Case Study: Garden Village District Biomass Heating

Introduction

District heating consists of energy generation technology and a means of distributing the heat generated in a centralized plant to homes or other buildings. The main viability indicators of such systems are the costs of the pipe work that distributes the heat and the sufficiency of customers for the heat. *(idea.gov.uk[1])*

When in the right location, district heating is an ideal opportunity for communities to use an effective, low-carbon, low-risk heating system that provides good long-term financial returns. In addition, the pipe work, if installed well, will last for many decades. This means that energy generators can be eventually changed to suit the most favorable fuel on the market. When the fuel used is renewable, such as wood chips and wood pellets, this can be a zero-carbon technology that is affordable, financially viable and environmentally friendly. *(idea.gov.uk[2])*

The Area

Garden Village, a Nipissing First Nation community, is located approximately 45 km east of North Bay, Ontario. The community is building a new sub-division consisting of approximately 88 residence lots. Technical infrastructure built so far consists of a water system, sewage system and paved roads. Approximately 7 houses have been built to date and the rest of lots are marked. The community has no access to natural gas and is looking for other options for heat besides electricity. With a preference for renewable energy, district biomass heating is one of the possibilities applicable.

This is a study about the feasibility, costs and possible benefits of placing a wood pellet boiler for community district heating in the new subdivision in Garden Village.

Heating with Electricity

One standard house was used to estimate the cost of heating with electricity. Basic specifications:

- 1000 sq ft
- 3 people living in the house
- Walls 2x6 construction
- 1 ½ foam insulation + blown insulation in 2009 (R2000 rating)

Electric bills from March 2009 to December 2010 were used to determine the costs for the heat.

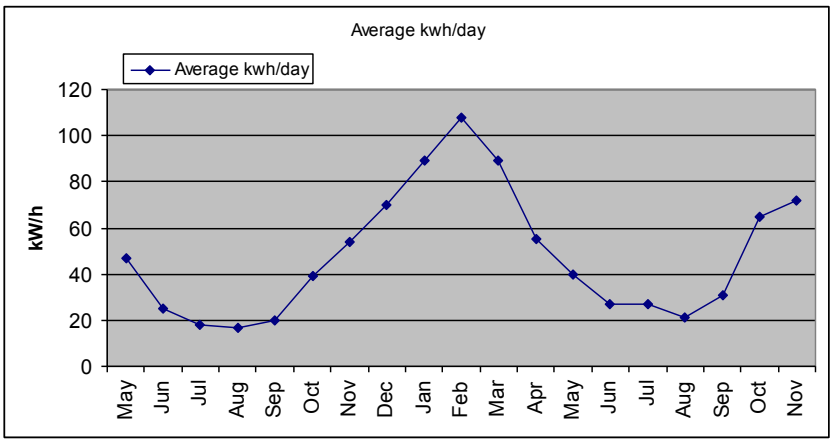

Figure 1. Electricity usage and estimated consumption for space and water heating (Mar 2009 – Dec 2010).

However, there's a need to eliminate the consumption of electrical appliances that are not used for heating by lowering the graph by average 22 kWh consumed in the summer. The assumption of 22 kWh was determined by the average usage of electricity in months June, July and August, when there's no expected heating consumption when all the electrical appliances except heating system are in use.

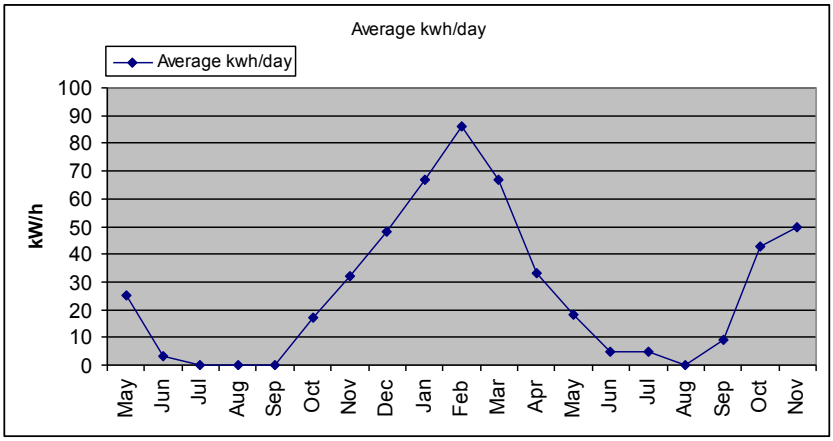

Figure 2. Assumed electricity consumption for heating only (Mar 2009 – Dec 2010).

