Biomass system	
Capacity	kW	630.0	206.5%
Heating delivered	MWh	787	100.0%
Peak load heating system			
Technology		Boiler	
Fuel type		Biomass	
Fuel rate	$/t		
Suggested capacity	kW	0.0	
Capacity	kW		0.0%
Heating delivered	MWh	0.0	0.0%
Manufacturer			*See PDB*
Model			
Seasonal efficiency	%		
Back-up heating system (optional)		Peak system not required	
Technology			
Capacity	kW		

System design graph



Proposed case system summary	Fuel type	Fuel consumption - unit	Fuel consumption	Capacity (kW)	Energy delivered (MWh)
Heating					
Base load	Biomass	t	191	630	787
Peak load	Biomass	t	0	0	0
			Total	**630**	**787**

17.g Appendix 7: RETScreen Analysis – St. Theresa Point Fire Hall & Garages System

RETScreen Load & Network Design - Heating project

Heating project	Unit					
Base case heating system	Multiple buildings - space heating					
See technical note on heating network design			**Building clusters**			
			1	2	3	4
Heated floor area per building cluster	m²	618	214	142	177	85
Number of buildings in building cluster	building	4	1	1	1	1
Fuel type			Biomass	Biomass	Biomass	Biomass
Seasonal efficiency	%	-	75%	75%	75%	75%
Heating load calculation						
Heating load for building cluster	W/m²	-	207	97	270	500
Domestic hot water heating base demand	%	10%				
Total heating	MWh	383	114	36	123	110
Total peak heating load	kW	148	44	14	48	43
Fuel consumption - unit		-	t	t	t	t
Fuel consumption - annual		-	28	9	30	27
Fuel rate - unit		-	$/t	$/t	$/t	$/t
Fuel rate		-	200.000	200.000	200.000	200.000
Fuel cost	$	18,596	$ 5,552	$ 1,726	$ 5,990	$ 5,327
Proposed case energy efficiency measures						
End-use energy efficiency measures	%	0%				
Net peak heating load	kW	148	44	14	48	43
Net heating	MWh	383	114	36	123	110

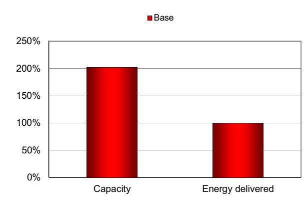
RETScreen Energy Model - Heating project

☐ Show alternative units

Proposed case heating system				
System selection	Base load system			
Base load heating system				
Technology	Biomass system			
Fuel selection method	Single fuel			
Fuel type	Biomass			
Fuel rate	$/t	200.000		
Biomass system				
Capacity	kW	300.0	202.2%	*See product database*
Heating delivered	MWh	383	100.0%	
Manufacturer				
Model				
Seasonal efficiency	%	75%		
Boiler type		Hot water		
Fuel required	GJ/h	1.4		

Proposed case system characteristics	Unit	Estimate	%	
Heating				
Base load heating system				
Technology		Biomass system		
Capacity	kW	300.0	202.2%	
Heating delivered	MWh	383	100.0%	
Peak load heating system				
Technology		Boiler		
Fuel type		Biomass		
Fuel rate	$/t	0.000		
Suggested capacity	kW	0.0		
Capacity	kW	0	0.0%	
Heating delivered	MWh	0.0	0.0%	
Manufacturer			*See PDB*	
Model				
Seasonal efficiency	%			
Back-up heating system (optional)		Peak system not required		
Technology				
Capacity	kW			

System design graph



Proposed case system summary	Fuel type	Fuel consumption - unit	Fuel consumption	Capacity (kW)	Energy delivered (MWh)
Heating					
Base load	Biomass	t	93	300	383
Peak load	Biomass	t	0	0	0
			Total	**300**	**383**

17.h Appendix 8: RETScreen Analysis – St. Theresa Point Schools System

RETScreen Load & Network Design - Heating project

Heating project	Unit		Building clusters 1	Building clusters 2
Base case heating system	Multiple buildings - space heating			
See technical note on heating network design			**1**	**2**
Heated floor area per building cluster	m²	8,200	5,300	2,900
Number of buildings in building cluster	building	2	1	1
Fuel type			Biomass	Biomass
Seasonal efficiency	%	-	75%	75%
Heating load calculation				
Heating load for building cluster	W/m²	-	84.5	68.4
Domestic hot water heating base demand	%	15%		
Total heating	MWh	1,752	1,214	538
Total peak heating load	kW	646	448	198
Fuel consumption - unit		-	t	t
Fuel consumption - annual		-	295	131
Fuel rate - unit		-	$/t	$/t
Fuel rate		-	200.000	200.000
Fuel cost		$ 85,107	$ 58,982	$ 26,124
Proposed case energy efficiency measures				
End-use energy efficiency measures	%	0%		
Net peak heating load	kW	646	448	198
Net heating	MWh	1,752	1,214	538

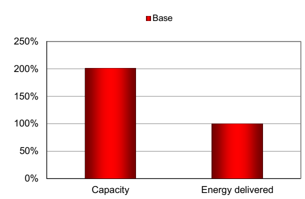
RETScreen Energy Model - Heating project

☐ Show alternative units

Proposed case heating system	Unit	Value	%	
System selection		Base load system		
Base load heating system				
Technology		Biomass system		
Fuel selection method		Single fuel		
Fuel type		Biomass		
Fuel rate	$/t	200.000		
Biomass system				
Capacity	kW	1,300.0	201.2%	*See product database*
Heating delivered	MWh	1,752	100.0%	
Manufacturer				
Model				
Seasonal efficiency	%	75%		
Boiler type		Hot water		
Fuel required	GJ/h	6.2		

Proposed case system characteristics	Unit	Estimate	%
Heating			
Base load heating system			
Technology		Biomass system	
Capacity	kW	1,300.0	201.2%
Heating delivered	MWh	1,752	100.0%
Peak load heating system			
Technology		Boiler	
Fuel type		Biomass	
Fuel rate	$/t	0.000	
Suggested capacity	kW	0.0	
Capacity	kW		0.0%
Heating delivered	MWh	0.0	0.0%
Manufacturer			*See PDB*
Model			
Seasonal efficiency	%		
Back-up heating system (optional)		Peak system not required	
Technology			
Capacity	kW		

System design graph



Proposed case system summary	Fuel type	Fuel consumption - unit	Fuel consumption	Capacity (kW)	Energy delivered (MWh)
Heating					
Base load	Biomass	t	426	1,300	1,752
Peak load	Biomass	t	0	0	0
			Total	**1,300**	**1,752**