WOODY BIOMASS-BASED BIOENERGY DEVELOPMENT AT THE ATIKOKAN POWER GENERATING STATION: LOCAL PERCEPTIONS AND PUBLIC OPINIONS

BY

CASSIA SANZIDA BATEN

A DOCTORAL THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY (FOREST SCIENCES)

FACULTY OF NATURAL RESOURCES MANAGEMENT
LAKEHEAD UNIVERSITY
APRIL 2014

LIBRARY RIGHTS STATEMENT

A CAUTION TO THE READER

This Ph.D. (Forest Sciences) thesis has been through a formal process of review and comment by three faculty members and an external examiner. It is made available for loan by the Faculty of Natural Resources Management for the purpose of advancing the practice of professional and scientific forestry.

The reader should be aware that opinions and conclusions expressed in this document are those of the student and do not necessarily reflect the opinions of the thesis supervisor, the faculty or Lakehead University.

ABSTRACT

Baten, C.S. 2014. Woody Biomass-based Bioenergy Development at the Atikokan Power Generating Station: Local Perceptions and Public Opinions. Ph.D. Thesis, Lakehead University, Thunder Bay. 272 pp.

Keywords: Woody biomass, bioenergy, local perceptions, public opinions.

To tackle climate change, reduce air pollution and promote development of renewable energy, the Ontario government is investing in the conversion of the coal-based Atikokan Power Generating Station (APGS) in Atikokan, Ontario, to woody biomass feedstock. This research offers one of the first looks at the perspectives of different individuals and groups on converting woody biomass to energy. Using a combination of study instruments which include literature review, surveys, interviews with key informants, semi-structured interviews, and focus group discussions, this dissertation uses qualitative research to provide a picture of the public's opinions and attitudes towards the APGS biomass energy development.

Given Ontario's huge and sustainably managed forest resource, woody biomass is expected to be a major component of renewable energy production in Ontario. The move towards renewable energy that replaces fossil fuels with woody biomass will have considerable socio-economic implications for local and First Nation communities living in and around the bioenergy power generating station. Findings indicate that there is wide support for biomass utilization at the APGS by local people, especially since the project would create sustainable employment. The connection of woody biomass-based energy generation and rural community development provides opportunities and challenges for Atikokan's economic development. Respondents identified economic, environmental and social barriers to biomass utilization, and emphasized trust and transparency as key elements in the successful implementation of the APGS project.

As demand for woody biomass-based energy increases, special attention will be needed to ensure and maintain the social, economic and environmental sustainability of biomass use at the APGS. In this research, respondents' views about biomass utilization for energy mainly focused on forest-related issues rather than energy. In Atikokan much

of the project's social acceptability is directly linked to woody biomass providing job creation and community stability. Given this, it will be important to design policies and projects from a community development perspective to ensure long term community support.

Information provided by this research creates a base for discussions as forest biomass energy becomes a vital issue in Northwestern Ontario, Canada, and other regions of the world. This research provides a look at a community's views using a method that provides breadth of information but that is specific in scope. Further research will be required to determine the reach of these opinions within the stakeholder groups, the general public, and across different regions.

CONTENTS

TABLES

FIGURES

FIGURE PAGE

ACRONYMS

AAC	Annual Allowable Cut
APGS	Atikokan Power Generating Station
CSIS	Canadian Security Intelligence Service
CHP	Combined Heat and Power
DEAT	Department of Environmental Affairs and Tourism
EIA	Energy Information Administration
EPSRC	Engineering and Physical Sciences Research Council
FAO	Food and Agricultural Organization of the United Nations
FBI	Forest BioProducts Inc.
FHR	Forest Harvest Residue
FMU	Forest Management Unit
FRI	Forest Resource Inventory
FSC	Forest Stewardship Council
GHG	Green House Gas
GJ	Gigajoule
gt	green tonne
IEA	International Energy Agency
ha	hectare
kg	kilogram
lbs	pounds
l	litre
MFRC	Minnesota Forest Resources Council
MNDM	Ministry of Northern Development and Mines
MW	Megawatt
MW_e	Megawatt (electricity)
MWh	Megawatt hour
NEB	National Energy Board
NRCan	Natural Resources Canada
ODt	Oven Dry tonne
OLS	Ordinary Linear Regression
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
OME	Ontario Ministry of Energy
OMMAH	Ontario Ministry of Municipal Affairs and Housing
OMNR	Ontario Ministry of Natural Resources
SFL	Sustainable Forest Licence
SEIA	Socio-economic impact assessment
SPSS	Statistical Package for the Social Sciences
PEFC	The Programme for the Endorsement of Forest Certification
t	tonne
USIP	United States Institute of Peace
UW	Underutilized Wood
WHO	World Health Organization

ACKNOWLEDGEMENTS

I would like to acknowledge people who helped me with this PhD study. First and foremost, I would like to thank my supervisor, Dr. Reino Pulkki, Professor, as well as supervisory committee members, Dr. Peggy Smith, Associate Professor and Dr. Chander Shahi, Associate Professor.They have all been very thorough and helpful advisors and guides, leading me to a better understanding than I would have accomplished on my own. I am grateful to Dr. Thomas Johnson, Professor of Agricultural Economics and Director of the Community Policy Analysis Center, University of Missouri-Columbia for reviewing my PhD dissertation as the external evaluator.

I am thankful to Dr. Ulf Runesson, Dean, Faculty of Natural Resources Management, Lakehead University, for his valuable suggestions during my PhD study. In addition, I am grateful that the Ontario Ministry of Energy and Infrastructure, through the Ontario Centres of Excellence, partly funded this research. I appreciate also the assistance from Ms. Anthea Kyle from Lakehead University's Writing Centre, in the final development of the manuscript.

I would like to thank my family for the support they provided on a very regular basis, particularly my husband, Dr. Md. Bedarul Alam, for supporting me to complete this thesis. I am grateful to my father, S. A. Baten, my mother, Nazne Ara, sisters Olia and Dalia, and brother Nasim who gave me courage to pursue my PhD research. Finally, I would like to thank all the other people who gave me support to complete my research and dissertation.

CHAPTER 1

INTRODUCTION

All living systems require energy for growth, development and protection. This principle is true from a single-cell organism to a complex ecological community and in the same way applies to human communities (Vertès 2010). Access to humanity's basic needs is mostly dependent on different forms of energy (Daily and Ehrlich 1996; Virginia *et al.* 2013). In ancient times until the middle of the 18th century, biomass was the energy used for survival and as global fuel for economic growth. After this period, fossil fuels such as coal were used not only because they were abundant, but also because they were denser in energy content (Abbasi and Abbasi 2010). The energy consumed through present day human activity is predominantly derived from carbon-based sources, with approximately 80% of the global primary energy supply met through three fossil-carbon sources: oil (35%), coal (26%) and natural gas (21%) (EIA 2008a). An additional 10% of the world's energy supply comes from the combustion of biomass materials such as wood, straw, dung and waste (EIA 2008b). Out of all energy sources, woody biomass has the best potential to be converted into renewable bioenergy since it has the advantage of reducing greenhouse gas (GHG) emissions while being a sustainable energy source (Ediger and Kentel 1999; Ushiyma 1999; Nagel 2000; Pari 2001; Berndes *et al.* 2003; Gan and Smith 2006a; Smith and Web 2013). In addition to its positive environmental effects, replacing fossil fuels with woody biomass for energy production provides an excellent opportunity to increase rural economic activities (Bradley 2006; van der Horst and Vermeylen 2011).

Globally, the projected future scarcity of fossil fuels and the adverse social, economic and ecological impacts related to its use have encouraged the growth of renewable based energy. Hall (2000) examined the importance of energy supply for wealth creation and sustainable development, and suggested that the creation of wealth has a close relationship with the use of energy per capita. Buchholz *et al.* (2007) suggested that the future development of woody biomass-based bioenergy should follow two principal directions: an increase in bioenergy production in developed countries as an alternative to fossil fuel based energy; and an increase in total bioenergy production in developing countries due to the change from traditional woody biomass use for cooking to modern bioenergy conversion.

Modern societies depend on forests to generate wealth and improve quality of life (Bauen 2006; Virginia *et al.* 2013). According to Morris (2008) and FAO (2008), humans harvest 3.44 billion m^3 of wood annually. Of the wood harvested, 1.88 billion m^3 is fuel wood used to meet daily energy needs for heating and cooking, mainly in developing countries. The remaining 1.56 billion m^3 is used for industrial purposes (FAO 2008).

Today, the complex global economic infrastructure is fuelled by non-renewable hydrocarbons that were formed millions of years ago (Heinberg 2007a). Access to adequate, affordable, and reliable energy is threatened by rising global energy demand and supply constraints. Furthermore, rapid industrialization of the developing world is driving up fossil fuel consumption (IEA 2007) while many oil-producing nations are experiencing declining production and resources. Global competition for the remaining fossil fuel resources could be a subverting factor that leads to shortages, price instability, violence and increased militarization of energy supplies (Hacatoglu 2008). Biomass could be a solution to some of the problems that have resulted from the global dependence on fossil fuels. Currently, advanced technologies of woody biomass utilization have been developed and woody biomass can also be converted to bio-electricity, heat, bio-fuel and bio-gas. The growing popularity of woody biomass in developed countries is due to its renewal and carbon-neutral characteristics (Stupak *et al.* 2007). Potential sources of woody biomass feedstock include forest harvest residues, unutilized wood, mill wood waste, landfill wood waste, energy crops and other solid waste. Unlike fossil fuels, biomass can be replaced within a harvest cycle (Hall 1997; DeYoe 2007). Yet, despite the environmental attractiveness of biomass use, in 2006, Canada obtained only 6% of its total energy needs from biomass sources **(**Hall and Helynen 2006).

According to Abraham (2004), the world is moving ahead on advanced technology options that have the potential to reduce future greenhouse gas (GHG) emissions. About 80% of current GHG emissions are energy related. Agrawal *et al.* (2007) suggested that to provide the energy necessary for continued economic growth, cost-effective technologies are necessary. Due to the complex relations among population growth, economic development, energy demand, resource availability, technology and other variables, it is difficult to accurately predict future greenhouse gas emissions on a 100-year time scale (Samson *et al*. 2008). Ontario's Action Plan on Climate Change includes greenhouse gas reduction targets of 6% below 1990 levels by 2014 and 80% below 1990 levels by 2050 (OMAFRA 2011). Much of these reductions will come from phasing out coal for electricity generation. Ontario is the first jurisdiction in North America and one of the first in the world to legislate the shutdown of coal-fired generation. In 2009, generation from Ontario's coal plants was at its lowest level in 45 years and down more than 70 per cent from 2003 (OMAFRA 2011). Although woody biomass is being considered as an alternative to coal at only two (Atikokan and Thunder Bay) of the existing four generating stations in Ontario, woody biomass-based power generation could provide opportunities at all four facilities after 2014.

In Ontario, climate change is considered as an important driver behind the development of woody biomass-based energy. The EPA (2013) found that when coal is burned, carbon dioxide, sulfur dioxide, nitrogen oxides and mercury compounds are released. According to the EPA (2013), the average emission rates in the United States from coal-fired generation are: 1020 kg/MWh of carbon dioxide, 6 kg/MWh of sulfur dioxide and 3 kg/MWh of nitrogen oxides. Furthermore, additional emissions are generated during mining, cleaning and transporting coal to the power plants (EPA 2013). One tonne of Indiana coal produces 2.26 tonnes CO_2 and 2.25 MWh electricity (1 MWh of power $\approx$ 1 tonne of CO_2 produced). During the same amount of electricity generation, and when compared to coal, woody biomass releases 1.5 times more CO_2 (MEEA 2013). However, the carbon in biomass is considered to be part of the natural carbon cycle, so biomass is considered carbon neutral (MEEA 2013). Trees take in CO_2 from the air, convert it into biomass, and when they die, it is freed back into the air, which mirrors the process when trees are burned or decompose naturally. The idea is that if trees harvested as biomass feedstock are replanted, new trees will take up the CO_2 that was produced by the woody biomass-based electricity generation. The carbon cycle ideally remains in balance, and no additional carbon is added to the air. Since nothing offsets the CO_2 that fossil fuel burning yields, replacing fossil fuels with biomass theoretically results in reduced carbon emissions (Cho 2011). If the forest harvest residues and unmerchantable trees are not used for biomass-based electricity production, they will naturally decompose, releasing CO_2 into the air without the benefit of electricity production (MNRE 2013). A life cycle assessment concluded that biomass generation at Ontario plants would reduce carbon emissions by over 90% compared to coal. These targets put Ontario among global leaders in addressing climate change (OMAFRA 2011).

Canada's biomass resources are extensive and their use as energy can provide many valuable benefits. The great challenge for bioenergy development is that it is not often the lowest cost option, but when disposal services of harvest residues are factored in, biomass use is society's best total package (Layzell *et al.* 2006). However, at the same time, forest managers need to ensure that biodiversity and site productivity are not negatively affected by woody biomass use for energy (DeYoe 2007).

Developing bioenergy projects in rural communities brings important social benefits. For example, the use of woody biomass for bioenergy by Aboriginal communities and small rural communities such as Atikokan, Ontario can bring practical and social advantages. However, the social effects of woody biomass-based energy production are complex and vary from region to region (Hall and Helynen 2006). Borsboom *et al.* (2006) and US Forest Service (2008) point out that the use of bioenergy would benefit small forest-based communities both directly and indirectly. For instance, direct benefits include lower heating costs, added long-term employment and an improved forest operations economy. These lead to the indirect benefits of money being retained in the community, greater community self-reliance and enhanced self-esteem. Furthermore, the use of bioenergy reduces negative environmental impacts (Sims 2003; Rhodes and Keith. 2007; Rhodes and Baker 2008; Evans and Finkral 2009). However, adoption of the new technology is a challenge to institutional conventions and traditional First Nations practices (Domac *et al.* 2005).

Natural Resources Canada (NRCan) reports that 300 rural and remote communities across Canada are economically dependent on the forest industry (OMNR 2008a). The well-being of rural Canada and the Canadian economy generally depends on a strong and vibrant forest products sector that provides opportunities for rural communities. At present, woody biomass in Canada is emerging as a potential important source of energy and other bio-products (Benoit 2008). However, a number of factors, both domestic and international, have led to reduced production, a decline in profitability, mill closures and job losses in Canada's forest products industry. Factors such as the downturn in the U.S. housing market, intensification of global competition, the rapid appreciation of the Canadian currency and productivity deficits have diminished the Canadian forest economy (Mulholland and Vincent 2007). A look at the declining number of people who were employed in the forestry sector in Canada each year from 2005 to 2011 tells the story (NRCan 2012; Rafferty 2012). In 2005, 339,600 Canadians were directly employed in the forestry sector, but in 2010 the numbers had dropped to 238,900, and by 2011, the workforce had dropped by another 5,000 forestry-related jobs (NRCan 2012). In Ontario, the number of people directly employed in the forestry sector was 84,500 in 2005, but in 2010 the number of forest jobs were at

57,000, and by 2011, there was a decline of another 3,500 jobs (NRCan 2012; Rafferty 2012). These losses have occurred almost exclusively in two thirds (200) of the forest dependent communities, mainly the smaller ones, scattered through northern and rural Canada, and the figures account for only ‘direct’ job losses in the sector, excluding ‘secondary’ employment (e.g., shippers, suppliers) and ‘tertiary’ spin-off jobs (i.e., local restaurants) (NRCan 2012; Rafferty 2012).

Business closures and job losses have significant social and economic impacts on forest-dependent communities: families are relocating and separating, health and education services are eroding, and municipal infrastructure is not being renewed in the affected communities (Borsboom *et al.* 2006). For instance, in Atikokan, during 2007 to 2008, Fibratech Mfg. and the Sapawe Sawmill were closed and about 350 people in the community lost their jobs. The total population of Atikokan was about 3,293 in 2006, but by 2011 it showed as being about 2,787 (Statistics Canada 2007a, 2009, 2012). Atikokan is consequently facing a severe economic downturn which threatens the future viability of the community (Town of Atikokan 2012). But luckily there is a turn-around now with the new Resolute Sawmill and the Rentech pellet plant, and the maintaining of the APGS through its conversion to woody-biomass feedstock.

In addition, recognizing the need to reduce air pollution, GHG in particular, in southern Ontario from coal-fired electricity generating stations in 2005, the Ontario government decided to close all four stations by 2014 or to replace coal with biomass or natural gas (OME 2007; McCarthy 2009). The Atikokan Power Generating Station (APGS), located 190 km west of Thunder Bay, is a coal-based power generating plant with a capacity of 215 MW that was operating at 30% of its capacity just before its conversion to woody biomass started (Sygration 2011). At present, the main source of tax income for the Municipality of Atikokan is the APGS. Until 2012, the main source of feedstock at APGS was lignite coal transported from western Canada. For Atikokan, faced with the closure of its coal-fired generating station, based on the province's commitment to decommission its four coal-fired plants, woody biomass can provide an alternative source of energy that will keep the station operating.

Wood pellets manufactured from woody biomass can be used as feedstock in the APGS to produce energy in a technologically and environmentally sound way (NRCan 2006). Since 2005, the APGS has been working on developing woody biomass feedstock for bioenergy production. In July 2008, APGS successfully tested 100% woody biomass (wood pellets) instead of coal (Meadows 2008). In order to replace coal with woody biomass, the APGS needs feedstock of 526,000 oven dry tonnes (ODt)/year, to produce 150 MWe of power. For such a supply, a sustained availability of biomass from the nearby region for APGS is vital. A study conducted by the OME (2007) found that within a 500 km radius of APGS, approximately 2.7 million ODt/year of woody biomass feedstock is available from forest harvest residues, unutilized wood supply and mill wood waste (FBI 2006; OME 2007). This supply of almost 2.7 million ODt/year is well above the just over 0.5 million ODt/year required by the APGS (Layzell *et al.* 2006). Although the capacity is 150 MWe of power, the APGS decision is to use 90,000 t of pellets/year to produce 22 MWe of electricity (OPG 2012).

Canada has a target of 20% of total primary energy demand from now until 2030 to be derived from bioenergy (OMAFRA 2011). It is estimated that the energy content of one ODt of woody biomass is about 19.6 GJ (Etcheverry *et al.* 2004; Hosegood

2010). With a prediction that the total primary energy demand will increase from 12 EJ in 2003 to 15 EJ by 2015 and 17 EJ by 2030 (NEB 2007), the bioenergy target would then increase from 2.4 EJ in 2003 to 3.0 in 2015 and 3.4 EJ by 2030. If woody biomass is estimated to have an average Lower Heating Value (LHV) of 16 GJ ODt $^{-1}$ (Layzell *et al.* 2006), about 150, 180 and 210 million ODt would be required to meet 20% of primary demand in 2003, 2015 and 2030, respectively. To put this into perspective, Canada's forestry and agriculture production is about 165 million ODt per year (Layzell and Pollard 2008), so meeting the target would require a substantial increase in woody biomass-based activities.

Ontario holds 2% of the world's forests and 17% of Canada's forests. The average annual harvest is 220,000 ha out of an allowable limit of 350,000 ha (OMAFRA 2011). Many forest resources are currently under-utilized due to weak markets for traditional forest products, but woody biomass-based bioenergy generation would create a new market for the forest industry. For example, combined heat and power plants can provide energy for mills and be fuelled with mill waste; excess power can be sold into the provincial grid (OMAFRA 2011).

The expected positive socio-economic impacts of a bioenergy project have encouraged development (Domic *et al.* 2004; Reynolds *et al.* 2008; Dwivedi and Alavalapati 2009). Atikokan is one such community that could benefit from a bioenergy project. At present, forest contractors and other stakeholders in the region are facing economic hardships, as most of the big forest industries are closed or have reduced their production. Consequently, the majority of forest industries are not utilizing all of the prescribed harvesting allocations on their allotted Crown forest land. As a result of mill closures and production reductions, abundant unutilized forest resources exist in Northwestern Ontario, which results in unutilized biomass becoming vulnerable to pest attack and wildfire (Reynolds *et al.* 2008). The Ontario government also loses stumpage revenues due to lack of harvesting.

At the present time the population of the of the remote First Nation communities of Northwestern Ontario is increasing (Benoit 2009). These remote First Nation communities use diesel-fuelled generators that consume a large amount of fossil fuels to generate electricity and heat buildings. Continued reliance on fossil fuels for meeting growing energy needs will increase the energy security concerns of these First Nation communities. By establishing collaborations between the existing forest industries and the emerging bioenergy industry, a win-win situation will develop that will ensure the health of the entire sector as well as the region and communities involved (Benoit 2009).

Since woody biomass utilization for electricity generation is relatively new in Canada, there have been few studies examining how different stakeholders and people perceive these projects. This research looks at the social perspectives of converting forest biomass to energy in the region from diverse levels of people from Atikokan and surrounding communities. The main research objective is to understand the views of individuals and groups within Atikokan and its surrounding communities on converting forest biomass to energy at the APGS. A goal of this research is to identify the key elements identified by the local public that must be considered for the development of the APGS bioenergy project.