After the elimination of all the other electrical appliances, the cost of electrical heating during one year would be as shown on the next figure.

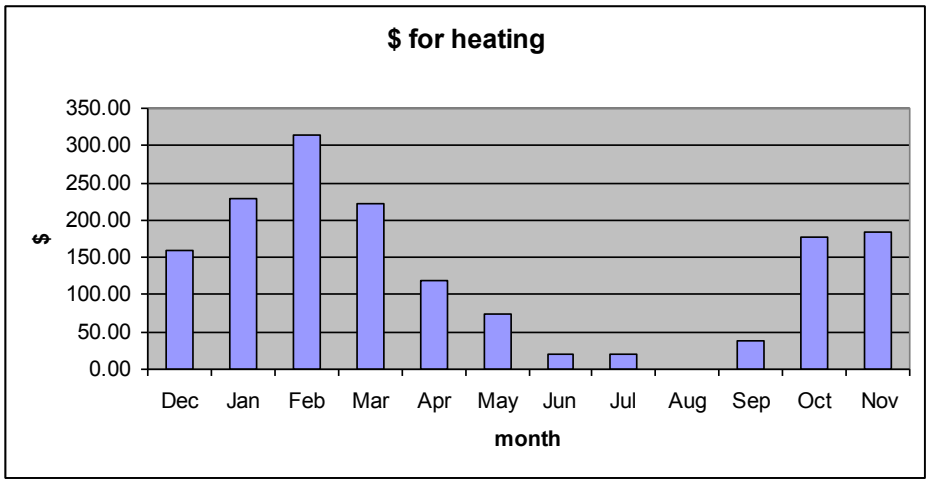

Figure 3. Cost of heating by electricity in the chosen standard house (Dec 2009 – Dec 2010).

According to the hydro bills, total consumption of electricity for heating for one year in one house equals 13096 kWh. The total cost for one year heating by electricity is 2576 $ (Nov 2009 – Nov 2010).

Based on previous findings, it can be assumed that for the whole subdivision of 88 houses there will be a need for 1,152 GWh worth of energy, which is approximately 4 GBtu/Year.

The peak load of the heating system for one house is estimated at 16 kW. Therefore, peak load of the electric system for the whole subdivision is 1.4 MW. The installation of an electric heating system into one house is estimated at $3000 *(Dom's Electric, personal communication, November 22, 2011).*

Heating with Biomass

The most important factor in selecting a boiler is the fuel. Wood pellets are the easiest fuel to handle and to burn since there are clear guidelines and codes for wood pellet production. Wood chips vary a lot in moisture and bark content, which will influence the efficiency of the boiler as well as the fuel handling system.

Viessmann biomass boiler, Pyrot, is best for pellets and consistent wood chips with up to 35% moisture. For a 1.4 MW system, the cost expectation is around $700,000 to $1,000,000 (total equipment list for installation), depending of the type of fuel and boiler combination *(Kai Menges, personal communication, November 28, 2011).*

Heating with Electricity

(the numbers and calculations can be found in appendix)

Based on estimations, the cost of electric heating in the whole subdivision would be:

- Installation of electric heating system for the subdivision: $264,000
- Cost of heating by electricity: $227,000/Year

Note: A few houses in the subdivision are already built; all of them are using electricity for heating.