For the development of a woody biomass-based bioenergy system, stakeholder analysis is a useful approach and, from the beginning, it is important to identify people who want to become involved in the woody biomass-based energy development process. Primarily, stakeholders are comprised of individuals and groups living and working in the surrounding area. Depending on the nature and scale of the development, others with a possible interest could include everyone from non-governmental organizations to policy planners and local government agencies, to heritage organizations and water, waste treatment and waste disposal sectors (Dwivedi and Alavalapati 2009). Other interested parties include First Nation communities, health and safety bodies, environmental and amenity groups, landowners, urban planners and potential growers of the biomass (Felix 2009).

The aim of the research is to explore local public attitudes and opinions about woody biomass utilization for energy development at the APGS. The study explores the major socio-economic characteristics which influenced people who decided to join in woody biomass-based activities linked to the APGS in the future. It evaluates the probable impacts of APGS' woody biomass-based bioenergy systems on the community. By communicating with diverse individuals such as those working in bioenergy development, community organizations and local industry, through formal and informal interviews, surveys, and group discussions, this study was able to identify the factors responsible for optimal management of the APGS bioenergy project.

The objectives of the study are:

1) To identify factors which influence people to participate in woody biomass-based businesses and activities linked to the APGS.

2) To assess the socio-economic impacts of woody biomass utilization for energy production and the impact on communities in the Atikokan area.

3) To explore public perspectives about woody biomass utilization for energy production at the APGS.

The research area covers Atikokan and its surrounding communities. The nearby forest management units (FMUs) surrounding the research area are Crossroute Forest, Dog-River Matawin Forest and Sapawe Forest which fall in two Ontario Ministry of Natural Resources (OMNR) Districts, Fort Frances and Thunder Bay (NWOPA 2007). Biomass utilization is an issue that requires multiple people from a variety of fields and perspectives to implement projects successfully.

To fulfill the first objective of this study, a survey was conducted among local people who are not directly involved in forest-related activities and with contractors and entrepreneurs who are involved in forest-related activities. The survey was conducted to identify factors that would influence their decision to become involved in woody biomass for bioenergy and their opinions on community development, quality of life and woody biomass utilization. The survey was designed to elicit respondents' demographic characteristics; social and economic variables, such as income, business interests, business decisions, access to credit; and perceived barriers to participating in bioenergy-related businesses. From the survey results, a statistical model was developed to identify the major factors that encourage people's involvement linked to the APGS project's activities.

To fulfil the second objective of this study, focus group discussions were held at research sites to gather potential socio-economic impact information concerning the strengths, weaknesses, threats and opportunities (SWOT analysis) of woody biomass-based energy production systems on communities. In Thunder Bay a survey was also conducted with participants of the Grassroots Approach Bioenergy conference for this purpose.

To fulfill the third objective of this study, interviews were conducted at the research sites to obtain social perspectives on converting woody biomass to energy in Atikokan. The third research objective attempted to understand the views of individuals and groups within the Atikokan community about converting woody biomass to energy in Northwestern Ontario; to identify, from the perspectives of Atikokan individuals, the opportunities for and barriers to converting woody biomass to energy; and to explore possible courses of actions to overcome those barriers. In this study, local resource personnel (experts) who are involved with the woody biomass utilization sector in Northwestern Ontario were interviewed to get their perspectives on the system and components of a sustainable woody biomass-based bioenergy system for APGS. The purpose of this process was to generate a sustainability model for the APGS bioenergy project.

As the aim of this research is to assess the probable impacts of APGS' woody biomass-based bioenergy systems on Atikokan and its surroundings, only the view, attitudes and opinions of local people were assessed. This local focus could be a limitation of the study since the attitudes and opinions of other groups such as governmental policy makers, private sector personnel, environmental non-government organizations outside the community are not included, although they may be involved in the decision making process for policy development of woody biomass-based bioenergy. To understand the current woody biomass-based energy development situation, the research methodology, the study's findings and significance, the dissertation is divided into six chapters.

Chapter 1 gives a general introduction to the research topic and thesis, followed by the background of the study. At the end of the chapter, the research objectives, thesis outline, and limitations of the study are described.

Chapter 2 presents the literature review in three sections. The first section discusses the importance of woody biomass for energy development at the APGS and other related issues of woody biomass utilization in Northwestern Ontario. This section describes woody biomass utilization for energy and considers the phase-out of coal for electricity generation in Ontario. The focus then shifts to biomass utilization in Northwestern Ontario, including policies and management guidelines for harvesting residue removal in Canada. The first section of the chapter ends with a description of the woody biomass-based bioenergy test at APGS to check its feasibility for development of a bioenergy plant at APGS. The second section describes Atikokan and discusses the social importance of woody biomass for energy development. Beginning with the history and socio-economic conditions of Atikokan, the section ends with a description of the social issues involved with woody biomass adaptation. The third section presents a sustainability model for the APGS bioenergy system and describes the sustainability potential of such a bioenergy system.

The study's research methods are described in Chapter 3, including the research approach, research methods and data analysis techniques. This section provides a description of the survey, focus group discussion and interview methods followed in the study.

Chapter 4 contains the results and it presents research findings in three sections that correspond to the research methods used. The first section presents the findings from the questionnaire survey that was administered in Atikokan and its surrounding communities. It explores factors affecting involvement in woody biomass production activities in the study area and presents participants' opinions on important factors of community development, quality of life and woody biomass utilization. The second section presents societal perceptions about socio-economic impacts of woody biomass-based bioenergy development in Atikokan. Data were collected from focus group discussions completed in Atikokan and surrounding area, using a SWOT analysis, and from a survey done in Thunder Bay. The third section presents local public opinions about utilizing woody biomass for energy at the APGS. These findings were obtained through interviews on people's perspectives about woody biomass utilization for energy production at the APGS. Interviewees identify the opportunities for and barriers to converting woody biomass to energy, and explore possible courses of actions to overcome those barriers.

Chapter 5 is the discussion; it presents and analyses important research findings that were obtained by the surveys, focus group discussions and interviews. In this section, the findings of the study are tied to the literature of other authors' findings, and looks at economic, environmental, social and policy viewpoints in the study's research and from the literature. This section also discusses woody biomass harvesting, policy guidelines and the sustainability potential for the APGS bioenergy system.

Chapter 6, the conclusion, presents a summary of the research, discussing the main findings and their significance, describing the implications of the study, and suggesting some important future directions for research.

CHAPTER 2

LITERATURE REVIEW

2.1 UTILIZATION OF WOODY BIOMASS FOR ENERGY AND ATIKOKAN POWER GENERATING STATION

2.1.1 Utilization of Woody Biomass for Energy

Biomass is all plant and animal matter on the Earth's surface. Biomass is defined as all non-fossil organic materials including water and land-based plants (trees, shrubs, herbs, grasses, algae, lichen and moss) and all waste biomass such as municipal solid waste, municipal sewage and animal manures, forestry and agricultural residues, and certain types of industrial wastes (Layzell and Pollard 2008). The Ontario Ministry of Natural Resources (OMNR 2008a, 2008b, 2013) defines biofibre/forest biomass as “forest resources from Crown forests that are not normally being utilized for conventional forest products,” and includes “tree tops, cull trees or portions of trees, individual and stands of unmerchantable and unmarketable trees, and trees that may be salvaged as a result of a natural disturbance”. Harvesting biomass such as crops, trees or dung, and using it to generate energy such as heat or electricity is bioenergy (IEA 2006). The interdependency of plants, animals and microbes in natural ecosystems has survived well for billions of years even though they only capture 0.1% of the sun's energy (Pimentel 2001). The solar energy captured by vegetation and converted into plant biomass provides basic resources for all life, including humans. About 50% of the world's biomass is used by humans for food, lumber, pulp, medicines and fuel, and the remaining 50% is used by all other animals and microbes in the natural ecosystem (Pimentel 2001).

The human population is increasing and contributes to the world's diverse environmental problems, including deforestation, industrialization, urbanization and chemical pollution. All these changes negatively impact on biomass production that is vital to human life and biodiversity (WHO 2006). At present and in the foreseeable future the needs of the rapidly growing human population will stress biomass supplies. Also, human intrusion throughout the natural environment is causing a serious loss of biodiversity with as many as 150 species being lost per day (Pimentel and Pimentel 1996; WHO 2006). On the other hand, biomass power is the largest source of renewable energy as well as a vital part of the waste management infrastructure. An increasing global awareness about environmental issues is acting as the driving force behind the use of renewable sources of energy. A greater emphasis is being laid on the promotion of bioenergy in the developed as well as developing world to offset environmental issues (CENBIO 2005; Miranowski 2007; Perley 2008; EPSRC 2009).

Biomass can be used for energy production at different scales, including large-scale power generation (e.g., Combined Heat and Power (CHP)), or small-scale thermal heating projects at governmental, non-governmental or other institutions (CENBIO 2005). A common source of energy from wood is pulping liquor or black liquor, a waste product from the pulp and paper industry (EPSRC 2009). Woody biomass is the most important renewable energy source if proper management of vegetation is ensured. The impacts of utilizing woody biomass for energy affect human environment, economics, society and energy resources (Morris 1999; CENBIO 2005).

The common types of woody biomass-based energy systems are heat production, ethanol production, gasification, pyrolysis and electricity generation. Heat production is the most common conversion system for using biomass resources. Heat from wood and other biomass resources is utilized for cooking food and heating homes, and for producing steam for industry. Each year 1.88 billion m^3 of wood is burned for energy (1,880 million m^3 would be about 850 million ODt). In addition, 300-350 million ODt of mill residues and black liquor are used for energy production (WHO 2006; FAO 2008). In developing countries, about 1.3 billion tonnes of crop residues, and 1 billion tonnes of dung are burned each year (WHO 2006; FAO 2008). The rural poor in developing countries obtain most of their energy needs by burning woody biomass, dung and crop residues: e.g., 55% in China, 77% in Egypt and 90% in Bangladesh (WHO 2006). In the developed countries steam production is used to produce electricity and for industrial use (Tripathi and Sah 2000).

Ethanol is produced by the fermentation of corn and other food crops (Klein *et al.* 2004) and can also get ethanol from woody biomass (Agrawal *et al.* 2007; Zerbe 2006). The ethanol yield from a large plant is about 9.5 litres (l) from 24.5 kg of corn. Large amounts of fossil energy are required to remove the 8% ethanol out of the 92% water (in the distillation process of ethanol production) (Ferguson 2003). In general, 12.4 l of water are needed to produce one litre of ethanol. Based on current ethanol production technology and recent oil prices, the production of ethanol is very costly (Klein *et al.* 2004; Licht 2005; Agrawal *et al.* 2007; NRCan 2009).

Woody biomass with less than 50% moisture can be heated in the presence of air and gasified. On an average, 1 kg of biomass produces about 2.5 m^3 of producer gas. About 11.4 kcal of wood fuel is required to produce 1 kcal of gas (Kishore 2013). The main disadvantage is the cost of operation and maintenance, because equipment for cleaning the gas is expensive (Pimentel *et al.* 2007). Air dried wood or other biomass heated in the absence of oxygen can be converted into oil, gas and other valuable fuels (Ferguson 2003). In addition, the gas from a gasifier-pyrolysis reactor can be further processed to produce methanol. Methanol is used as a liquid fuel in the combustion engines. Based on tropical dry-wood, about 1 ODt of wood yields 14 l of methanol (Ellington *et al.* 1993).

Though most biomass will continue to be used for cooking and heating, it can be converted into electricity. The economic benefits of woody biomass-based electricity are maximized when the source of biomass is close to the processing plant (Pimentel *et al.* 2002). Generally, the cost of producing a kilowatt of electricity from woody biomass ranges from US $0.07-$0.13 (IEA 2006). Approximately 3 kcal of thermal energy is expended to produce 1 kcal of electricity (Gan and Smith 2006a; IEA 2006). In general, about 60-70% of the heat energy produced from burning biomass is lost in its conversion into electricity; this is similar to losses experienced in coal-fired plants (Gan and Smith 2006b). Canada has a competitive advantage to produce bioenergy from woody biomass because it is the world's second largest country; it has 10% of the world's forests, but has only 0.5% of the population (Layzell and Pollard 2008).

2.1.2 The Phase-out of Coal for Electricity Generation in Ontario

In 2009, the Province of Ontario announced that by the end 2014, coal would no longer be used to generate electricity (OME 2009). The main advantage of existing Ontario coal plants – Nanticoke (3,920MW), Lambton (1,975 MW), Atikokan (215MW) and Thunder Bay (310MW) – is that they can be quickly fired up to meet peak energy demands of the province (OPG 2010a). Because the plants are located in the province, transmission costs are minimal, and the plants support overall grid reliability in Ontario and the neighboring U.S. states. Using Fluidized Bed technology, the plants are dependable and flexible in using different forms of combustible materials, including coal, biomass and general waste (World Coal Association 2011). As a fuel, coal is considered convenient since it can be stored on site and comes from relatively abundant and safe sources (World Coal Association 2011). The province's initial case for the suspension of the use of coal was based mainly on air quality and health impacts, then later to counteract climate change by reducing the use of fossil fuels. The literature reveals support for and against the arguments for Ontario's phase out of coal for electricity.

McKitrick (2007) questioned the argument that stopping coal-fired electricity generation would improve air quality. His study showed that closing coal plants has a minimal effect on Ontario's air quality, and that only a slight improvement would be achieved by adding more air pollution control equipment. Toronto's air quality has improved since the 1960's and 1970's and currently meets North American standards although coal is still being used. McKitrick further states that plant closures may impose a larger economic cost on low income consumers, put electricity supplies at risk and slow economic growth.

Forman (2011), the executive director of the Canadian Association of Physicians for the Environment, suggested in *Ontario Nature* magazine that the government should phase out coal-fired energy generation now rather than wait until the proposed date in 2014. He argued that coal is currently not necessary since even without coal, Ontario is still generating more energy than it is using. He contends that Ontario is currently using 18,460 megawatts of electricity, a small portion of which (1,215 MW) is coming from coal-fired generators. Ontario's overall generation capacity is 34,557MW, of which 4,484 MW comes from coal. He concludes that without coal Ontario can still generate over 30,000 MW at maximum capacity, an amount which greatly exceeds the projected peak demands for summer 2011, which was 25,861MW. Forman (2011) is emphatic in his criticisms of coal for electricity generation:

> "Elimination of this dirty black rock is not just practical, it's morally and environmentally essential. No other fuel so powerfully attacks human and environmental health. In 2010, Ontario's coal plants were responsible for 316 deaths and over 150,000 cases of illness (e.g., asthma attacks). The plants are major sources of chromium and arsenic (which cause cancer), sulphur dioxide and nitrogen oxide (which cause acid rain) and lead and mercury (brain poisons)."

Forman argues strongly for phasing out coal-fired generating stations because they are the largest sources of GHGs emissions, not only in Ontario but across North America. He suggests using wind turbines which do not lead to human death, cancer, smog or climate change, and thinks it is time to put "coal in its coffin" (Forman 2011).

In contrast, Adams (2007), at a Conference on the Future of Coal in Ontario, focused on the risks associated with replacing coal by relying on natural gas, wind power and nuclear energy through renovations or new builds. He argued for new coal plants as a "reliable, cost-effective source for base-load electricity that also has ramping capability", which is the ability of a power station to change its output over time (Keith 2007; Kalich and Utilities 2011). Kalich and Utilities (2011) note that wind power has risen in cost in Ontario from 0.08-0.11 $/kWh, which is far above the 0.04-0.05 $/kWh cost of existing coal-fired generation. The feed-in-tariff rate for on-shore wind power is

0.11$/kWh. In addition, evidence suggests wind is not available when needed most and is extremely variable, making balancing system loads more challenging (Adams 2007; Keith 2007; Kalich and Utilities 2011).

Another alternative to coal as a fuel for electricity generation is natural gas. Natural gas has the advantage that it burns more cleanly and with less carbon dioxide emissions than oil or coal. But Ontario already gets 32% of its energy from this source. If the province becomes more dependent on natural gas for its electricity production, the resource's availability may constrain supply and increase cost (OME 2009; OMEnv 2013).

Arguments to preserve coal-fired electricity plants point to supply. Canada has plenty of reserves of coal, mainly in Alberta, Saskatchewan and British Columbia. In Alberta, coal represents 86% of the energy content of all hydrocarbons. Its abundance, relative global dispersion and lower cost per unit of energy than either oil or natural gas mean that coal will continue to be widely utilized on a global basis. As well, coal supporters point out that investing in new technologies to mitigate coal's environmental impacts should be a priority in energy research (OMEnv 2013).

Dewees (2007) reviewed the advantages and disadvantages of two policy options: a ban on coal in Ontario and a carbon tax on each unit (e.g., tonne) of emission. He argued that the only advantage of a ban on coal was its simplicity. The main disadvantage was that it required the costly destruction of existing generation facilities as well as the use of more costly and less reliable energy substitutes. Dewees noted that large industrial polluters usually prefer cap-and-trade models to emissions charges, because they are most often given the initial quota of emissions rights, whereas the tax requires payment on all emissions. Environmentalists also prefer a cap-and-trade model because it regulates the quantity of emissions permitted (Dewees 2007; Markel 2007).

Paris (2011), reporting for CBC, stated that among the four parties in the Canadian House of Commons, three parties support the idea of introducing a cap-and-trade system to control carbon emissions. According to Paris (2011):

> "Cap-and-trade is a market-based system where the government puts a cap on the total amount of pollution industry is allowed to emit. Each company would receive permits for how much pollution it could produce. If a company produced less than its limit, it could sell or trade permits to other companies that have gone over their limit."

But he argued that very few Canadians have understood how this system would work (Paris 2011).

Hill (2007) reported that people are more accepting of a carbon tax than a cap-and-trade system, and that acceptance depends on the belief in the seriousness of the global warming problem. Hill (2007) recommended that the tax should be started low and be increased over time. McKitrick (2007) recommended that the tax should be between 16 and 50 $/t (CAD) of carbon dioxide. He recommends that Ontario should follow the Quebec system where such a tax has already been introduced (McKitrick 2007).

In the US, Japan and Europe, research that leads to initiatives promoting clean coal is supported by their governments. Ontario has an opportunity to undertake a similar focused effort, not on clean coal, but on the use of woody biomass to replace coal-fired generation (Bayless 2007). In 2010, the Ontario government gave permission to the APGS to burn woody biomass instead of coal. Woody biomass is a renewable energy source that has many of the advantages for power generation that coal has (fuel storage, load following or base-load) but is greenhouse gas neutral. Moreover, it adds to geopolitical security by being a locally-based resource of Ontario (Bayless 2007).

Layzell (2007) mentioned that to replace all coal used in Ontario (not just in electricity production), it would take roughly 30 million ODt of biomass. This is only half of Layzell's conservative estimate of the amount of dry biomass that could be produced sustainably each year in Ontario (Layzell 2007). According to Layzell (2007) Ontario's biomass is spread over a large area and major processing and transportation infrastructure will have to be developed or existing ship, pipeline or rail transport will have to be utilized. In terms of the cost of the basic energy content, biomass is cheaper than oil at current prices. But it is still more expensive than coal plus transportation costs (Layzell 2007). Supporters of woody biomass state the costs are justified, citing the benefits of rural and regional economic development and geopolitical security (Bayless 2007).

Adams (2007) states that Ontario's plan for the future electricity generation mix increases the Province's risk to expensive and fluctuating natural gas prices and resource availability in North America. Furthermore, the article considers the government's coal exit plan as an inefficient and minimalist policy to address global warming.

Bayless (2007) reported that the Province of Ontario's current plan fails because it does not actively incorporate an Ontario based bio-energy strategy that would see the phasing in of woody biomass as a fuel in existing coal plants and the adding in of appropriate pollution control equipment. He suggested that the existing coal-fired capacity could be left in place longer as a back-up to the nuclear plan. However, the long-term goal would be to ramp up the biomass feedstock supply to replace the coal, an

Ontario-based resource. To make this happen, Ontario Power Authority (OPA) requires a clear mandate to invest in the entire supply chain, and to ensure appropriate policy development, more research is required on these issues.

2.1.3 Biomass Utilization in Northwestern Ontario, Canada

Biomass can be a major piece of the renewable energy and fuels picture for Canada, but prior to the first energy crisis in the 1970s, biomass did not receive the attention it deserves given the benefits it can provide. Biomass energy generation produces two distinct and important products: renewable energy and environmentally-preferable disposal of wood waste (Hall and Helynen 2006; Layzell *et al.* 2006). Biomass from intensive silviculture is commonly used in Europe for combined heat and power production (CHP) (FERIC 2008). Biomass production systems require people to procure and process the feedstock, thus creating jobs, with the employment impact of the industry felt primarily in rural areas (Beckley 1999; Beckley and Reimer 1999; Kimmins 2008).

In 2007, 75% of electricity in Ontario was generated without the production of GHGs, with 59% hydro, 15% nuclear, 1% wind and biomass (Marshall *et al.* 2010). In February 2009, the Ontario government also announced its Green Energy Act (Bill 150), aimed at expanding renewable energy generation. Since 2005, OPG has been investigating the use of woody biomass as a coal offset option (Marshall *et al.* 2010). Compared to other renewable energies such as wind and solar, woody biomass has the added benefit of being dispatchable, which means that it is capable of responding to peak load demands when needed. The principles governing OPG's biomass testing program include: not using food products fit for human consumption; using only woody biomass extracted using sustainable practices; and maximizing the use of existing assets (Marshall *et al.* 2010). Communities such as Oujé-Bougoumou in Quebec and several communities in the Northwest Territories have benefitted from a shift to locally-produced bioenergy in district heating plants (DHP) that have been very successful (McCallum 1997; Parkins 1999; DeYoe 2007).

Woody biomass is a commodity in the Northwestern Ontario region that is increasing in importance for generating heat and electricity. Much of the biomass is in roadside delimber piles left on logged sites that have traditionally been piled and burnt (Alam *et al.* 2012), but which could be a good source of bioenergy. Besides forest and mill waste, areas devastated by fire, insects, disease and wind throw are excellent candidates for bio-energy projects. The major current initiatives of wood biomass utilization for energy production in Northwestern Ontario (Ride 2008) focus on heat and electricity production at four pulp mills: Dryden (30 MW), Fort Frances (50 MW), Terrace Bay (45 MW) and Thunder Bay (55 MW). As well, a biomass-based heating system in Grassy Narrows, a First Nation community (<1 MW) has been piloted, although the system is currently operating on natural gas. Finally, the APGS and Thunder coal-fired plants intend to produce electricity through wood pellet-based bioenergy.

2.1.4 Policies and Management Guidelines for Utilizing Woody Biomass for Bioenergy in Canada

In Canada, forest management and harvesting woody biomass for energy are controlled by the 10 provinces, three territories, and First Nations where land claims are settled.

The federal government has jurisdiction over water, fisheries and air when they are affected by forestry practices, as well as forest management on federally-owned lands (NRCan 2012). About 94% of the forests in Canada are publicly owned (FPAC 2012). During the energy crisis of the 1970s, using woody biomass as feedstock for bioenergy was started, and during the 1980s full-tree use for bioenergy was increased due to cheaper log production costs for traditional forest products (Titus *et al.* 2013). On May 20, 2013, Ontario approved Forest Management Directives and Procedures for forest biofibre on allocation and use of harvesting residues. In this directive, feedstock for bioenergy is not the single objective, and the Ontario policy applies to all “biofibre” for all forest products (OMNR 2008b; OMNR 2013; Titus *et al.* 2013). OMNR (2013) refers:

> “Forest biofibre are forest resources from Crown forests that are not normally being utilized for conventional forest products and that are made available under an approved forest management plan. Forest biofibre includes tree tops, cull trees or portions of trees, individual and stands of unmerchantable and unmarketable trees, and trees that may be salvaged as a result of a natural disturbance. Forest biofibre does not include residual by-products such as wood shavings, sawdust, bark or wood chips produced during mill operations.”

Ecologically, there is a wide range of forest ecosystems in Canada, from temperate coastal rainforests (in British Columbia) to forests in dry zones (three territories), and from temperate hardwoods (southern Ontario and Quebec) to boreal forests (Northern Ontario, Alberta and Quebec) (Pennock *et al.* 2011; Canadian Forest Service 2012; NRCan 2012). In 2012, at a workshop titled "Forest Bioenergy and Soil Sustainability" at Bari, Italy, Stupak *et al.*(2013) emphasized that soils should be protected during the removal of harvesting residues for bioenergy production. This removal includes woody residue at roadside or landings when full-tree harvesting is used (Stupak *et al.* 2013;

Titus *et al.* 2013). Regulations and guidance for site-level harvesting residues (or woody biomass/ biofibre) removals have been developed in different countries although in most Canadian provinces they are still in progress. The challenge in developing guidelines for harvesting residues removals in Canada is significant because of the size of the country and the range of natural conditions (Titus *et al.* 2013). In Canada the proportion of the forest harvested annually is very small (<0.2%) relative to the forest area, and is small (688,000 ha in 2010) compared to the area affected by insect defoliation (>12 million ha) and fire (>3 million ha) in 2010 (National Forestry Database 2012a; National Forestry Database 2012b). These natural disturbances produced a large amount of coarse woody debris. Stevens (1996) and Paré *et al.* (2013) reported that removal of this coarse woody debris has a minor impact on future site productivity.

In most parts of Canada extensive forest management (National Forestry Database 2012c, 2012d) practices are followed. Some provinces use natural regeneration as the main method of reforestation; for example, in Quebec only 20% of harvested areas are planted (Bureau du forestier en chef 2010). Commercial thinning is not a common practice in Canada: during 1990-2010, yearly pre-commercial thinning ranged from 10% to 20% of the harvested area (Titus *et al.* 2013). Normally, two types of full tree harvesting systems are practised across Canada, namely single-pass and multi-pass. Between these two systems, the single pass system results in less soil disturbance and produces more forest harvest residues (Titus *et al.* 2013). In two mixed wood sites in Ontario, for example, Ralevic *et al.* (2010) calculated that 37% to 51% of harvesting residues (not including standing residual trees) were left on the ground from the single-pass system. In a study of spatial analysis of woody biomass availability in

Northwestern Ontario, Alam *et al.* (2012) found 60 m^3/ha of forest harvest residue and 60 m^3/ha of under-utilized wood available in the forest. They suggested that 67% of forest harvest residues can be harvested for bioenergy production purposes. Using up to 67% harvest residues increases procurement costs while quality is reduced; therefore, this percentage could be lower and will not influence costs significantly (Alam *et al.* 2012).

A workshop held at Toronto in 2008 and attended by the researcher (as a note taker) brought together scientists from throughout Canada, the United States and Sweden to review current science supporting biomass utilization and the development of guidelines and policies for harvesting. Workshop participants suggested that, international forest certification programs, such as the Programme for the Endorsement of Forest Certification schemes (PEFC) and the Forest Stewardship Council (FSC) forest certification program may have important roles to play in supporting the development of biomass harvesting guidelines. Though none of these programs has developed biomass harvesting guidelines, each provides some guidance related to the responsible management of site productivity, diversified product utilization, and other considerations. The certification programs are also reacting to potential impacts of biofuel development on forest management. Recent forest certification standards review processes have included consideration of biomass harvesting within the context of responsible forest management.

The Forest Guild (2009) (Evans 2008a; 2008b) compiled a collection of woody biomass removal case studies from throughout the United States. The case studies provide information about lessons learned and recommended strategies that can help support successful biomass harvesting efforts. This report concluded that biomass harvesting guidelines should address six areas of potential biomass harvesting impacts, including: dead wood (coarse woody material, fine woody material and snags); wildlife and biodiversity (including sensitive plants, animals and natural communities); water quality and riparian zones (including wetlands, erosion and non-point source pollution); soil productivity; silviculture (including regeneration, aesthetics, re-entry, roads and skid trail layout); and disturbance (insects, disease, fire and fuels, pesticides, invasive species and conversion of native forests to non-forest uses or plantations). Evans and Perschel (2009), Minnesota Forest Resources Council (MFRC)(2007a, 2007b, 2007c), Pennsylvania Department of Conservation and Natural Resources (2008), and Wisconsin Council on Forestry (2008) also released reports assessing biomass harvesting guidelines that have been established in Maine, Minnesota, Missouri, Pennsylvania and Wisconsin. These assessments found that existing United States' state guidelines comprehensively address the impacts that are associated with dead wood, wildlife and biodiversity, water quality and riparian zones. However, existing guidelines did not effectively address disturbances, fuel reduction, needs for pesticide use, invasive species and conversion threats. More work is needed to address soil protection for the purposes of biomass harvesting. Additional recommendations from the Forest Guild report that biomass harvesting should include sections that incorporate "eco-regional science" practices, public input, and stakeholder consultation when developing harvesting practices and guidelines. As well, the document emphasizes clear definitions of the terms related to woody biomass and comments on specific harvesting techniques that protect forest integrity and biodiversity.

Thiffault *et al.* (2010, 2011a) briefly reviewed the Canadian scientific regulations and guidelines for forest soils and sites. Weetman and Weber (1972), and Bhatti *et al.* (1998) reported that among the different types of soils only dry coarse textured soil and wet organic soil are sensitive to removal of forest harvest residues. Thiffault *et al.* (2011b), Kabzems (2012) and Titus *et al.* (2013) conducted field trials (>15-year-old) to compare full-tree and tree-length clear cut harvesting sites (46 sites) across Canada. Except on one jack pine site on coarse textured soils in Quebec, they found no evidence of growth decline with harvesting residues removals in these sites. Results of harvesting residues removal for 10 year trials in Canada showed that only some poor sites have growth decline (Ponder *et al.* 2012). Additionally Hakkila (2002) suggested that negative ecological impacts can be reduced by appropriate timing of operations, minimizing the nutrient removals from the forest sites and recycling of ash from the woody biomass combustion installation. Titus *et al.* (2013) also reviewed the woody biomass harvesting guidelines of UK, Sweden, Finland and some areas of the U.S. (e.g. Maine, Minnesota, Missouri, Pennsylvania and Wisconsin), and suggested that adaptive management processes of biomass harvesting guidelines are suitable for Canada. They find that Canada currently takes a wider range of “second-generation” field trials based on the past experience on stand histories, silvicultural systems and removal treatments. Some of these field trials include thinning trials, harvesting residues removal treatments, biodiversity and nutritional research, and ash returning treatments (Titus *et al.* 2013). Evans *et al.* (2010), Abbas *et al.* (2011) Stewart *et al.* (2011) and Thiffault *et al.* (2011b) also worked on harvesting residues removal and found that for protecting the soil, harvesting residues or woody biomass removal is not suitable on sensitive soils. In

Canada, only New Brunswick has specific site-level guidance for harvesting residues removals for bioenergy (Helmisaari and Vanguelova 2013). All the provinces of Canada have forest harvest residues removal criteria within their sustainable forest management (SFM) policies and regulations (Waito and Johnson 2010).

The Ontario Biofibre Policy (OMNR 2013) provides site-specific guidance for full- tree harvesting in Northwestern Ontario under the SFM guidelines (Titus *et al.* 2013). Ontario's guidelines for Northwestern Ontario do not recommend harvest residues removal on very shallow soils where the O horizon with mineral soil is less than 20 cm deep (OMNR 1997; OMNR 2013).

The Ontario Biofibre Policy guides the use of woody biomass to create and support new opportunities to develop new technologies and products in order to diversify Ontario's economy (OMNR 2013). This Policy gives priority to Aboriginal communities and/or partnership projects to provide economic benefits to Aboriginal peoples for biofibre based business development (OMNR 2013). A Forest Resource Processing Facility Licence and a business plan are required to use biofibre from Crown forests. For providing a Forest Resource Processing Facility Licence, OMNR inspects the resources area to ensure a sustainable supply of requested forest resources (OMNR 2013). To support the growth of new and existing industry using forest biofibre, a pricing strategy has also been suggested by OMNR. It includes minimum prices and residual values as Crown charges, and Forest Renewal and Forestry Futures (including Forest Resource Inventory) charges, for forest biofibre (OMNR 2013). A level of incentives is set to develop new opportunities from the use of this under-utilized forest resource. Forest Renewal and Forestry Futures charges will be applicable to merchantable material, and the MNR monitors the markets forest biofibre. The Biofibre Policy will be reviewed within five years, and an adaptive management approach will be used to ensure the success of this new industry (OMNR 2013). Recommendations provided in the Forest Guild report and other literature on biomass harvesting (e.g., Titus *et al.* 2013; Lattimore *et al.* 2013) should be considered for developing woody biomass harvesting guidelines for Ontario.

2.1.5 Woody Biomass-based Bioenergy Test at Atikokan Power Generating Station (APGS)

Atikokan Power Generating Station is a coal fired station owned by Ontario Power Generation (OPG), located 8 km north of Atikokan, 190 km west of Thunder Bay, in Northwestern Ontario, occupying 300 ha. The plant is connected to the provincial power grid by 230,000 volt transmission lines. The APGS began operation in 1985, but on Sept. 11, 2012, Atikokan ended using coal and the unit was taken out of service to be converted to use woody biomass (pellets) as fuel. The conversion project is now underway (OPG 2013), and it will be the first generating station to be converted by OPG to be fuelled by woody biomass. The conversion will come at a cost of $200 (CAD) million, and is scheduled to be completed by 2014 (CBC News 2012). Total CO_2 emissions at Atikokan Power Generating Station from 2004-2012 (Environment Canada 2013) are given in Table 2.1.1 The particularly high emissions levels for 2004 and 2005 (Table 2.1.1) are related to a blackout in August 2003 that caused by a power outage in Niagara Falls, Ontario (OPG 2004). At that time APGS generated more electricity than it normally generates annually to cover the province's electricity requirements (OPG 2004).

Table 2.1.1 Total emissions at Atikokan Power Generating Station from 2004-2012.

Year	Power Production (GWh)	Emissions (tonnes CO_2 equivalent)
2004	1,018	1,181,122
2005	965	1,108,437
2006	732	851,094
2007	643	754,148
2008	313	415,000
2009	133	197,000
2010	417	496,220
2011	39	75,280
2012	13	44,830

Source: OPG 2012; Environment Canada 2013

The Ontario government investigated the possibility of replacing lignite coal with renewable woody biomass as feedstock at the APGS. The APGS is a 227 MW capacity plant and is equipped with a single Babcock & Wilcox natural circulation boiler of opposed-fired design (Marshall *et al.* 2010). Until 2012, APGS fired lignite coal from Saskatchewan with a baseline coal consumption capacity of 40.8 t/h (Marshall *et al.* 2010). In a series of tests during January to July 2008 that looked at fuel alternatives to coal, a total of 1,622 t of commercial grade pellets were used at various levels of co-firing and 100% pellet feed stock (Marshall *et al.* 2010).

The first pellet-based test at the APGS was during January 2008. This test consisted of 26 t of wood pellets that were co-fired with coal at a wood pellet flow of 5 kg/s (18 t/h) and a cold primary airflow of 20 kg/s (Marshall *et al.* 2010). The pulverizer differential pressure while operating with wood was observed to be much higher than that for coal only and the period for stabilization was also longer. With this test a significant reduction in SO_2 emissions was observed (Marshall *et al.* 2010).

In March 2008 a second co-firing test was conducted with the complete displacement of coal on a single burner row. In this test 181 t of pellets were used, accounting for 20% of the furnace energy input level (Marshall *et al.* 2010). The cold primary airflow was at a base value of 20 kg/s and the wood pellet flow was 6.8 kg/s (24.5 t/h). The flame conditions on the burners firing wood were observed to be bright (Marshall *et al.* 2010). During the co-firing, the NOx emissions were mostly unchanged compared to the baseline lignite performance (Meadows 2008; Marshall *et al.* 2010). In May 2008 a third co-firing test with 177 t of pellets was run.

During July 2008, a series of tests over the month were conducted to assess the plant's potential to operate on 100% wood pellet fuel. During early to mid-July, 796 t of pellets were used in various tests with one of the tests in mid-July using 100% pellets. On July 31, 2008 a 100% run of pellets was made and 442 t were used (Meadows 2008; Marshall *et al.* 2010). For the APGS, the generation of electricity using a 100% wood biomass (wood pellets) feedstock instead of coal was significant since the plant utilizes an unmodified pulverized coal fired boiler (see Marshall *et al.* 2010 for the results of these tests). For generating electricity at APGS during tests it was found that wood pellet has a number of advantages than coal. Marshall *et al.* (2010) made a comparison between the electricity generation with wood pellets from New Brunswick and lignite coal from Saskatchewan, and mentioned that wood pellet has moisture content 5-10%, ash content less than 1%, sulphur content 0.01% whereas coal has moisture content 37-41%, ash content 9-17%, sulphur content 0.3-0.7%. They also mentioned that wood pellet yields more energy (17-18 MJ/kg) than coal (10-15 MJ/kg) (Marshall *et al.* 2010).

2.2 ATIKOKAN AND SOCIAL FACTORS OF BIOENERGY DEVELOPMENT

2.2.1 History and Socio-economic Conditions of Atikokan

The Town of Atikokan is located along Highway 11 in the Unorganized District of Rainy River, approximately 200 km west of the City of Thunder Bay in the Province of Ontario, Canada (OMMAH 2014). Figure 2.2.1 presents the map of Northwestern Ontario and Figure 2.2.2 and 2.2.3 shows the location of Atikokan. Located at the margin between the boreal and Great Lakes St. Lawrence (mixed wood forest), Atikokan has a humid climate with four seasons: winters are long, cold and snowy, and summers are warm. Precipitation is higher during the summer months and lower during the winter months (Environment Canada 2013). Atikokan is in the Central Time Zone but observes Eastern Standard Time year round. The original settlers to the Atikokan area were the "Oschekamega Wenenewak" (The people of the cross ridges) Ojibwa/Chippewa (Vita 1974). The people lived by themselves until the arrival of the courier de bois Jacques de Noyon in 1688 from Montreal (Vita 1974). Tom Rawn and his wife were the first permanent non-Native residents of Atikokan, arriving by canoe in 1899. By 1950, the population had grown to 3,000 people (Vita 1974).

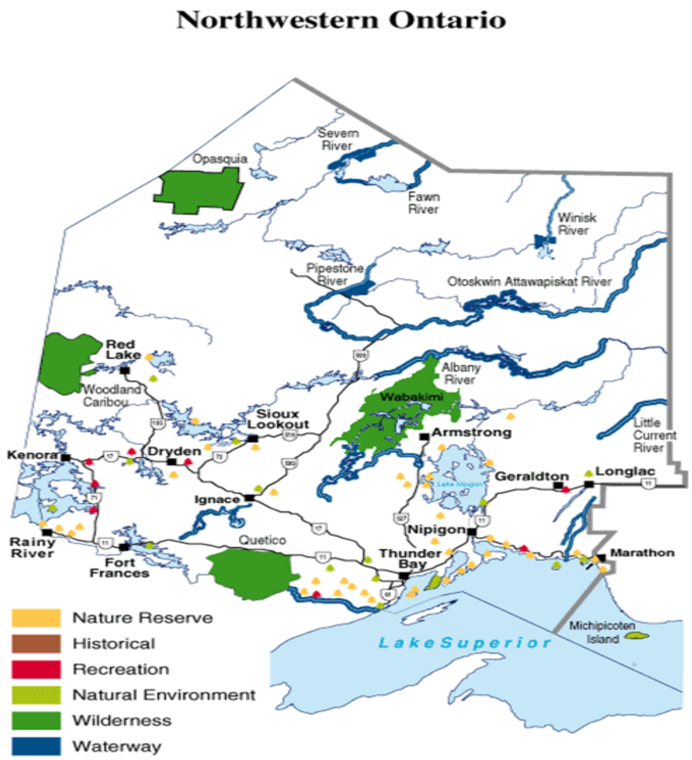

Figure 2.2.1 Map of Northwestern Ontario (Northwest Ontario 2009).

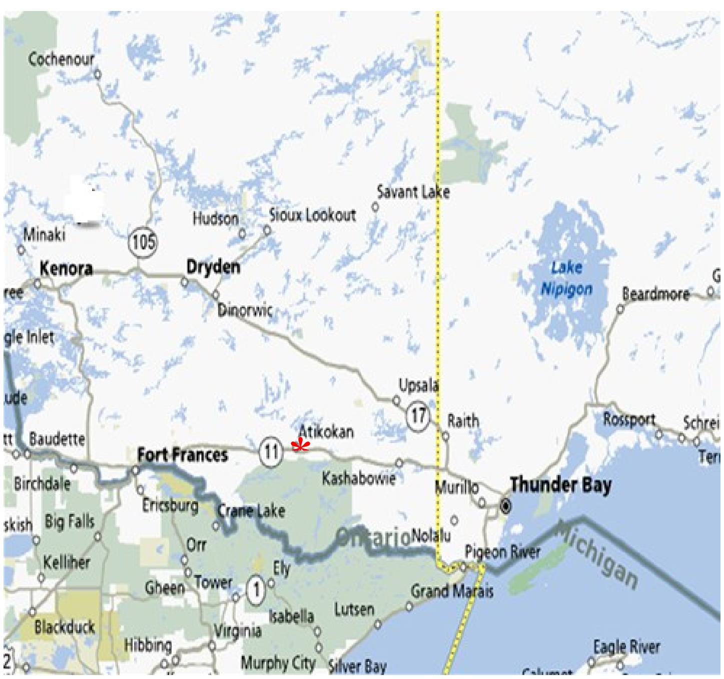

Figure 2.2.2 Map shows the location of Atikokan (Ontario Towns 2014).