Heating with Wood Pellets

- Installation of biomass boiler: $700,000 up to $1,000,000
- Cost of heating: $63,000/Year

For this project wood pellets are chosen. The cost of pellets is set to $220/ton. Further, wood pellets have heat content of approximately 17.6 MBtu/tonne. However, after the consideration of reasonable combustion efficiency, from 1 ton of wood pellets it is possible to get approximately 14 MBtu/ton. With these numbers, it is estimated that 286 tons of wood pellets are needed for the subdivision per year. (*Roland Kilpatrick, personal communication, December 5, 2011)*

Distribution System

The distribution system is the most expensive item on the list. The estimation for this project is $2000/1 meter of piping (thus $2,000,000 for the subdivision heat distribution system). Another significant item is the cost of installing the heat distribution system within each house, including an energy meter. This could be either:

a) a hot water radiator system, or
b) a forced air furnace system.

(Roland Kilpatrick, personal communication, December 5, 2011)

The estimated cost of heat distribution system within each house (which would serve for both space heating and domestic hot water) would be $10,000 to $12,000 per home. *(Bard Skagestad, personal communication, November 30, 2011).* Based on the information, total estimated price of the distribution system including piping and system in individual houses would be $3,000,000.

Conclusions

The price and heat content of wood pellets can vary. For this calculation, the approximate price of 220$/tonne and 14MBtu/tonne is used. Thus, heating with wood pellets would annually cost only approximately 28% of the electricity heating price. Still, there's a need to consider the installation costs of a biomass boiler and even more, the distribution system, which would be the biggest item on the list.

Comparison

	Electric	**Biomass**
Installation	$264,000	$4,000,000
Annual Costs for fuel	$227,000	$63,000

If the current price of electricity and wood pellets would stay the same for the next few decades, the economic return of the investment into this biomass boiler would be approximately 23 years. Forecasting of the prices of electricity and wood pellets are outside of the area of this study. Further, in order to have a safe heating system, there's a need to have a backup heating unit, which is also not a part of this study.

References

idea.gov.uk[1] – Local Government Improvement and Development: District heating, Page published on January 2011, Document retrieved: November 28, 2011 from: http://www.idea.gov.uk/idk/core/page.do?pageId=23210852

idea.gov.uk[2] – Local Government Improvement and Development: Benefits and potential impacts of district heating, Page published on January 2011, Document retrieved: November 28, 2011 from: http://www.idea.gov.uk/idk/core/page.do?pageId=24409332

Appendix: Numbers and Calculations

Total cost for one year heating by electricity: $2576 (Nov 2009 – Nov 2010)
Total cost of heating the subdivision by electricity for 1 year: $2576 * 88 houses = $226,688
Total consumption of electricity for heating for one year in one house: 13096 kWh
Total estimated energy consumption of the subdivision: 13096kWh * 88 = 1.152 GWh
(1 kWh = 3412.3 BTU); after conversion: 4 GBtu/Year
(Hydro One electric bills 2009-2010)

Energy possible to get from 1 ton of wood pellets: 14 MBtu/ton
Amount of wood pellets needed for the subdivision for 1 year: 4000 MBtu / 14 Mbtu = 286 ton
The price of wood pellets: $220/ton
Price of wood pellets for heating the subdivision for 1 year: $62,920
(Roland Kilpatrick, personal communication, December 5, 2011)

Peak energy needed in coldest days in specified location: 16 kW (Dom's Electric)
Peak energy needed for the subdivision: 16 kW * 88 = 1.4 MW
Installation of electric heating system in one house: $3000
Installation of electric heating into all 88 houses: $3000 * 88 = $264,000
(Dom's Electric, personal communication, November 22, 2011)

Estimated cost of biomass boiler installation: $700.000 up to $1.000.000 (total equipment list price for 1.4 MW system)
(Kai Menges, personal communication, November 28, 2011)

Length of the distribution system needed: 2000m
(Blueprints of the subdivision)

1 meter of distribution system – piping: $1000
Distribution system – piping for the whole subdivision: 2000 m * $1000 = $2,000,000
(Roland Kilpatrick, personal communication, December 5, 2011)

Estimated cost of heat distribution system within each house: $11,000
Estimated cost of heat distribution system in each house in the subdivision: $10,000 * 88 = $1,000,000
(Bard Skagestad, personal communication, November 30, 2011)

Note: because of estimation purposes, calculations are rounded

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