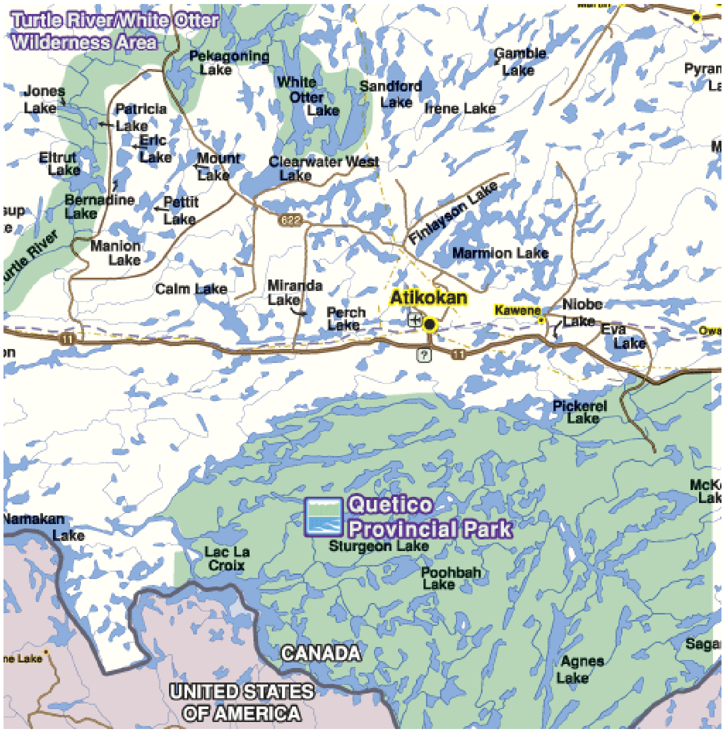

Figure 2.2.3 Map shows the location of Atikokan and its surrounding (Ontario Towns 2014).

Originally established as a rail stop for the Canadian Northern Railway in 1899 (Town of Atikokan 2012), the town of Atikokan was officially declared as “the Canoeing Capital of Canada” in 1982. The town is an enclave within the unorganized Rainy River district. The areas of this district include the First Nation communities of Rainy Lake 17A, 17B, 26A; Seine River 23A, and 23B; and the areas of Arbor Vitae, Burditt Lake, Calm Lake, Flanders, Crilly, Gameland, Glenorchy, Government Landing, Kawene, Mine Centre, Off Lake Corner, Rocky Inlet and Sapawe (hereafter referred to as the Atikokan area) (Vita 1974; Town of Atikokan 2012).

Before the Second World War, mineral exploration in the area revealed the presence of high grade, iron ore deposits at the bottom of Steep Rock Lake. After the war, a large water diversion project on the Seine River system was undertaken to enable the draining and dredging of Steep Rock Lake in order to develop open-pit mining operations (Town of Atikokan 2012; Seine River Watershed 2013). In the late 1950s Steep Rock Iron Mines and Caland Ore Co. began operations and continued for more than 30 years; however, in the early 1980s these mines closed and the town of Atikokan suffered economically. At that time natural resource-based industries and tourism supported its economy (Town of Atikokan 2012). In 1994, Valerie Falls Power, a 10 MW hydroelectric generating station, was developed on the Seine River diversion (Seine River Watershed 2013). The plant continues to operate today.

In 1991 the population of Atikokan was 4,047 (Johnston and Lorch 1996). The municipality has a current population of 2,787, as compared to 3,293 in 2006 (Table 2.2.1) (Statistics Canada 2007a, 2009 and 2012). Within Atikokan's boundaries, 319.29 km^2 of land are developed under four general headings: industrial and commercial, residential, recreational and conservational (Town of Atikokan 2012). A large percentage of the land remains in a natural state with the urban town site being the major land user. Industrial areas are located in the northern half of the town. Recreational uses are generally located in conjunction with the Seine River, although some parks are located in residential areas. The soil characteristics of Atikokan are too shallow, sandy and rocky to support most farming operations (Edward Hoshizaki Development Consulting 2008).

Table 2.2.1 Atikokan community profile.

	2011	2006	2001
Population	2,787 (-15.4 from 2006)	3,293 (-9.3% from 2001)	3,632 (-10.2% from 1996)
Land area	319.29 km^2	316.75 km^2	316.81 km^2
Population density	8.7 /km^2	10.4 /km^2	11.5 /km^2
Median age	48.5(M:48, F:49)	43.0 (M:43, F:43)	39.2 (M:38, F:40)
Total private dwellings	1,460	1,535	1,621
Mean household income	Data not available	$48,119	$46,511

Source: Statistics Canada 2007a, 2007b, 2009 and 2012.

The economy of Atikokan is based on forestry, the APGS, government services, retail services, tourism, mining and a mixture of light manufacturing businesses. During 2007, the leading employers were Atikokan Forest Products (random length/width lumber and woodchip mill), Fibratech Manufacturing Ltd. (particle board plant) and the Atikokan Power Generating Station (APGS) (Township of Atikokan 2008). At present only the APGS is running, however, Resolute Forest Products is building a new sawmill at Sapawe and Rentech Inc. is establishing a 100,000 t/yr pellet plant on the former Fibratech site; both plants are expected to begin production in 2014. APGS has the capacity to supply about one-quarter of the energy demand for northwestern Ontario (Marshall *et al.* 2010). Before its current conversion to pellets, APGS burned low sulfur lignite coal brought in by rail from Saskatchewan, Canada. It is responsible for providing 90 jobs and a significant amount of tax revenue for the Township of Atikokan. If the decision to convert the APGS to pellet feedstock had not been made it would have forced closure by the end of 2014. Without its revenue and jobs, the Township of Atikokan would have faced an insurmountable financial problem as its tax base would be considerably reduced. In November of 2007, Atikokan Renewable Fuels took full control of the former Fibratech Mill after it went into receivership. Atikokan Renewable Fuels invested an initial $15 million to renovate the plant to produce 140,000 t/a of industrial wood pellets that could potentially be used at APGS. This wood pellet operation expected to create 40 jobs (Reynolds *et al.* 2008; OPG 2010b). Another benefit of the plant is additional economic development in the area. For example, on February 1, 2013 Resolute Forest Products announced its plans to develop a new single-line random-length sawmill located in the Atikokan area to be operational in 2014. As reported in June 2013, Thunder Bay's newspaper, *The Chronicle Journal* reported the plant would create 90 direct jobs in Atikokan (The Chronicle Journal 2013).

In May 7, 2013, Rentech Inc., an American renewable energy and fertilizer company, bought Atikokan Renewable Fuels. As part of the deal, Rentech inherits the 10-year off-take agreement that Atikokan Renewables signed in 2012 with Ontario Power Generation (OPG) to supply 45,000 tonnes of pellets to APGS, now being converted to burn pellets (McKinnon 2013; Ross 2013). Rentech has also signed a 10-year agreement with Britain's Drax Power to supply them with 400,000 tonnes a year of pellets from Atikokan and Wawa (McKinnon 2013).

The retail sector is also a major employment contributor in Atikokan. Atikokan has a number of stores, shops and restaurants that cater to the town's residents and visitors. Tourism is a major industry in Atikokan with the town considered the "gateway" to Quetico Provincial Park. There are a number of resorts, lodges, camps and outfitters in the Atikokan area. The outdoors and wildlife are a central theme for most of the light manufacturing businesses in Atikokan; its unique wilderness setting has resulted in canoe and paddle manufacturers becoming established in Atikokan (Patrick Reid and Associates 2006; Township of Atikokan 2008).

2.2.2 Social Importance of Woody Biomass-based Energy

Woody biomass-based bioenergy production raises issues related to retention of forest cover, regeneration of natural forests and engagement in intensive forest management (Hall and Helynen 2006; Layzell *et al.* 2006; Kimmins 2008; FERIC 2008). To establish a sustainable bioenergy production system it is important to identify the issues that are necessary to develop it (Wegener and Kelly 2008). The use of woody biomass-based bioenergy as an alternative to fossil fuel based energy will create numerous benefits in both Atikokan, and at the regional and national level.

Bioenergy has provided millions of people with incomes, livelihood activities and employment worldwide (Gan and Smith 2006a). The social aspect of the sustainability of bioenergy projects concerns how they are recognized by the society and how different societies benefit from such projects (Domac *et al.* 2005). Environmental protection, avoiding carbon emissions and security of energy supply at a national level are also important for local communities. But for local communities the primary driving forces are much more likely to be job creation or employment, contribution to a regional economy and income improvement (Faaij 2006; Elghali *et al.* 2007). Employment creation in the bioenergy sector is a challenging factor. People depend on bioenergy as their main source of fuel, not only for cooking and heating, but also for their employment and incomes. To-date, research has shown that community experiences are location based, site-specific and situation-specific (Astley 1985; Faaij 2006). Domac *et* *al.* (2004) also reported that employment created by traditional and modern bioenergy production systems was distinct and different.

The introduction of an income-generating source, such as pellet production for electricity production at Atikokan, could help to stem adverse social and cohesion trends such as high levels of unemployment and rural depopulation. It is evident that rural areas in Northwestern Ontario are suffering from significant outward migration, which leads to population instability (Moazzami 2006). Consequently, given the tendency for woody biomass-based bioenergy to be located in rural locations, the deployment of bioenergy plants may have positive effects upon rural labour markets, first, by introducing direct employment and, second, by supporting related industries and the employment therein: e.g., loggers, local renewable energy technology providers, installers and service providers. Finally, it is possible to achieve significant and sustained development of local initiatives by ensuring the local involvement of key stakeholders (Domac *et al.* 2005; Faaij 2006).

Without a secure long term biomass fuel supply, a bioenergy developer will not invest in the construction of a bioenergy plant. Samson *et al.* (2008) proposed for large scale woody biomass-based electricity incentives at a rate of $4.00 /GJ (CAD) for biomass pellets in Ontario, which can offset 82.94 kgCO_2/GJ of carbon dioxide emission. The authors proposed $48.26 (CAD) for the offset of 1 t of carbon emissions when displacing coal (Samson *et al.* 2008). A reliable market for the heat, power or biofuel to be produced also needs to be identified and purchase agreements signed. A bioenergy project will proceed only when these issues have been resolved. Many bioenergy projects are technically feasible but investments do not proceed because other forms of energy appear to be more cost competitive (IEA 2007). As a result, the economic risks of using woody biomass for power generation in the electricity market are high due to competitive costs from coal and natural gas, and from other renewable energy plants including hydro, geothermal, solar and wind. Bioenergy also faces some barriers: e.g., a common perception is that burning biomass is a dirty process (Myles 2001; Domac *et al.* 2004). Another perception is that bioenergy requires feedstock from large-scale monocultures, possibly genetically modified, that negatively impact the landscape and biodiversity (Myles 2001; Domac *et al.* 2004).

Lack of available information on a proposed bioenergy plant is also a barrier, as uncertainties are associated with the decision about the use of the new technologies (Gan and Smith 2006b). People living in close proximity to a proposed plant may well lack the appropriate information regarding its possible impacts. As a rule, the public are interested to know where the biomass feedstock will grow, which will especially be the case if the proposed project can also provide opportunity for local recreational activity (IEA 2007). Normally, a fast growing tree species (e.g., poplar, willow, birch) requires good supplies of water; therefore, local land management authorities should consider the possible impacts on water demand when selecting land for raising fast growing tree species for woody biomass-based bioenergy production (Catania *et al.* 2008; Muth 2012).

Solid planning measures are required for the development of a woody biomass-based bioenergy plant in Atikokan. Formal permission to construct a plant is required from local planning and other authorities who will consider potential problems such as road access, and air and effluent discharge (Felix 2009; Muth 2012). Consultation also includes issues relating to the transport of the feedstock, noise from vehicles and plant operation, possible landscape changes from energy plantations, and the potential that increased workforce numbers will affect local house prices and demands on service facilities (Lee *et al.* 1990; Bratkovich 2009).

All energy plants have some form of impact on society, but a problem can occur when the local benefit is less than the national benefits. For example, a bioenergy plant constructed in a region may cause increased local heavy traffic, unwanted noise and visual impacts for the residents. At APGS, two silos were recently built that have the capacity of 5000 tonnes each to store wood pellets. When APGS runs with 100% woody pellets, 350-370 tonnes/day of the wood pellets will be required and daily 10 trucks with the capacity of 35 tonnes per truck will deliver the woody pellets to the APGS's silos. While Atikokan residents will have to adjust to the traffic and noise, APGS will be sending the power generated to the electricity grid for distribution. Operation of the APGS plant may also mitigate thousands of tonnes of carbon dioxide each year which could have national and international benefits. No easy solution exists to ensure all levels of society benefit and each bioenergy system needs to be assessed based on its individual merits (Domac *et al.* 2004).

2.2.3 Social Factors and Bioenergy Development at APGS

The technological development of APGS's bioenergy initiative does not occur in isolation. In fact, it will only be successful if the people of Atikokan area embrace the new plant and understand its social, economic, environmental and political benefits (Evans and Durant 1995). The social effects of developing woody biomass-based bioenergy in rural forest-based communities are advantageous in direct and indirect ways. The social implications arising from local bioenergy investment can be broken down into two categories: those relating to an increased standard of living and those that contribute to increased social cohesion and stability. There are other factors which contribute to a person's standard of living that have no immediate economic value, such as employment opportunities and the health of the surrounding environment (Lee *et al.* 1990; Domac *et al.* 2004).

Numerous issues related to the social structure of the community affect its cohesion and the kinds of interests different groups may wish to protect as they seek solutions to resource management problems. Two of them are ethnicity and gender relations. Though ethnicity is not necessarily a divisive factor in communities, there are times when it can have a divisive effect. It may be compounded by other issues such as the ways different ethnic groups pursue their livelihoods. One ethnic group may make its living mainly from herding, for example, while another practices cultivation or fishing (Faaij 2006). Gender considerations are also a key to understanding whether communities will be able to organize action in response to some of the more complex resource governance problems. If both men and women feel that their concerns are reflected in resource governance agreements, they will have a stronger incentive to participate in making the management plans work.

Economic factors play a role in determining whether people have similar or divergent interests concerning how resources should be managed. Two significant issues are differences or similarities in livelihood strategies, and the degree of economic stratification in the community. People's perceptions of resources and their attitudes toward those resources will differ depending on how the resources fit into their individual livelihood strategies (Campbell and Barker 1998; Domac *et al.* 2004).

Many cultural factors affect the motivation of people in protecting and exploiting their tree and forest resources. Cultural beliefs play a reflective role in people's sense of ownership of resources. For example, in some Aboriginal communities of the Northwestern Ontario, it is absurd that an individual might be considered the owner of a tree or forest since Aboriginal peoples believe that those resources are only in the temporary stewardship of the current generation, which manages them on behalf of the ancestors and future generations (AJIC 2013). This creates inducements that are different from those in another culture where people believe that trees can be property like anything else (Domac *et al.* 2005). However, there are also some First Nation communities in Southern Ontario who have ownership title of their property, and they can grow, cut and sell trees as they see fit (Alcantara 2003).

Factors that are likely to influence, facilitate or constrain the introduction of new technologies in resource communities such as Atikokan's woody biomass-based power plant tend to be environmental, social and economic. For example, environmental factors include access to resources, energy supply and land ownership, whereas social factors include protection of human safety and health, rights of children, women, ethnicity, community well-being, length of living in locality, acceptance of the impacts of change and adequate quality of life. Economic considerations involve the community's labor conditions, workers' economic status, skills and self-directed participation in opportunities (Faaij 2006). A bioenergy production system is socially acceptable when social and institutional issues such as land tenure, benefits to the local society and a safe working environment are present (Domac *et al.* 2005).

In this thesis, the following factors were considered for assessing people's interest in woody biomass-based energy production at the APGS. First, demographic information was considered: the respondents' ethnic group, sex, age distribution, education, occupation and length of local residency. Next, their socio-economic and environmental considerations were taken into account: types of energy use, percent of income spent for energy, membership in local organizations, business ownership, access to credit, concerns about the surrounding environment, woody biomass use for bioenergy development and cutting of unmerchantable/non-commercial trees, and interest in becoming involved in woody biomass-based energy development at APGS. These factors were assessed by using a questionnaire survey in Atikokan and its surroundings (see Appendix I). How these social factors of the survey respondents are likely to impact the decision to become involved in future woody biomass-based energy development in Atikokan and surroundings is explored in the chapter 4 under section 4.1.

Atikokan area survey participants' opinions on important factors of community development, quality of life and woody biomass utilization are also important for the development of the woody biomass-based APGS bioenergy project. During the Atikokan area survey participants were asked to provide their opinions on these factors. A community system is unique and continuously evolving containing different patterns of participation. Community development does not provide full prescriptions suitable to every community system, nor can it identify the topic of a particular improvement program (Cook 1994). Community development theory is a conceptual framework that expresses a unique outlook on development. It presents a logical basis and guide to the use of an open system, through a holistic approach that encourages capacity building in community systems. Generally, community development theory establishes an orientation toward community systems. It does not purport to give answers to the basic questions of what, why or how for all community systems; rather, it provides a conceptual platform or grounding for building a community. Community systems are complex and dynamic, and the members of the community are the source of intelligence and information (Dodge 1980; Cook 1994).

Community development generally focuses on change and on the increase in the ability of community systems to create desirable change, and to adapt to unavoidable change (Cook 1994). As the rates and range of change accelerate and expand, a community's capacity to deal with change becomes even more critical (Botkins *et al.* 1979). Communities are considered instrumental systems: people associate with them to secure returns through the production of certain goods, services, environments and the preservation of valued conditions (Botkins *et al.* 1979; Cook 1994). However, for a community system to work in terms of return to its members, it must incorporate the capacity to continue operations that are satisfactory to community members (Dodge 1980; Cook 1994).

A community system has a dual structure. One side is designed for stability, regular performance, and predictability. The core of this side of the system is the theme. The other side of the system is designed for evaluation and change. The core of this side of the system is made up of autonomous citizen roles. When these two sides interact, tension is usually experienced between them. When a community system is experiencing difficulties coping with internal or external pressures for change, community development intervention concentrates on elaborating and strengthening the side geared for change (Cook 1994). The introduction of democratic principles, modes of organization and regime norms improves the roles of the system. Deficiencies of these elements in systems tend to be in the lack of legal influence of citizen roles. Increasing the use of and dependence on democracy is an important factor to balance the system in order for the community to achieve stability or change (Botkins *et al.* 1979). Community development is a broad term referring to the practices of civic activists to build stronger and more resilient local communities (Cook 1994). Community development seeks to empower individuals and groups of people by providing them with the skills they need to effect change in their own communities, skills that are often created through the formation of large social groups working for a common agenda. Since the 1960s and 1970s, through various anti-poverty programs in both developed and developing countries, community development practitioners have been influenced by structural analyses as to the causes of disadvantage and poverty; i.e., inequalities in the distribution of such things as wealth, income and land, and especially political power and the need to mobilise people power to affect social change.

Community development approaches are generally used by the United Nations, World Health Organization, Organization for Economic Cooperation and Development, World Bank and European Union for assessing local social, economic, cultural, environmental and political development (Dodge 1980).

2.3 SUSTAINABILITY AND MODELING OF APGS BIOENERGY SYSTEM

2.3.1 Sustainability and Bioenergy System

Woody biomass-based bioenergy production raises issues related to retention of forest cover, regeneration of natural forests, slowing of deforestation, and engagement in intensive forest management (Hall and Helynen 2006; Layzell *et al.* 2006; Kimmins 2008; FERIC 2008; CANBIO 2009). Biomass energy plantations can be developed in rural areas such as Atikokan where forest lands are available for management (DeYoe 2007). To establish a sustainable bioenergy production system, it is important to identify the factors that are necessary to develop it (Wegener and Kelly 2008). As well, any utilization of biomass for bioenergy must be planned within the context of national and provincial policies relating to economic growth and sustainable development (Domac *et al.* 2004). In Canada this will be through endeavoring to meet the needs for energy services by the present generation without compromising the ability of future generations to meet their own needs (Layzell *et al.* 2006). The use of bioenergy as an alternative to fossil fuels will create numerous benefits in both Atikokan and at the regional and national levels. By 2010, there was 35 Giga Watt (GW) installed bioenergy capacity for electricity generation in the world, of which Canada's share is minor (Urban and Mitchell 2011).

Bioenergy is a complex system and its components of feedstock supply, conversion technology and energy allocations are influenced by social, economic and ecological factors (Karekezi 2001). At present, most of the work on bioenergy systems has been done on its technical aspects (Volk *et al.* 2004; Smeets *et al.* 2005; IEA 2006; Reijnders 2006; Sustainable Bioenergy Wiki 2006; and Lewandowski and Faaij 2006).

Heller *et al.* (2003, 2004) conducted a life cycle analysis for bioenergy from short-rotation coppice. Furthermore, van den Broek *et al.* (2000, 2002) assessed socio-economic issues such as cost and jobs produced from bioenergy and non-bioenergy alternatives in different countries. However, for the proper development of woody biomass utilization for energy, it is important to develop models that depend on a bioenergy system's factors and components. According to Andersson *et al*. (2006) and Domac *et al.* (2005) an integrated approach is needed to model all of the components and impacts of a bioenergy system. Buchholz *et al.* (2007) and OMNR (2013) suggested that for such integration an adaptive systems approach is suitable to measure the sustainability of a bioenergy system. This model was developed by the researcher and is based on information gleaned from informal interviews, the work of bioenergy experts and research from the literature by different authors.

Sustainability is a dynamic and challenging concept (Costanza and Patten1995; Mog 2004; Bradley 2012; Sen 2013) that Buchholz *et al.* (2007) describe as diverse and evolving. Holling (2001) defined sustainability as the capacity to create, test and maintain adaptive capability. Sustainability is a process-oriented system that considers the ecological, economic and social values, but it can also be controversial since it covers human values, perceptions and political interests (Holling 2001). Some researchers place the social, economic and ecological factors of sustainability on the same level (Gowdy 1999), while others support the view of nested sustainability with the belief that sustainability can only be achieved when its social and economic factors do not violate ecological limits (Janowiak and Webster 2010).

2.3.2 System Approach for Examining Bioenergy Systems

Sustainability is an important component of any natural resource-based system that is best described as a holistic and evolving procedure. A systems approach is suitable to model the impacts of any forest-based bioenergy systems (Buchholz *et al.* 2007), although this approach is also widely used by scientists in ecosystem modeling, and in the areas of economics and psychology. A systems approach is the term that is useful for describing the woody bioenergy system of the APGS. Because it is an integrated approach to biomass production, conversion and use, it identifies all factors and interactions within a system in a wider range. In a systems approach, the whole system is broken into parts and valued separately (von Bertalanffy 1968). Farley *et al.* (2005) suggested that a systems approach should be followed when the problems are complex and risks are high. The objective of this section is to develop a model, considering the sustainability issues of woody biomass utilization for energy production at the APGS.

Before looking at APGS's system specifically, it is important to understand the basics of a systems approach. Systems can be dynamic or adaptive. Dynamic systems have the ability of self-control or self-correction; thus, they have an adequate degree of control within their boundaries. These systems employ a mechanistic paradigm and strive for stability and equilibrium (Hammond 2003). According to Oliver and Twery (1999), the bioenergy system cannot be described as only a dynamic system because factors such as climate change, conversion technologies, harvesting methods, etc., frequently change and their effects are beyond control (Titus 2013). In order to succeed in these ever-changing environments, new systems referred to as adaptive systems have evolved (Stupak *et al.* 2007). According to Odum (1988), adaptive systems have all the characteristics of dynamic systems but have abilities that go beyond self-control. They are differentiated by self-design (Odum 1971, 1988). A bioenergy system is normally described as adaptive because it is able to design its own shape (Buchholz *et al.* 2007). Modeling and diagramming help to clarify the basic principles and organizational structure of a system (McCormick 2005) although models do not provide solutions but are methods to understand and learn more about the system being modeled (Mendoza and Prabhu 2003). A diagram provides a visual view of a system at a large-scale and a diagram can be expressed as a "model." Developing models is a means to simplify the system or reduce its complexity to a degree perceivable to the human brain (Buchholz *et al.* 2007). Eppen *et al.* (1998) defined a model as a selective representation of reality, an abstraction, an approximation and an idealization.

2.3.3 Modeling the APGS Bioenergy System for Sustainability

A model developed by Smith and Gan (2005) on the critical components of sustainable woody biomass-based bioenergy production systems is present in Figure 2.3.1. It displays the steps of a sustainable woody biomass-based bioenergy production systems ─ sustainable production of bio-based products, sustainable forest operations, product delivery logistics, manufacturing pellets and energy production, environmental sustainability by captivating CO_2 and other GHS by forests. Consumer demand for electricity and rural economic development is the primary output of this system. It also shows, CO_2 captured by growing crops and forests; O_2 released and Carbon (C) is stored in the biomass of plants; C in harvested biomass is transported to the power station; and released C from burning biomass is made available again.

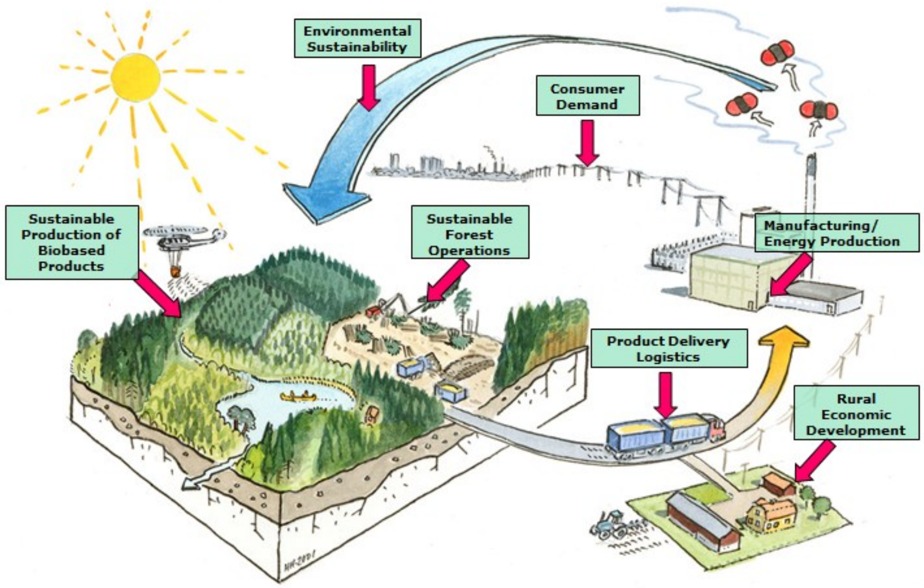

Figure 2.3.1 Critical Components of Sustainable Bioenergy Production Systems

Source: IEA Bioenergy Task 31(Smith and Gan 2005).

In consideration of the information gathered by field visits, interviews and discussion with the APGS resources personnel, forestry and energy personnel, and information gained through different literature reviews, a model of the bioenergy system for Atikokan is developed and displayed in this section by Figure 2.3.2. The model focuses on the interactions among the components of the bioenergy production system of Atikokan area.

In Figure 2.3.2 the bioenergy system is located within the watershed boundary of Atikokan community. Its feedstock is woody pellets, which are primarily derived from short-rotation trees mainly poplar, birch and logging residues of other trees. The bioenergy production technology is a combustion system; the expected output energy is electricity delivered to Ontario's electricity grid. Shapes symbolize subsystems and components, and feedback loops interconnecting the subsystems are represented as arrows. The symbols and modeling process of this diagram is based on the Energy Systems Language developed by Odum (1996) for circuit diagrams (Refer to Odum (1996) for an in-depth description of the symbols).

In Figure 2.3.2, energy flows in from the sun into four ecosystems: “natural system,” “long-rotation plantations/forest system,” “short-rotation plantations,” and “degraded lands,” which are denoted by bullets. For long-rotation plantations/forests, land was developed by clear cutting the natural forests (natural systems), and is symbolized by an arrow pointing from “natural systems” to “long-rotation forest system.” In “short-rotation plantations,” poplar and willow can be planted in lands which were degraded by insect, fire, wind or other natural disturbances, and the “degraded land” bullet can be linked to the “short-rotation plantations.” Here, the idea is that the “short-rotation plantations” system will be established on degraded lands for biomass supply to develop pellet for APGS bioenergy, and in the long run, after site restoration has taken place, it will be turned into “long-rotation plantation/forest system.” The long-rotation forests will be used for timber and residuals will be used for bioenergy. These interactions are represented by the arrows linking the different production systems. Drawing the boundary of the system and its cross-boundary interactions indicates that the Atikokan community is nested within a larger ecosystem. This pattern of system is called hierarchical emergence (Hammond 2003).

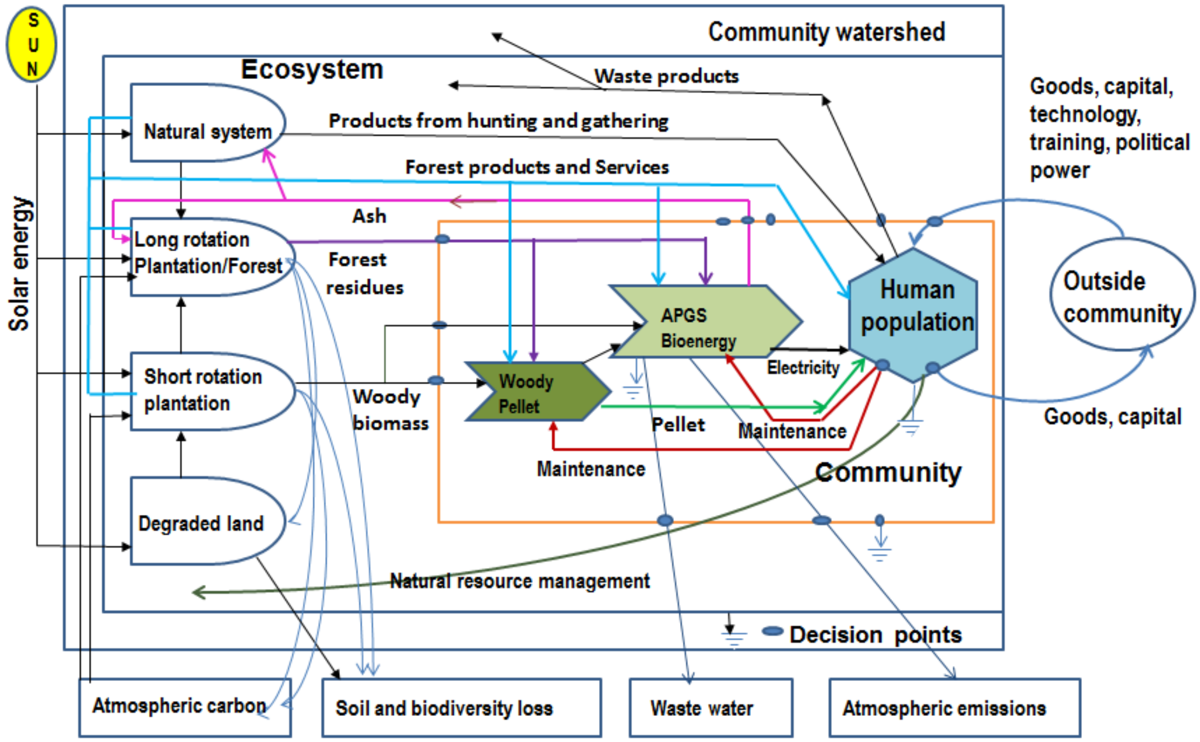

Figure 2.3.2 System diagram for woody biomass-based bioenergy in Atikokan community

A hierarchical emergence system is an organized set of components that are composed of a series of smaller sets of components, which themselves shape a larger system (Hammond 2003). In the APGS system model in Figure 2.3.2, a component cannot be fully realized without studying the next upper and lower hierarchical levels in which it is nested. By hierarchical control, each level helps or restricts the actions of the level below (Hammond 2003).

The “natural resource management” arrow in Figure 2.3.2 represents the decision or feedback of the community to the ecosystem's productivity. For this, good communication and information are needed to allow the bioenergy producer to access and control the new productive alternatives (McCormick 2005). According to Odum (1988) and McCormick (2005), to make decisions about sustainable dynamic alternatives, society requires a huge amount of information on human values, perceptions and the political interests of past generations.

In this model, in the Atikokan community, the power plant; logs and pellets (from the neighboring forests) are produced for use in the community (logs produced for sawmilling, pellet production; and pellets produced for APGS bioenergy, household use) and trade. Atikokan receives royalties from the APGS plant that are needed to run the community (e.g. policing, community services, etc.); it also receives training, funding and technology from outside communities to run the APGS woody biomass feedstock based power plant and pellet industry. Also, a saw mill is being built to supply woody biomass to Thunder Bay and Fort Frances. Long-term arrival of funds, technology and knowledge shows a dependency on external resources, reflecting a weak management at the local level (Buchholz *et al.* 2007; Lee *et al.* 2008). Local people and stakeholders' views and opinions can help the bioenergy system to adapt to the new setting (Upreti 2004; Banerjee 2006).

Normally, adaptive systems evolve over time, which makes them more difficult to predict, and therefore the outcome of the evolution is also unpredictable. For this reason, a lack of information and uncertainty are linked with the potential failure of adaptive systems (Holling 1978). Buchholz *et al.* (2007) reported that bioenergy systems that are poorly planned and managed, risk accelerating environmental degradation by the supply of unsustainable biomass sources, nutrient loss and overexploitation of forest residues. The supply of feedstock is also an important factor for the success of any new development. Reijnders (2006) mentioned that a poorly managed feedstock supply can contribute to environmental damage even in a well-organized system. It is reported that an estimated annual supply of 2.2 million green tonnes (gt) of wood biomass is required to meet the feedstock requirements of three existing and one proposed woody biomass-based power generating stations in Northwestern Ontario (Alam *et al.* 2012). Alam *et al.* (2012) suggested that a future sustainable supply 9.7 million gt of biomass per year is possible for Northwestern Ontario.

Despite the potential benefits of a bioenergy system and because it is a changing adaptive system, the uncertainties and risks associated with it often create a problem for its development (Holling 2001; Millet and Wedley 2002; Lee *et al.* 2008). To reduce uncertainty about the system, it is important to assess local concerns. Ludwig *et al.* (1993) and Holling (2001) suggests that uncertainty could be managed by using educational actions, monitoring and continuous evaluation policy. The model in Figure 2.3.2 shows that each setting of the bioenergy system is unique. This means that there are no standard solutions for different locations in terms of technology, trade-offs between negative impacts on ecological systems, and the economic profit of the bioenergy system. Costanza (1996) suggested that to enhance the evolution of new bioenergy approaches, it makes sense to have multiple equilibria in terms of different technologies existing next to each other.

The irregular production cycle of bioenergy can lead to uncertainty in this system (Odum 1988), and reversed feedback loops can lead to alternate the system itself (Holling 2001). For a successful bioenergy system, first a small scale bioenergy system should be built, with its feedback and outcome, and then a large-scale unit should be built later (Lovins 2002). To avoid a failure of the system, Brown *et al.* (2004) suggested that small-scale projects allow more testing due to their small associated impacts. Pétry (1990) reported that with increasing scale, techniques have to be adopted to reduce associated uncertainties and risks of failure. Norgaard (1994), however, argued that the sustainability of the bioenergy system would be worsened when it comes to increasing the bioenergy production for supplying energy for an increasing human population. Norgaard (1994) further mentioned that for small-scale bioenergy systems, higher risks could be accepted in assessing its sustainability than for large-scale projects. According to Costanza and Patten (1995), an important aspect of bioenergy systems is associated with the increasing longevity of systems with increasing scale. A small system can be sustainable in a smaller time scale than a larger system (Costanza and Patten 1995, Holling 2001; Buchholz *et al.* 2007).

The roles of bioenergy resources in ensuring energy flows within community systems are important for sustainability assessment (Buchholz *et al.* 2007). Odum (1988) described the importance of energy flows, the laws of thermodynamics, and the switch over between efficiency and power output as the primary drivers for all energy systems. In Figure 2.3.2, the diagram shows the energy flows and balances in the system, i.e., the natural, financial, human and social capital that the community has to invest into the bioenergy production system.

Through APGS bioenergy, Atikokan Township can earn revenue. Karekezi (2001), however, argued that revenue from bioenergy does not guarantee communities' human development as many of its benefits are related to the wealthy members of the community. The World Energy Council (1999) also expresses the same view, and this social fact has to be considered in sustainability assessments of bioenergy systems. In Figure 2.3.2, natural resource management improvement is represented by an interactions diagram within the community. In Atikokan, the APGS is responsible for the overall maintenance and control of APGS's bioenergy system, and Atikokan Renewable Resources (now Rentech Inc.) supplies woody pellets to APGS. Atikokan Renewable Resources (now Rentech Inc.) has made a partnership with the Rainy River First Nation to supply the woody biomass for producing woody pellets, which will be used as the feedstock of APGS bioenergy (OPG 2012).

According to Buchholz *et al.* (2007), on the basis of general systems principles, sustainability of bioenergy systems can be assessed by identifying the organizational points for great control. General systems principles also require the important participation of stakeholders and other interested people. Buchholz *et al.* (2007) also suggest that multi-criteria analysis is a useful tool to model the sustainability of bioenergy systems. The Center for International Forestry Research (CIFOR 2012) defines multi-criteria analysis as a decision-making tool developed for complex problems. This dissertation considers social, economic and environmental criteria to categorize respondents' perceptions of the APGS bioenergy project's impacts on the Atikokan community. In a condition where multiple criteria are involved, a logical, well-structured decision-making process is required. In the multi-criteria analysis process, every member enters his or her own judgments and makes individual contributions to a jointly reached ending (CIFOR 2012). It is an important tool to assess the impacts of the bioenergy system, and at the same time it can be used to improve the chances of successfully implementing a bioenergy system.

Finally, this section of the thesis outlines the issues associated with broader execution of APGS bioenergy systems and suggests a methodology for minimizing its complexity. To assess the potential of the APGS bioenergy system, an integrated approach is needed for modeling the social, economic and ecological impacts of APGS bioenergy. During planning and evaluation, proper criteria should be used to decide when, where and how this bioenergy system can contribute to development. Assessing sustainability of the APGS woody biomass-based bioenergy system, using integrated modeling can offer the integration of its impacts and provide useful information for decision-making through participation. A bioenergy system is normally described as adaptive because of its ability to change in response to changing circumstances. As the concept of sustainability keeps evolving, adaptive systems have also proved suitable for its assessment.

CHAPTER 3

RESEARCH METHODS

3.1 RESEARCH APPROACH

The methodological aspects of research set the stage for acting on theories and carrying out empirical investigation. Methodology is defined as a "system of explicit rules and procedures on which research is based and against which claims for knowledge are evaluated" (Nachmias and Nachmias 1992). Methodology facilitates communication between concerned parties (mainly, the researcher and respondents) and serves as a basis for logical reasoning. It helps to verify the empirical findings of other studies and to facilitate replication. Although there is no ideal or universal methodological prescription for research, a sound methodology is the core of any scientific research. The suitability of research techniques and approach is "essentially relative" (Isokun 1985) and is influenced by the particular research topic, its demands and contextual setting, the level of competence of the researcher, and structural and logistic limitations of the research.

Socio-economics emerged as a separate field of study in the late twentieth century (ENCANA 2006); it is the study of the relationship between economic activity and social life. The field is often considered multidisciplinary, using theories and methods from sociology, economics, history, psychology and related disciplines. In many cases, socio-economists focus on the social impact of some sort of economic change. Such changes might include a factory closure, market manipulation, international trade treaties, new natural gas regulation, etc. (Australian Government 2005; ENCANA 2006). A socio-economic impact assessment (SEIA) is a useful tool to help understand the potential range of impacts of a proposed change, and the likely responses of those impacted if the change occurs (Tamborra 2002; LAMFN 2009). The perspective can help researchers and communities to design impact mitigation strategies that minimize negative and maximize positive impacts of any change (Hektor 2001; Domac *et al*. 2004). It is important to determine not only the full range of impacts, such as changes to levels of income and employment, quality of life and access to services, but also the implications of each particular change (DEAT 2006; ENCANA 2006; McLoughlin *et al*. 2008; MVEIRB 2009). A socio-economic impact assessment is a specialized type of social impact assessment (Becker 2001; DEAT 2006; Madlener and Domac 2007; LAMFN 2009). According to Dietz (1987), SEIA can be an effective tool for informing the public and encouraging their participation. It can also clarify the relationship between scientific information and values. SEIA is a way to enhance benefits or make a better policy decision. In addition, SEIA provides a foundation for assessing the cumulative impacts of development on a community's social and economic resources (ENCANA 2006).

The SEIA approach is used for this research, as the aim of this APGS woody biomass-based bioenergy development study is to conduct a socio-economic impact assessment to understand the possible changes and impacts on communities in Northwestern Ontario due to introducing woody biomass-based energy production at APGS. The methods employed for undertaking SEIA vary on a case-by-case basis from area to area (Mary 2009; Ozone 2009). For example, factors which are considered for the woody biomass-based energy development study at APGS are location specific, and include the likely level of perceived impact on utilization of woody biomass for energy development at the APGS, community concerns, and the value of woody biomass utilization for energy development.

SEIA is designed to assist communities in making decisions that promote social well-being through economic opportunity. Social well-being is a state in which basic human needs (water, food, shelter, education and health services) are met and people are able to live peacefully in communities with opportunities for advancement (USIP 2013). Assessing socio-economic impacts requires both quantitative and qualitative measurements of the impact of a proposed development. Vanclay (2003a, b) categorized the indicators that are usually used to measure the potential socio-economic impacts of a development, including changes in community demographics, demand for public services, changes in employment and income levels, and changes in the aesthetic quality of the community. Quantitative measurement of such factors is an important component of the SEIA (Vanclay 2003b).

DEAT (2006) and Vanclay (2003a) provided a set of categories of social impacts that can be used as guidelines to the SEIA. They include health and social well-being, quality of the living environment, economic effects and material well-being, cultural impacts, family and community impacts, institutional, legal, political, and equity impacts, and gender relations. Baumann *et al.* (2004) and FAO (2009) identify the major SEIA approaches for development as: Capacity Development Approaches; Participatory and Related Approaches (including the Participatory Approach, Action Research, Rapid Rural Appraisal); Community-Based Approaches (including Asset-based Development, Sustainable Livelihoods Approach); and Sector-wide Approaches.

Generally, there are two approaches to scientific research: quantitative and qualitative. The quantitative approach is used to measure the social world objectively, to test hypotheses and to predict human behaviour (Hoyle *et al.* 2002). On the other hand, a qualitative approach is concerned with understanding social life and the meaning that people attach to everyday life (Midgley 1999; DEAT 2006). Qualitative techniques are widely used in SEIA, and a number of research methods have been suggested. Some of these methods, according to DEAT (2006), include ethnographic research, focus group interviews, individual interviews, participatory rural appraisal (PRA), key informants interviews, community forums, and workshops. Questionnaires are also used to find out what people think are important community needs and problems. Surveys are useful for collecting specific information from a sample of a population (Taylor *et al.* 2004). The most important quantitative technique used in SEIA is the analysis of census data. This research study uses both qualitative and quantitative methods.

Traditionally, there are two main approaches to SEIA: a technocratic approach or a participatory approach. A technocratic approach demands that a researcher remains a neutral observer of social phenomena. The role of the researcher is to identify indicators, obtain objective measures relevant to the situation and provide an expert assessment on how the system will change. A key assumption is that, given sufficient data, accurate predictions can be made by trained social scientists (researcher) (Becker *et al.* 2004). The technocratic approach is product-orientated (Hugo *et al.* 1997). The principle of this approach is to make top-down decisions based on expert knowledge within a formal and structured bureaucracy (Schoenhuth and Kievelitz 1994; Taylor *et al.* 2004).

A participatory approach uses the knowledge and experiences of individuals most affected by the proposed changes as the basis for projecting impacts. In this case, the role of the researcher is as a facilitator of knowledge sharing, interpretation and reporting of impacts. The assumption is that, when effectively implemented, elicitation and reflection of individuals' perceptions, attitudes and beliefs become key components of impact assessment (Becker *et al.* 2004). The participatory approach is process-oriented (Hugo *et al.* 1997, Schoenhuth and Kievelitz 1994) and is a bottom-up approach (Schoenhuth and Kievelitz 1994). The major differences between the two approaches occur in the areas of data collection and analyses. By using both qualitative and quantitative methodologies, more comprehensive data are obtained and a more holistic product results (DEAT 2006). Both qualitative and quantitative approaches are essential to the research process in the social sciences; however, each has its own rules of practice (Creswell 2003; Bouma *et al.* 2009).

In the APGS woody biomass-based energy development study, both technocratic and participatory approaches were used. The integrated approach was used to provide a comprehensive and cost effective outcome (Vanclay 2003a; McLoughlin *et al.* 2008; Selfa 2009). Using an integrated approach in this study also helped to plan development activities that are people-centered, responsive and dynamic. As identified by several researchers, the integrated approach has some benefits and weaknesses in social studies (Neuman 1994; Creswell 2003; Bazeley 2004; Olsen 2004; Johnson and Christensen 2004; and Bryman 2006). Strengths of the integrated approach are that it can provide quantitative and qualitative research where a researcher can generate a grounded theory. Qualitative and quantitative research used together produces more complete knowledge necessary to inform theory and practice, allowing participants to answer a broader and more complete range of research questions, adding insights that might be missed when only a single method is used. This method can increase the generalizability of the results. Generalizability is a statistical framework for conceptualizing, investigating and designing reliable observations (Creswell 2003). As well, the researcher can use the strengths of an additional method to overcome the weaknesses in another method by using both in a research study, and the integrated approach can provide stronger evidence for a conclusion through convergence and corroboration of findings. This is the principle of triangulation. Finally, the verbal text and the statistical or illustrative information can support and complement each other (Creswell 2003; Bazeley 2004). There are some weaknesses to the integrated approach. It can be difficult for a single researcher to carry out both qualitative and quantitative research, especially if two or more approaches are expected to be done concurrently. As well, the researcher has to learn about multiple methods and approaches and understand how to mix them appropriately. Methodological purists contend that one should always work within either a qualitative or a quantitative paradigm. Other commentators describe an integrated approach as more expensive and time consuming (Creswell 2003; Bryman 2006).

There is no method that is universally acceptable or absolutely flawless for social sciences research. One logical way to minimize the weaknesses of a particular method is to administer a combination of methods. This has been popularly known as “methodological pluralism” where various qualitative and quantitative methods are combined to complement each other (Baten 2005). In this study, “methodological pluralism” was used for two reasons: first, it provides more flexibility to the researcher by offering a choice of alternative techniques and useful combination of methods to obtain optimal results; second, it reduces the shortcomings of any particular method.

3.2 RESEARCH METHODS

3.2.1 General Synopsis

The aim of the research is to explore the attitudes and opinions of the people about woody biomass utilization for energy production at the APGS (see Table 3.2.1 about the research design). The study explores the major socio-economic characteristics of the people which influence their possible decision to join in woody biomass-based activities. The Rapid Rural Appraisal (RRA) method of the SEIA approach for development was used to collect socio-economic impact data of biomass utilization for energy development at the APGS. It was developed in the late 1970s, and applied mainly to rural areas (Michael and Kievelitz 1994). According to Michael and Kievelitz (1994), "RRA can be defined as a systematic, semi-structured activity conducted on-site by a multidisciplinary team with the aim of quickly and efficiently acquiring new information and hypotheses about rural life and rural resources." RRA has been successfully used to help plan, monitor, implement and evaluate extension programs and activities. RRA methods are used during the implementation phase of projects to ascertain needs and create priorities for development activities (Michael and Kievelitz 1994). It is also used within the scope of monitoring and evaluating projects (FAO 1990; Baten 1998, 2005), for studies of specific topics (Schoenhuth and Kievelitz 1994), and to identify conflicting interests between groups (Schoenhuth and Kievelitz 1994).

The RRA study instruments which were used for this research include secondary data and literature reviews, surveys, focus group discussions and interviews. This research employed two main sources of data for the analysis: secondary data from Statistics Canada census; and primary data from the study communities. Primary data for this study were collected by the researcher. Most of the data were collected during 2009 and 2010. At research sites, to select the participants for the survey and focus group discussions, advertisements were placed in public areas (grocery stores, restaurants, different government institutions, banks, hospital, etc.) to ensure that a broad range of potential participants were informed about the study. The survey questionnaire is given in Appendix I. The total number of surveyed individuals is 147 and among them 49 are First Nations people. At research sites, six focus group discussions were held to gather information concerning the strengths, weaknesses, threats and opportunities of woody biomass-based energy production systems at the APGS (see Appendix II). During 2009-2011, 77 face-to-face interviews were also conducted with semi-structured questionnaires (see Appendix III). The researcher interviewed people from a wide cross section of class and occupational categories, including local business persons, social service workers, mill workers, trappers, homemakers, wage labourers, professionals, members of community groups, OMNR, and unemployed persons.

Secondary data and information sources for this research also came from annual reports of the involved industries, brochures, reports by the Ontario Ministry of Natural Resources, FPInnovations and other organizations involved in bioenergy. Findings from the surveys, focus groups, interviews, literature, and a critical assessment of existing government policy (document review) were used to develop recommendations to improve policies for better implementation of the woody bioenergy system at the APGS.

The research design is presented in Table 3.2.1. A brief description about the study instruments survey, group discussion and interview processes and analysis are provided in the following sections of the dissertation.

Table 3.2.1 Research design

Purpose of enquiry	Research approach	Methods	Target group	Number of people	Analysis of results	Presentation of results
Explore factors which influence people to participate in wood biomass-based businesses and their opinions on community development, quality of life and woody biomass utilization	Qualitative	Survey in Atikokan area to collect both quantitative and qualitative data (hereafter referred to as the Atikokan survey)	Individual community members	Invited = 257 Participated = 177 Retained= 147	Ethnographic design	Descriptive analysis and statistical methods
Evaluate socio-economic impacts of wood biomass utilization for energy production and its impact on community	Mixed Method	Survey in Thunder Bay (hereafter referred to as the Thunder Bay survey) and Focus Group in Atikokan area to collect both quantitative and qualitative data	Resource personnel; individual community members	Focus group = 6 (47 persons) Survey: Invited = 50 Participated = 26 Retained= 26	Ethnographic design; SWOT analysis	SWOT matrix and description
To assess people's perspectives about wood biomass for energy production and community development	Qualitative	Inductive; semi-structured and key informant interviews	Individual community members; contractors; resource personnel	Approached = 125 Interviewed: Formal = 77 Informal = 11	Ethnographic design; thematic Analysis	Descriptive analysis with tables and graphs; model development

Sources: Creswell 2003, MIG 2004.

3.2.2 Atikokan and its Surrounding Communities Survey

3.2.2.1 General Overview

For this study a survey was conducted in different communities of Northwestern Ontario. The survey is an efficient way of collecting data from a large number of targeted respondents about their opinions, behaviour or knowledge (Nancy 2004). Surveys are standardized to ensure reliability, generalizability and validity and are relatively free of errors (Ornstein 1998; Abramson and Abramson 1999).

For this research, the survey was conducted among residents of Atikokan, First Nations individuals, and contractors and entrepreneurs who are or potentially could supply woody biomass (pellets) for bioenergy production. The survey was designed to elicit social and economic variables, such as income, business interests, business decisions, access to credit and probable barriers to participating in bioenergy businesses. From the survey results, a statistical model was developed to identify the major factors that encourage people's involvement in the APGS bioenergy project's activities.

For this research, survey participants were selected from respondents to a public posting about the study and were selected based on their interest in participation. A questionnaire consisting of open and closed questions that were pretested inside the Atikokan community before the final survey was distributed. Pretest results helped to improve the quality of the questionnaire and identify possible problems with analysis of the data. For the survey, 257 individuals showed their interest to participate and survey packages that included a cover letter, consent form and the questionnaires were provided. Of the 257 packages handed out, 177 individuals participated and returned questionnaires. However, 30 responded questionnaires had to be discarded because they were incomplete. As a result, 147 questionnaires (57%) were retained for the analysis, greater than a typical return rate of 30%, which is in line with studies of this type (Shaughnessy *et al.*2006; Lemelin 2009).

Data collected from the survey included: demographic characteristics and socio-economic profiles of survey participants; indications of interest in becoming involved in woody biomass-based activities linked to the APGS; attitudes and opinions about community development in the Atikokan area; and attitudes and opinions about the APGS woody based bioenergy project (see Appendix I).

When participants did not show up at the agreed upon day to return questionnaires, the researcher visited locations again to pick up the material. As a result, the data collection process took more time in the field than it was planned. In addition, the nature of data and the educational background of the respondents contributed to more time being used for data collection than what was originally planned. On the basis of collected data and information, output tables were prepared. Both the parametric and non-parametric statistics were used for analyzing the data. The research outputs are presented in tables, graphs and bar charts in the Results section and Appendix IV, V, VI and VII.

For this thesis, generally three types of analysis are used. The most common, a descriptive analysis, involves the calculation of means for continuous variables and percentages for categorical variables. The second type of analysis is a stratified descriptive analysis that is used to compare a variable between two sub-groups. Finally, inferential analysis is used to look for associations between different variables.

Before processing survey data, it is important to know the type of data and analysis we have to handle according to our pre-specified objective. Selecting the appropriate statistical package depends on what sort of analysis is required. Often, the statistics package used comes down to personal preference (Korey 2009). The packages commonly used to analyze survey data are SPSS, SAS, STATA, S-plus/R, MATLAB, etc. For this study SPSS software version 18.0 was used to analyze the survey data because the user interface is better than for the other software. As well, the syntax of SPSS is consistent, it has comprehensible displays, and it can be used on many different types of computers and operating systems (Korey 2009). Finally, SPSS is quite good for big data sets, and if the research requires multiple response variables or the need to quickly analyze subgroups (Korey 2009).

Parametric statistics is a branch of statistics which assumes that the data has come from a type of probability distribution and makes inferences about the parameters of the distribution. Generally statistical tests which require that data be taken from a normally distributed population are described as parametric tests. Where the data cannot be assumed to come from a normally distributed population, non-parametric tests should be used. Non-parametric tests such as the Mann-Whitney U test are usually employed when the distribution of the data is unknown (Ettarh 2004; Wasserman 2006). A portion of data of the Atikokan survey was analyzed by using non-parametric methods. Non-parametric methods are widely used for studying populations that take on a ranked order (StatSoft Inc. 2009). Nonparametric methods are most appropriate when the sample sizes are small. As non-parametric methods make fewer assumptions, their applicability is much wider than the corresponding parametric methods. Another justification for the use of non-parametric methods is simplicity (Corder and Foreman 2009), but for a larger sample size, data can be analyzed by parametric tests and also by non-parametric tests (Gibbons and Chakraborti 2003; Hill and Lewicki 2007; Corder and Foreman 2009).

3.2.2.2 Factors Affecting Involvement in Woody Biomass Production Activities in the Atikokan Area

The effects of the prevailing socio-economic conditions on potential stakeholders in woody biomass-based activities for bioenergy generation at the APGS can be studied under two closely related and interdependent categories: economic and social. The first category includes variables that are relevant to the surveyed respondents' economic activities and characteristics. The study of these variables is normally based on an analysis of monthly income, access to credit for business, monthly expenditures for household energy purposes, and the economic performance of woody biomass harvesting and bioenergy production. The second category includes the social aspects of involved personnel, which comprises personal and demographic characteristics such as gender, age, education, occupation, length of residence in the area, and knowledge, belief and awareness of indirect benefits of woody biomass-based energy. Since the APGS bioenergy project has not fully started production, details about the economic performance of biomass harvesting and bioenergy production are not available. This study mainly deals with the variables of the development's social aspects. For analysis the surveyed respondents were classified into three categories: low income, middle income and high income. Respondents were also divided by their education levels: below primary, primary, Grade 12, college, university and post graduate. Likewise, respondents were grouped as to the length of time they have resided in the present locality. The respondents living in Atikokan, Mine Centre and Seine River First Nation were treated as one sample for statistical analyses.

The major types of services flowing from the standing trees of Northwestern Ontario include the production of woody biomass, the conservation of soil fertility, safeguarding of habitat for wildlife species, preservation of water quality and protection of soil against erosion. An increase in the value of these services will occur if people are involved in woody biomass-based activities. At the same time, utilization of residual and unmerchantable forest stands for bioenergy generation will discourage wasteful practices such as burning of residue. In the study area the socio-economic characteristics of surveyed respondents are assumed to have an enormous influence on people's decisions to become involved in woody biomass-based activities. In the Atikokan survey, participants were asked to indicate whether they were interested in becoming involved in woody biomass-based activities such as harvesting, transporting and providing a storage facility for pellets at APGS (see Appendix I for questionnaire). According to their responses, participants were then categorized as willing or unwilling to become involved in woody biomass-based activities. The socio-economic factors that influenced their decision are described in the following section including ethnicity, sex, age, education, occupation, length of residency, and monthly household expenditure for energy. The respondents' organizational memberships, business ownership, concern about the environment, access to credit, concern about cutting unmerchantable trees for energy, and concern about using forest harvesting residues for bioenergy production were also considered as socio-economic factors that influenced decisions to participate in woody biomass-based activities.

3.2.2.3 Model Expressing Surveyed Respondents' Decision to Become Involved in Woody Biomass-Based Activities

The philosophy of the model used in this study is based on the theory of random utility (McFadden 1981). Simply put, a person will show unwillingness to support woody biomass activities if he/she believes that there is no profitable benefit to them. Perception of (future) benefits and profit generation from bioenergy activities will vary among people. The involved people are assumed to maximize the utility of net benefit. If a person is willing to become involved in bioenergy activities, his/her utility is $u_1 = u(1, X)$ and if not, the utility is $u_0 = u(0, X)$, where X is a vector of variables assumed to influence net benefit. Although the person is assumed to know his/her utility function with certainty, this function contains some elements that are unobservable to the analyst and they are treated as stochastic. For this reason, u_0 and u_1 are treated as random variables with some given parametric probability distribution. Let v (0, X) and v (1, X) denote the means of u_0 and u_1 respectively, and u_0 and u_1 can be written as equation (1).

$$u(j, X) = v(j, X) + e_j \qquad [1]$$

Where, j = 0, 1.

Further, j = 0 indicates when the person is not willing to be involved in biomass activities and j = 1 when he/she does. The person's decision on becoming involved in biomass activities will depend on which is greater, u_0 or u_1. A person is willing to be involved in biomass activities only if $u_1 \geq u_0$ and given by equation (2).

$$v(1, X) + e_1 \geq v(0, X) + e_0 \qquad [2]$$

Where, e_0 and e_1 are independently and identically distributed random variables with zero means. Based on his/her economic situation and other socio-economic characteristics, the person knows which is greater, u_0 or u_1. However, from the analyst's viewpoint, the surveyed respondent's decision (willing or unwilling) is a random variable whose probability distribution is given by equations (3) and (4).

$P_0 = P_r$ (the person is not willing to be involved)

$= P_r (v (1, X) + e_1 < v (0, X) + e_0)$ [3]

$P_1 = P_r$ (the person is willing to be involved)

$= P_r (v (1, X) + e_1 > v (0, X) + e_0) = 1 – P_0$ [4]

Where, P_r stands for the probability of a decision whether the person is willing to be involved in biomass-based activities. Predicting whether an event will or will not occur as well as identifying the variables that are useful in making the prediction is important in theory and in the real world (Norusis 1992).

A series of statistical techniques can be used to predict a dependent variable from a set of independent variables. These techniques include multiple regression analysis, discriminant analysis and logistic regression analysis. However, multiple regression and discriminant analysis create difficulties when the dependent variable has only two values – an event occurring or not occurring (Hosmer and Lemeshow 2000). Another difficulty with multiple regression analysis is that predicted values cannot be interpreted as probabilities and they do not fall in the interval between 0 and 1(Norusis 1992). The probability (prob) of the surveyed respondents' willingness or unwillingness to become involved in woody biomass-based activities as a component of their income is estimated using the logistic regression. A logistic regression model is used in this study, as it requires fewer assumptions than discriminant analysis, and even when the assumptions required for discriminant analysis are satisfied, logistic regression also performs well

(Hosmer and Lemeshow 2000). For the case of a single independent variable, the logistic regression model can be written as equations (5) and (6).

$$prob(event) = \frac{e^{\beta_0+\beta_1 X}}{1+e^{\beta_0+\beta_1 X}} \qquad [5]$$

or equivalently,

$$prob(event) = \frac{1}{1+e^{-(\beta_0+\beta_1 X)}} \qquad [6]$$

Where, B_0 and B_1 are coefficients estimated from the data, X is the independent variable, and e is the base of the natural logarithms, approximately 2.178. For more than one independent variable (like in the case of a survey respondent's decision on involvement in woody biomass-based activities), the model can be written as equations (7) or (8).

$$prob(event) = \frac{e^{Z}}{1+e^{Z}} \qquad [7]$$

or equivalently,

$$prob(event) = \frac{1}{1+e^{-Z}} \qquad [8]$$

When Z is the linear combination it yields equation (9).

$$Z = B_0 + B_1X_1 + B_2X_2 + ... + B_pX_p \qquad [9]$$

The probability of an event not occurring is estimated by equation (10).

$$Prob(no\ event) = 1 - Prob(event) \qquad [10]$$

The method of maximum likelihood provides the foundation from which one can estimate other unknown parameters with the logistic regression model (Hosmer and Lemeshow 2000). The coefficients make the observed results, which are most likely to be selected. Normally the method of maximum likelihood yields values for the unknown parameters which minimize the probability of obtaining the observed set of data (Valavanis 1959; Hosmer and Lemeshow 2000). Using the method of maximum likelihood, values of the unknown coefficients (B_0, B_1, B_2, ... B_p) in equation (9) that maximize the sum of the squared deviations of the observed values of the dependent variable from the predicted values based upon the model are chosen. According to Valavanis (1959), the use of maximum likelihood generates estimates that are unbiased, consistent and efficient. In statistics probability and likelihood have distinct meanings: probability is a possession of the sample whereas likelihood is a property of the unknown parameter values (Valavanis 1959). In order to apply the method of maximum likelihood, first the likelihood function that expresses the probability of the observed data as a function of the unknown parameters is constructed. The unknown coefficients are found by manipulating this function and the maximum likelihood estimators of an unknown parameter are chosen to be those values which maximize this function (Hosmer and Lemeshow 2000).

Figure 3.2.1 is plot of a logistic regression curve when the values of Z are between -5 and +5. The curve is S-shaped and the relationship between the independent variable (z) and the probability is non-linear. The probability estimates are always between 0 and 1, regardless of the value of Z. For example, in our case, the surveyed respondents with Z values of ≥ 0.5 were classified as willing to be involved in woody biomass activities; conversely, those with Z values ≤ 0.5 are classified as unwilling to be involved in woody biomass activities. If the predicted and actual outcomes match, the individual is correctly predicted.

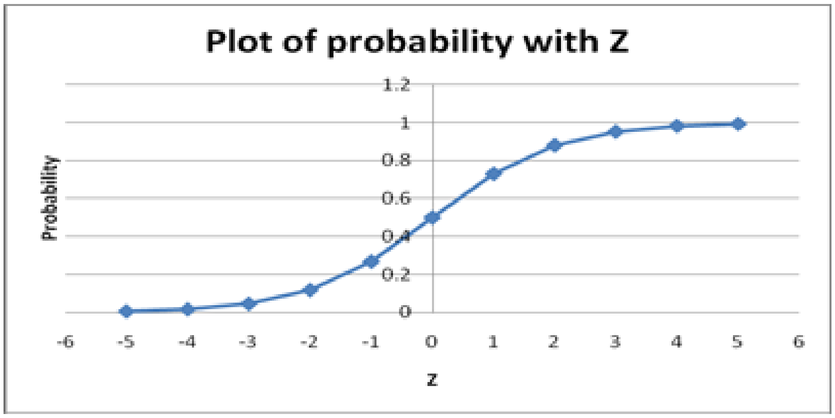

Figure 3.2.1 Plot of logistic regression curve (Hosmer and Lemeshow 2000).

The data used in this part of the study were collected through a questionnaire survey of individuals in Atikokan and its surrounding areas, i.e., Mine Centre and Seine River Aboriginal First Nation. The survey was designed to obtain information about socio-economic factors that are expected to influence a decision about becoming involved in woody biomass-based activities. To assess respondents' willingness to become involved, the questionnaire asked individuals whether they were willing to develop a new business or willing to become involved in woody biomass-based activities in the future (see questionnaire survey format Appendix I). The researcher then categorized the decision expressed on the survey and grouped participants as willing or unwilling to become involved in wood biomass-based business or activities.

To assess the willingness of the survey respondents for biomass-based business, a logistic regression was run to explore any relationship between the response variable and a set of independent variables (Norusis 1992; Hosmer and Lemeshow 2000). Logistic regression applies maximum likelihood estimation after transforming the dependent into a logit variable (the natural log of the odds of the dependent occurring or not). In this way, logistic regression estimates the odds of a certain event occurring (Norusis 1992;

Hosmer and Lemeshow 2000). Unlike ordinary linear regression (OLR), logistic regression does not assume linearity of relationship between the independent and dependent variables (Hosmer and Lemeshow 2000). It does, however, require that observations be independent and that the independent variables be linearly related to the logit of the dependent variable (Christensen 1990; Hosmer and Lemeshow 2000). The predictive success of the logistic regression can be assessed by looking at the classification table, showing correct and incorrect classifications of the dichotomous or ordinal dependent variable. Goodness-of-fit tests such as the likelihood ratio test are available as indicators of model appropriateness, as in the Wald statistic to test the significance of individual independent variables (Hosmer and Lemeshow 2000; Korey 2009).

In the Atikokan area survey about woody biomass utilization for energy, participants were asked to provide their opinions on factors they considered important for the development of their community. Seven factors were provided in the questionnaire based on the literature of Dodge (1980) and Cook (1994). These are: employment, natural environment, culture, services (banking, transportation, etc.), access to amenities, diverse population and rural values. Respondents were requested to rank these factors according to their importance. Among the total 147 participants who completed the survey, 127 gave their opinions on the seven identified factors. Additionally, 131 participants gave their opinions on the important factors of quality of life, using six different categories (Appendix V): clean air and water, good jobs, arts and culture, security and safety, good community relationships and good place to raise a family. Furthermore, 124 respondents gave their opinions on the purpose of developing woody biomass-based bioenergy projects (Appendix VI) using ten different characteristics: renewable, affordable, job opportunities, business opportunities, reduces global warming, generates profit from waste, provides energy self-sufficiency, energy for industry and develops alternative energy to fossil fuels.

3.2.3 Focus Group Discussions and Thunder Bay Survey

As shown in the section 2.1.5, the conversion of the APGS to wood pellets as 100% of the feedstock is technically feasible; however, in addition to technical feasibility, a suitable policy is essential for promoting and sustaining growth in any sector of the economy. Policy makers always need relevant information for formulating effective and enabling policies, which can help in integrated development. An example of vital information for the development of the woody biomass-based bioenergy sector is the perception of different occupational groups within the region. Incorporating the perceptions of such groups is essential for ensuring the successful formulation and execution of any bioenergy policy that focuses on woody biomass-based bioenergy development in the region. Understanding the perceptions of such groups will help to identify the issues to be addressed in a future bioenergy policy. Addressing such issues will also help reduce conflicts and improve cooperation amongst government, industry, non-governmental organizations, general people and other stakeholder groups (Beckley and Reimer 1999).

Focus groups were comprised of community members who share characteristics so that the researcher could gain an understanding of how attitudes and behaviours work in a group (Tracy *et al.* 2006; Itaoka *et al.* 2011). A focus group is a form of qualitative research where people are asked about their attitudes and viewpoints towards a product, service, concept, advertisement or idea. Questions are asked in an interactive group setting where participants are free to talk with other group members (Creswell 2003). The benefit of using focus groups is that they provide an opportunity for disclosure within a setting where participants share characteristics and their comments are validated (Lemelin 2009). However, focus groups also have disadvantages: the researcher has less control over a group than in a one-on-one interview and thus time can be lost on issues irrelevant to the topic (Creswell 2007).

A mixed method research approach was used for this study to understand the perceptions of the local communities about woody biomass-based bioenergy development in the region. At research sites six focus group discussion sessions were arranged and a survey was conducted in Thunder Bay. In Atikokan, three sessions of focus group discussions were organized with the help of the local economic development corporation and the Mayor of Atikokan. In the Seine River First Nation, three sessions of focus group discussions were arranged with the help of the economic development councillor of the Seine River First Nation Band. In Thunder Bay the survey was organized with the help of the Centre for Research and Innovation in the Bio-Economy (CRIBE) in Thunder Bay (CRIBE 2013). Focus groups in Atikokan area were conducted during 2010 and 2011, with different professionals (13 persons, mainly retirees, youths (15 persons, mainly female), and First Nations (19 persons, mainly male). As well, the Thunder Bay survey was conducted in 2011 with different professionals (academic persons, students, government, non-governmental organizations and industry) (26 persons, mainly male).

Each focus group consisted of six to 15 participants, and the length of group discussions was about two hours. Participants were free to leave at any time and all their comments on the topic were documented on paper. The researcher initiated the sessions of group discussions by introducing the key themes in a SWOT (strength, weaknesses, opportunities and threats) analysis framework that was used to classify and evaluate the perceptions of the community members about woody biomass-based bioenergy development at the APGS (see Appendix II).

In Atikokan, two focus group discussions occurred with different representatives of professional groups. The combined participants of the two groups included: a retired manager (engineering and process) of the APGS, an area forester from the MNR, the Chief Executive Officer (CEO) of the Atikokan hospital, a librarian, three business owners (small forest industries), the Quetico Park manager, a school teacher, three retired school board and economic development members, and the mayor of Atikokan. These participants were 60 to 70 years old. A SWOT matrix was developed based on the responses of these two groups. With the information of this SWOT matrix and that obtained from different literature about the impacts of woody biomass-based bioenergy, a new SWOT matrix sheet was developed; and this new matrix was used as an enquiry sheet for the Thunder Bay survey.

In Thunder Bay, the survey was conducted with participants of the Grassroots Approach Bioenergy conference organized by the Centre for Research & Innovation in the Bio-economy (CRIBE) and the Canadian Bioenergy Association (CanBio) at the Valhalla Inn, on April 26-27, 2011. It was the second Northwestern Ontario Bio-economy Corporation (NOBEC) conference. The conference focussed on entrepreneurship for small, community-based initiatives for Northwestern Ontario. There were 66 participants belonging to different occupations including administration, academics, energy, forestry, business, students, non-government organizations and industry (NOBEC 2011). In Thunder Bay, invitations were given to 50 participants, and they were provided with the survey matrix, cover letter and consent form. Respondents were asked to select four points from each section of the matrix and instructed to rank them according to their importance. They were also requested to provide additional points to the matrix. Of the surveys distributed, 26 (52% return rate) of the conference professionals returned the package. Responses were categorized into five distinct groups that were organized according to occupation: academic personnel, students, non-government organizations, forest related business holders and government personnel.

A SWOT analysis was chosen for this study to assess the people's perceptions about the socio-economic impact of woody biomass-based bioenergy development at the APGS. The analysis aims to identify internal strengths and weaknesses of woody biomass utilization as well as examining the external opportunities and threats which can hamper its growth at APGS. Here strengths are internal attributes that add value to the local community and give a positive view for establishing woody biomass-based bioenergy and weaknesses are internal factors that may hamper its development potential. Opportunities are external positive factors such as positive legislation for renewable bioenergy development whereas threats are external problems that are largely beyond any control (MSG 2013).

3.2.4 Interviews

The topic of the qualitative research interview is to discover the real world of the subjects and their relation to it. The main task in interviewing is to understand the meaning of what the interviewees say, and the purpose is to describe and understand the central themes that the subjects express (Kvale 1996). A qualitative research interview seeks to discover information on both a factual and a meaning level, though it is usually more difficult to interview on a meaning level (Kvale 1996). Normally, formal interviews involve asking a fixed written set of questions on specific topics that are recorded in detail. In informal interviews, open-ended questions are asked around a specific topic or topics, but in a flexible manner to allow other issues to be addressed (Creswell 2003).

Both formal and informal face-to-face interviews are the primary source of data for this research. Most of the data were collected during 2009 and 2010 at Atikokan and surrounding First Nations communities. The formal interviews were semi-structured, consisting of open questions that were addressed to both experts and local people. The responses were recorded (audio) and later transcribed in order to obtain the most relevant and related information. However, informal face-to-face interviews were not recorded and were used strictly for the researcher's personal understanding of the research issues. These informal interviews helped to familiarize the researcher with the circumstances prior to conducting formal interviews, as well as acting to 'pre-test' the interview questions on local people. The results of informal interviews were not documented.

Woody biomass utilization for electricity generation is relatively new in Ontario, and no study has examined how professionals and the public perceive these developments. Interviews for this thesis have been completed by consultations with a diverse group of local professionals, the general public of Atikokan, and some of its surrounding forestry-dependent communities. It looks at the social perspectives of converting forest woody biomass to energy at the APGS. The objectives of this section are to: understand the views of individuals within Atikokan and its surrounding communities on converting woody biomass to energy at the APGS; identify, from the perspectives of individuals within Atikokan and its surrounding communities, the opportunities for and barriers to converting woody biomass to energy; and explore possible courses of action to overcome those barriers. Woody biomass utilization is an issue that requires multiple people from a variety of fields and perspectives to implement projects successfully. A goal of this research section is to identify the key elements that must be considered for the development of the APGS bioenergy project.

A purposive sampling strategy was used to identify suitable research participants for these interviews. Interviewees included people who are currently involved in the development of woody biomass-based bioenergy activities at the APGS and those working within forestry-based livelihoods who expressed interest in being involved in the APGS bioenergy production system in the future. This purposive sampling strategy allowed the participant selection process to be systematic and logistically manageable given the large area under study. To select participants, community leaders (mayor and town council), members of the economic development corporation of Atikokan, and chiefs and band councils of First Nation communities throughout the region were invited to participate in June 2009. Initial contact with the Atikokan municipality and First Nation communities was made by phone since this approach extracted the best response. In addition, a snowball sampling procedure where people familiar with and interested in bioenergy development were recommended by community leaders or the chiefs of First Nation communities during their interviews. These people were subsequently invited to participate. Four personnel from First Nation non-government organizations were also invited. While this sampling approach is not statistically representative of all communities in Northwestern Ontario, it reflects a cross section of perspectives from community members who are aware of and interested in the existing situation of woody biomass-based bioenergy in the region.

A total of 77 interviews (Table 3.2.2) were conducted with participants from the municipality of Atikokan and nine First Nation communities ─ Grassy Narrows First Nation, Wabigoon First Nation, Seine River First Nation, Lac La Croix First Nation, Rainy River First Nation, Couchiching First Nation, Naicatchewenin First Nation, Nigigoonsiminikaaning First Nation and Fort William First Nation. In a number of cases there were several participants from the same community. From the nine First Nation communities, of the 39 individuals contacted, 17 agreed to an interview. A number of these interviewees said they were hesitant to voice their opinions on the APGS project development, saying they were not familiar enough with it to comment specifically. Interviewees from the Atikokan township consisted of mayor and councillors, economic development officers, professionals from different private and public organizations (including OMNR, the APGS personnel, the small forest industry, schools and the hospital), forestry workers, and retirees from different local organizations (school, social service, forest industry, OMNR). All interviews were completed in person with a single individual at a time. The respondent categories of individuals interviewed, including the number of interviewees and the percentage of total interviewees are given in Table 3.2.2.

Small forest industry group members belonged to forest-based business holders (saw mill), canoe manufacturing, aspen based furniture manufacturing, wooden handicrafts, forest machinery supply companies, and forestry based entrepreneurs (contractors, loggers, biomass and wood suppliers). Interviewees from First Nation communities consisted of chiefs, councillors, elders, forestry workers, and economic and social development staff. Members from the First Nation non-government organizations were mainly from Pwi-Di-Goo-Zing Ne-Yaa-Zhing Advisory Services, which consults with First Nations on economic and community development.

Table 3.2.2 Respondent categories of individuals interviewed.

Respondent Categories	Code	Number of Interviewees	Percentage of Total Interviewees
Small Forest Industry	SFI	12	16%
Ontario Ministry of Natural Resources	MNR	6	8%
Atikokan Power Generating Station	APGS	5	6%
Education Institutions	EI	10	13%
Social Service Sector	SSS	12	16%
First Nation Individuals	FNI	17	22%
First Nation Non-Government Organizations	FNGO	4	5%
Local Community Organizations	LCO	6	8%
Elected Leaders	EL	5	6%
Total		77	100%

The OMNR group was made up by personnel from local OMNR, and the APGS group consisted of APGS employees. School teachers from the Atikokan area made up the education institutions group. The social service sector group consisted of community volunteers, personnel from hospitals, lawyers, journalists, and other community members from various tourism and cultural occupations. First Nation individuals included different staff from the First Nation bands (chiefs, councillors) and individuals from outside band offices. The First Nation non-government organization (Pwi-Di-Goo-Zing Ne-Yaa-Zhing Advisory Services) worked with the education, development, health, and training of First Nation individuals. Local community organizations were comprised of the personnel from the economic development commission, youth organizations, golf clubs, adult learning centres and shelter houses. The elected leaders group consisted of local MPs, MMPs and the mayor of Atikokan. Interviews lasted from 30 minutes to two hours depending upon the interest and response of the interviewee. Most interviews were recorded on audiotape, except when the participant was not comfortable doing so. For all cases, notes were taken during interviews.

All interviews were transcribed and analyzed, using the thematic analysis method (Braun and Clarke 2006), where trends and differences in perspectives among interviewees are examined for each theme to assess variation in perspectives as well as differences or similarities. Thematic analysis is a qualitative analytic method for identifying, analysing and reporting patterns within data (Braun and Clarke 2006). According to Guest *et al.* (2012), researchers consider thematic analysis a useful method for capturing the facts of meaning within a data set. In qualitative research, thematic analysis examines themes within data (Daly and Gliksman 1997) to pinpoint, examine, and record patterns within data (Braun and Clarke 2006); thus, the themes become the categories for analysis (Fereday and Muir-Cochrane 2006). Thematic analysis also focuses on the human experience subjectively (Guest *et al.*2012), and emphasizes participants' perceptions, feelings and experiences, allowing respondents to discuss a topic in their own words, free of constraints from fixed-response questions (Braun and Clarke 2006).

Thematic analysis is performed through the process of coding in six phases to create established, meaningful patterns (Braun and Clarke 2006). The first phase is familiarisation with the data that involves reading and re-reading the data to become familiar with content. The second phase is coding, which involves generating concise labels (codes) that identify important features of the data that might be relevant to answering the research question. After coding the entire data set, all relevant data are extracted for later stages of analysis. Third is searching for themes. This phase involves examining the codes and collated data to identify broader patterns of meaning (potential themes), then collating data relevant to each individual theme. Next, themes are reviewed to check the interviewee themes against the dataset. In this phase, themes are refined, split, combined or discarded. Defining and naming themes is the fifth phase; it involves a detailed analysis that works out the scope and focus of each theme. At this point, each theme also receives an informative name. The final phase is writing up, where the analytic narrative and data extracts are woven together. Writing out contextualises the analysis in relation to existing literature (Braun and Clarke 2006). Though these phases are sequential, and each builds on the prior, analysis is usually a recursive process, with movement back and forth between different phases. Therefore it is not rigid, and with smaller datasets, the analytic process can combine some of these phases (Braun and Clarke 2006).Thematic analysis offers a number of advantages to researchers: it is flexible, allowing researchers to apply multiple theories across a variety of epistemologies (Braun and Clarke 2006). It is also well-suited to large data sets so that researchers are able to expand their range of study past individual experiences (Braun and Clarke 2006). It allows for interpretation of themes supported by data (Guest *et al.* 2012) so that categories emerge from data naturally (Saldana 2013). Guest *et al.* (2012) have concerns about the technique's reliability because of the wide variety of interpretations from multiple researchers that might overlook nuanced data (Guest *et al.* 2012). The flexibility that can be advantageous might also make it difficult to concentrate on what aspect of the data to focus on (Braun and Clarke 2006). As well, Braun and Clarke (2006) point out that its interpretive power is questionable if the analysis excludes a theoretical framework. As well, there may be impaired continuity of data in individual accounts (Braun and Clarke 2006), especially when the discovery and verification of themes and codes are meshed together (Charmaz 1988, 2006).

In addition, resource personnel (experts) who are involved with the woody biomass utilization sector in Northwestern Ontario were interviewed to get their views on the system and components of sustainable woody biomass-based bioenergy for the APGS. These informants were recruited through the purposive sampling and snowball networking. The purpose of this process was to generate a model which is later presented and illustrated by Figure 2.3.2.

CHAPTER 4

RESULTS

4.1 FINDINGS FROM THE ATIKOKAN AREA SURVEY

4.1.1 Factors Affecting Involvement in Woody Biomass-Based Energy Production Activities in the Atikokan Area

4.1.1.1 Socio-Economic Factors of the Respondents' Regarding the Willingness to be Involved in Woody Biomass-Based Activities.

The success of the APGS woody biomass-based electricity generation will depend on the support and interest of the local people. During the survey, local people were asked about their interest in getting involved in future woody biomass-based activities to support the APGS. It was assumed that respondents who believe in direct and indirect benefits from woody biomass-based bioenergy activities will be more interested to become involved. More than half of the surveyed respondents (52%) expressed a willingness to get involved in activities related to small business development in harvesting, communition and transportation of woody biomass, and/or the production of pellets. The only direct use of woody biomass at the APGS is in the form of pellets.

The socio-economic characteristics of the surveyed individuals (147) and the influence of these characteristics on people's willingness to be involved in woody biomass-based activities are discussed as follows:

Ethnicity: Aboriginal and non-Aboriginal people are expected to be involved in woody biomass-based activities to support the APGS. Of the 147 respondents, 33% (49) were Aboriginal people and 67% (98) non-Aboriginal people. Among the Aboriginal respondents, 63% were willing to be involved in woody biomass-based activities, while the percentage for non-Aboriginal respondents was 46%.

Sex: Most of the survey respondents were male. They represented 76 % of the total respondents. Only 24% of the respondents were female. Within the two groups, 53% of male respondents and 43% of female respondents were willing to be involved in woody biomass-based activities.

Age: Age is an important factor for influencing any decision. The respondents are categorized under five age groups for the purpose of analysis: below 35 years, 36-45 years, 46-55 years, 56-65 years and above 65 years. Among the five age groups, the highest number of respondents (29%) belonged to the age group 36-45 years. The age group 56-65 years had the second highest number of respondents (24%). The percentages of respondents in the other three age groups are: 46-55 years, 22%; below 35 years, 20%; and above 65 years, 5%. Of the respondents who are 40 years or less, 46% were willing to be involved in woody biomass-based activities. For respondents above 40-years-old, an even higher number, 58%, were willing to do woody biomass-based activities. People over 40 years of age were more interested in being involved in woody biomass-based activities than those who were under 40.

Education level: Education levels were expected to have an influence on the length of residency, awareness of the indirect benefits, total monthly expenditure for energy, total monthly income and in turn will affect the surveyed respondents' willingness to become involved in woody biomass-based activities. The surveyed respondents were classified as: very low education (below primary and primary), low education (12th grade), medium education (college degree) and high education (university and post-graduate education). The high education level, in particular, was expected to affect directly both the degrees of perception of indirect benefits from woody biomass harvesting and awareness of its utilization for energy purposes. It was expected that respondents with a high education level would be more interested in woody biomass-based activities in future. Table 4.1.1 shows the distribution of age groups of respondents based on their educational level. Among the respondents with a very low or low education level, 44% are interested in getting involved in woody biomass-based activities. Respondents whose education level is higher than grade 12 are also interested (58%) in getting involved.

Table 4.1.1 Relationship between age groups of respondents and education level as an expression of interest in biomass-based activities (Field survey, 2009).

Education level of respondents	Percentage distribution of respondents by age groups in the study areas					Total value
	35 years and below	36-45 years	46-55 years	56-65 years	Above 65 years	
Very low (below primary & primary)	10%	24%	13%	5%	0%	13%
Low (grade 12)	21%	24%	53%	59%	86%	41%
Medium (college)	21%	26%	19%	14%	14%	20%
High (university/post graduate	48%	26%	16%	22%	0%	26%
Total sample	100%	100%	100%	100%	100%	100%

Occupation: In Northwestern Ontario, a number of people are involved in the forest-related activities for their livelihood. Among the survey respondents, 57% were involved in forest related activities and the rest of the respondents (43%) were involved in non-forest-based occupations. It was expected that those who have been involved in forest-related occupations would be more interested in being involved in woody biomass-based activities. People in forest related occupations covered a range of jobs, including foresters from the Ontario Ministry of Natural Resources (OMNR), park superintendents, contractors, industry workers, loggers, truck drivers, technicians, forest labourers, biofuel business holders, scalars and planners. Respondents from non-forestry occupations (43%) included a social worker, labourers, clerks, economic development officers, project managers, local administrative jobs, custodians, business owners, health personnel, and sales managers. People who were involved in forest-related occupations were more interested (55%) in being involved in woody biomass-based activities than those in non-forest related occupations (48%).

Length of residency: It is assumed that people who have been living longer in Atikokan have more knowledge of the community and its surrounding natural resources. Since 2007, most of the forest-based industries have been closed in Atikokan. People who previously worked in those industries might be interested in new jobs and businesses related to woody biomass activities. This is because these people have experience related to woody biomass activities as well as knowledge and skill in forest-based activities. The minimum length of residency of people in this locality is six months, and the maximum length 72 years. Most of the people have lived for more than 10 years (84%) in the area, and only a small proportion of people (16%) have lived 10 years or less in the area. Among the survey respondents who have been in this locality for 20 years or less, 52% are willing to be involved in biomass-based activities. Of the respondents who have been in this locality for more than 20 years, 50% are willing to be involved in woody biomass-based activities.

Monthly household expenditure for energy: The monthly household expenditure for energy is an important factor for considering people's willingness to be involved in woody biomass-based activities in future. It was expected that people who spend a higher percentage of their income for energy are likely to search for an alternative and cheap source of energy for their consumption. Earnings also influence what income people have to spend on energy; the monthly household expenditure for energy ranges from $80 to $2400. Out of 147 (100%) respondents, 35% spent $301–$500, 22% spent more than $500, 21% spent $201–$300, 16% spent $101–$200 and 6% spent ≤ $100 per month on energy respectively. Among the respondents whose monthly expenditure for energy was $500 or less, 51% expressed a willingness to be involved in woody biomass-based activities. Of respondents whose monthly expenditure for energy is more than $500, 52% were willing to be involved in biomass-based activities.

Organizational membership: It was believed that people who belong to a local organization have the facilities for more communication and better information exchange. It was also expected that people who are members of one or more organization have more awareness about woody biomass-based energy and have more interest in it. Out of 147 respondents, 75 (51%) reported memberships in organizations. People who are not members of a local organization showed more interest (54% respondents) in being involved in woody biomass-based activities than people who are members of the local organizations (49% respondents).

Business owners: People who operate their own business have experience in running a business and it was expected that they would be interested in being involved in new woody biomass-based business or activities. In Northwestern Ontario, there are a number of people involved in a range of small businesses, such as wood harvesting, transportation, canoe making, furniture manufacturing, tourism, landscaping, small manufacturing, value added products, blueberry harvesting and manufacturing of herbal medicines. Most of the respondents (82%) did not have their own business, but of the 18% who have businesses, 73% showed more interest in involvement in woody biomass-based activities than people who do not have their own business, where less than half (47%) expressed interest.

Concern about the environment: During the survey people were asked to evaluate the environmental condition of their community for the last five years. They were asked to express their opinion on whether there has been improvement or worsening of the surrounding environment of their community. It was expected that the community environment has been improved over the last five years by the development of science, government support and community initiative. According to the local government members, the environmental condition of the Atikokan community has improved, but among the surveyed respondents 56% (82) mentioned that the condition of the environment in Atikokan and its surroundings has worsened over the last five years, in contrast to 44% respondents (65) who reported that the environmental conditions had improved. Those respondents who thought the environment had improved over the last five years were more willing (66%) to get involved in woody biomass-based activities than people who thought environmental conditions had worsened (40%).

Credit: Access to credit is an important factor for starting a business. It was thought that people who have access to credit would be more interested in being involved in woody biomass-based activities. Most of the respondents (89%) did not have access to credit and only a few (11%) respondents received credit to run businesses. Respondents who have access to credit were more interested (81%) in being involved in biomass-based activities than respondents who did not have access to credit (48%).

Concern about cutting unmerchantable trees for energy: Northwestern Ontario forests belong to the temperate and boreal zones, and trees in these types of forests take a long time to grow and mature. Most of the First Nation and rural communities of Northwestern Ontario depend somewhat on forests for their livelihood, such as for hunting, fishing and firewood collection. In fact, people, wildlife and trees are a part of a sustainable ecosystem of Northwestern Ontario. Since it is believed that a large number of trees are required to run the full capacity of the APGS, the provincial government decided to start at10% capacity with biomass by 2014. For this 10% capacity of electricity generation at APGS, the annual requirement of biomass feedstock is about 200,000 gt or 90,000 t of pellets (Alam *et al.* 2012). A number of entrepreneurs who are involved in tourism, camping, hunting, fishing and small furniture making businesses reported that their activities will be affected by the cutting of big blocks of trees for woody biomass. Concern about cutting trees, even those thought to be unmerchantable, is an important factor for people involved in biomass-based activities or businesses in future. At this point, however, most of the respondents (78%) were not concerned about cutting unmerchantable trees for bioenergy production, with only a small percentage of respondents (22%) expressing concern. The respondents who are not concerned about cutting unmerchantable trees showed slightly more interest (53%) in being involved in woody biomass-based activities than respondents who expressed concern (51%).

Concern about utilizing forest harvest residues for bioenergy production: Utilization of forest harvest residues for bioenergy in NWO is a fairly new concept. APGS is the first coal-fired power plant in Ontario which will be converted to woody biomass-based feedstock (OPG 2013). There is still a mix of support and concern about woody biomass utilization for generating electricity, so it is an important issue for those people involved in woody biomass-based activities or businesses in future. Most of the respondents (73%) are not concerned about using forest harvest residues (FHR) for bioenergy production, though some respondents (27%) are concerned. Respondents who are not concerned about harvesting forest harvest residues showed slightly more willingness (52%) to be involved in woody biomass-based activities than respondents who are concerned (50%). A summary of results about the relationship between surveyed respondents' willingness to be involved in biomass-based activities and the different factors assumed to influence such a decision is given in Table 4.1.2.

Table 4.1.2 Relationship between respondents' willingness to be involved in woody biomass-based activities and influencing socio-economic factors

Socio-economic Factors	Variables	Total survey population (%)	Willing to involve (%)	Relationship between respondents' willingness
Ethnicity	Aboriginal	33%	63%	Have strong willingness to be involved in APGS
	Non-aboriginal	67%	46%	Not strong willingness to be involved in APGS
Gender	Male	76%	53%	Have strong willingness to be involved in APGS
	Female	24%	43%	Not strong willingness to be involved in APGS
Age	40 years or less	48%	46%	Not strong willingness to be involved in APGS
	Above 40 years	52%	58%	Have strong willingness to be involved in APGS
Education level	12 Grade or less	54%	44%	Not strong willingness to be involved in APGS
	Higher than 12 Grade	46%	58%	Have strong willingness to be involved in APGS
Main occupation	Forest related	57%	55%	Have strong willingness to be involved in APGS
	Others	43%	48%	Not strong willingness to be involved in APGS
Have own business	Yes	18%	73%	Have strong willingness to be involved in APGS
	No	82%	47%	Not strong willingness to be involved in APGS
Have access to credit	Yes	11%	81%	Have strong willingness to be involved in APGS
	No	89%	48%	Not strong willingness to be involved in APGS
Change in environmental condition by last 5 years	Improved	44%	66%	Have strong willingness to be involved in APGS
	Not improved	56%	40%	Not strong willingness to be involved in APGS
Concern about utilizing forest harvest residues for bioenergy	Have concern	27%	50%	Not strong willingness to be involved in APGS
	No concern	73%	52%	Have strong willingness to be involved in APGS
Concern about cutting unmerchantable trees for bioenergy	Have concern	22%	51%	Not strong willingness to be involved in APGS
	No concern	78%	53%	Have strong willingness to be involved in APGS

4.1.1.2 Logistic Regression Model Expressing the Surveyed Respondents' Decision to be Involved in Woody Biomass-Based Activities in APGS.

The logistic regression model expressing the probability of the survey respondent's decision and/or willingness to be involved in woody biomass-based activities is estimated based on the independent explanatory factors that are found to influence the respondent's decision. Such independent factors constitute both continuous variables (i.e., age of the respondents, residence time in locality, monthly expenditure for energy, percentage of monthly income spent for energy purpose) and categorical qualitative parameters (that is, sex, ethnicity, education, occupation, membership of organization, business ownership, access to credit information, concern about the surrounding environment, concern about cutting unmerchantable trees for bioenergy, concern about using forest harvest residues for energy). In logistic regression, the codes for the independent explanatory variables must be meaningful. In case of two category variables, such as gender, one codes these variables as 'M' for male and 'F' for female, into a quantitative variable called SEX which takes the value '0' for female and '1' for male. This is called a dummy variable or indicator variable coding (Suits 1984; Norusis 1992). Dummy variables are those that take values of either 0 or 1 and are used to indicate the presence or absence of one or more qualitative characteristic(s). They are used extensively in economic and business research to account for qualitative characteristics that are not measurable except by a signal indicating whether a characteristic is absent or present (Wallace and Silver 1998).

In the case of a variable with more than two categories, for instance with three classes of education level, it is possible to create a dummy variable for each sample. In this case, one category in the sample should be dropped; that is, the number of the new variables required to represent a categorical variable is less than the number of the categories (Norusis 1992; Suits 1984). Suits (1984) suggested that the researcher should use the dummy variable category to his or her advantage in interpreting the results or keeping in mind the purpose of the result.

Norusis (1992) discussed several methods available for model selection in the logistic regression procedure. Both forward stepwise selection and backward stepwise elimination can be used for automated model building. In case of the backward stepwise procedure, all variables are entered into the model at once, then after eliminated one after another. The reverse is true when the forward stepwise selection procedure is used: variables will be entered in the model one by one, and the score statistic is always used for entering variables into a model. The Wald-statistic or the change in likelihood can be used for removing a variable from a model. All variables that are used to represent the same categorical variable are entered or removed from the model together.

To achieve the best model for willingness to be involved in biomass-based activities, both the forward and backward stepwise entry procedures were applied to build the logistic regression model. The surveyed respondents' decision about their willingness was specified as the dependent variable, for which the probability of occurring was estimated. Likewise, the independent variables were specified and included: distribution of respondents by age groups (40 years or less = 0, more than 40 years = 1), residency (20 years or less = 0, more than 20 years = 1), monthly expenditure for energy ($500 or less = 0, more than $500 = 1), percentage of monthly income for energy purposes (20% or less = 0, more than 20% = 1), sex (male = 1, female = 0), ethnic groups (Aboriginal = 0, Non-Aboriginal = 1), education (below primary, primary and grade 12 = 0, college, university and post-graduate = 1), occupation (forestry related = 1, otherwise 0), membership of organization (member = 1, otherwise 0), business ownership (business owner = 1, otherwise 0), credit information (have access to credit = 1, otherwise 0), concern about surrounding environment (surrounding environmental life improved over the last 5 years = 1, life worsen over the last 5 years = 0), concern about cutting unmerchantable trees for bioenergy (support cutting unmerchantable trees for bioenergy = 1, opposing the cutting unmerchantable trees for bioenergy = 0), and concern about using forest residues for energy (support for utilizing forest residues for bioenergy = 1, opposing the utilization of forest residues for bioenergy = 0). See Table 4.1.3 and 4.1.4 for results.

According to the discussion in previous sections, the logistic regression model of surveyed respondents' decision to be involved in biomass-based activities to support the APGS in future (P_r) is as in equation (12):

$$P_r(WIBA_i = W_1) = \frac{1}{(1+e^{-z})} \qquad [12]$$

Where, Z = 1.267 - 0.712(Education) – 1.204(Sex) - 1.046(Environmental Factor)

Where for the ith respondent,

$WIBA_i$ = 1 if respondent is willing to involve in biomass-based activities, otherwise 0.

W_1 = 1 if respondent is willing to involve in biomass-based activities, otherwise 0.

Education = Education level = 1 if the respondent's education level is higher than 12 grade, otherwise 0.

Sex = 1 if the respondent is male, otherwise 0.

Environmental Factor = Condition of the surrounding environment = 1 if condition improved over the last five years, otherwise 0 (worsen).

The functional form of equation (12) was based on a choice from the broader range of categorical (ordinal or nominal) variables and other continuous variables specified above. The score statistic and the Wald-statistic were then used for entering or dropping insignificant variables from the model one at a time. When we investigate the regression model in equation (12), we see that the willingness is the function of education, sex and environment. The model shows that all the independent factors of the regression model – education, sex and environment – have negative slopes with the willingness of the respondents to become involved in woody biomass-based activities in Atikokan. The model indicates that male participants are most likely to become involved in woody biomass-based activities. The model shows that the environmental conditions of Atikokan and its surrounding area have been improved over the last five years. It also indicates that the participants who are educated more than the Grade 12 have a greater likelihood of becoming involved in future woody biomass-based activities at APGS (equation 12). Correlation matrix of the survey variables is given in Table 4.1.3 and variables in the equation for willingness to be involved in biomass-based activities or businesses are given in Table 4.1.4. There are 14 variables used in the model and seven variables are entered in step 1. As shown in Tables 4.1.3 and 4.1.4, the survey variables are presented as: V1an is Ethnic group; V2mf is Sex; V3ag is Age distribution of respondents; V4el is Education; V12cl is Concern about surrounding environment; V13cr is Concern about residue use; and V14cu is Concern about cutting unmerchantable trees.

Table 4.1.3 Correlation matrix.

		Constant	V4el(1)	V1an(1)	V2mf(1)	V3ag(1)	V12cl(1)	V13cr(1)	V14cu(1)
Step 1	Constant	1.000	-.330	-.425	-.142	-.458	-.638	-.226	.018
	V4el(1)	-.330	1.000	-.068	.057	-.175	.052	-.052	.085
	V1an(1)	-.425	-.068	1.000	-.202	.144	.326	-.031	-.058
	V2mf(1)	-.142	.057	-.202	1.000	.002	-.108	.053	.039
	V3ag(1)	-.458	-.175	.144	.002	1.000	.169	.090	-.167
	V12cl(1)	-.638	.052	.326	-.108	.169	1.000	.083	-.203
	V13cr(1)	-.226	-.052	-.031	.053	.090	.083	1.000	-.417
	V14cu(1)	.018	.085	-.058	.039	-.167	-.203	-.417	1.000
Step 2	Constant	1.000	-.337	-.427	-.137	-.462	-.647	-.233	
	V4el(1)	-.337	1.000	-.059	.059	-.160	.073	-.017	
	V1an(1)	-.427	-.059	1.000	-.203	.138	.321	-.062	
	V2mf(1)	-.137	.059	-.203	1.000	-.001	-.104	.067	
	V3ag(1)	-.462	-.160	.138	-.001	1.000	.138	.017	
	V12cl(1)	-.647	.073	.321	-.104	.138	1.000	-.007	
	V13cr(1)	-.233	-.017	-.062	.067	.017	-.007	1.000	
Step 3	Constant	1.000	-.351	-.453	-.126	-.471	-.668		
	V4el(1)	-.351	1.000	-.062	.065	-.162	.073		
	V1an(1)	-.453	-.062	1.000	-.202	.137	.323		
	V2mf(1)	-.126	.065	-.202	1.000	-.005	-.102		
	V3ag(1)	-.471	-.162	.137	-.005	1.000	.139		
	V12cl(1)	-.668	.073	.323	-.102	.139	1.000		
Step 4	Constant	1.000	-.491	-.436	-.154		-.690		
	V4el(1)	-.491	1.000	-.052	.077		.101		
	V1an(1)	-.436	-.052	1.000	-.205		.307		
	V2mf(1)	-.154	.077	-.205	1.000		-.097		
	V12cl(1)	-.690	.101	.307	-.097		1.000		
Step 5	Constant	1.000	-.582		-.280		-.653		
	V4el(1)	-.582	1.000		.070		.135		
	V2mf(1)	-.280	.070		1.000		-.029		
	V12cl(1)	-.653	.135		-.029		1.000		

Variable(s) entered on step 1: Ethnic group (V1an), Sex (V2mf), Age distribution of respondents (V3ag), Education (V4el), Concern on surrounding environment (V12cl), Concern on residue use (V13cr), Concern on cutting unmerchantable trees (V14cu).

Table 4.1.4 Variables in the equation for willingness to involve in biomass-based activities or business (Field Survey 2009).

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1[a]	V4el(1)	-.630	.372	2.867	1	.090[ns]	.532
	V1an(1)	.558	.421	1.753	1	.186 [ns]	1.747
	V2mf(1)	-1.299	.455	8.130	1	.004**	.273
	V3ag(1)	-.456	.378	1.450	1	.228 [ns]	.634
	V12cl(1)	-.945	.400	5.590	1	.018**	.389
	V13cr(1)	-.323	.451	.514	1	.474 [ns]	.724
	V14cu(1)	.307	.490	.394	1	.530 [ns]	1.360
	Constant	1.259	.458	7.567	1	.006**	3.522
Step 2[a]	V4el(1)	-.652	.370	3.101	1	.078 [ns]	.521
	V1an(1)	.575	.420	1.872	1	.171 [ns]	1.777
	V2mf(1)	-1.315	.454	8.376	1	.004**	.269
	V3ag(1)	-.416	.372	1.252	1	.263 [ns]	.659
	V12cl(1)	-.896	.391	5.255	1	.022*	.408
	V13cr(1)	-.206	.409	.254	1	.614 [ns]	.814
	Constant	1.257	.457	7.550	1	.006**	3.515
Step 3[a]	V4el(1)	-.657	.370	3.147	1	.076 [ns]	.519
	V1an(1)	.563	.420	1.799	1	.180 [ns]	1.756
	V2mf(1)	-1.302	.453	8.258	1	.004**	.272
	V3ag(1)	-.414	.372	1.243	1	.265 [ns]	.661
	V12cl(1)	-.899	.391	5.294	1	.021**	.407
	Constant	1.205	.445	7.344	1	.007**	3.338
Step 4[a]	V4el(1)	-.730	.364	4.010	1	.045*	.482
	V1an(1)	.633	.415	2.330	1	.127 [ns]	1.883
	V2mf(1)	-1.317	.450	8.549	1	.003**	.268
	V12cl(1)	-.848	.385	4.853	1	.028*	.428
	Constant	.982	.390	6.335	1	.012**	2.669
Step 5[a]	V4el(1)	-.712	.361	3.888	1	.049*	.491
	V2mf(1)	-1.204	.437	7.594	1	.006**	.300
	V12cl(1)	-1.046	.364	8.263	1	.004**	.351
	Constant	1.267	.351	13.014	1	.000***	3.550

a. Variable(s) entered on step 1: Ethnic group (V1an), Sex (V2mf), Age distribution of respondents (V3ag), Education (V4el), Concern about surrounding environment (V12cl), Concern about residue use (V13cr), Concern about cutting unmerchantable trees (V14cu).

Note: ns is non-significant, * is significant ($\alpha = 0.05$), ** is highly significant ($\alpha = 0.01$) and *** is very highly significant ($\alpha = 0.001$).

4.1.1.3 Assessing the Goodness of Fit of the Regression Model.

There are various ways to assess whether the model fits the data. The classification table (Table 4.1.5) discussed the goodness of fit of the model by comparing the computed predictions to the observed outcomes. Goodness of fit is a matter of answering the question of whether the predicted values are an accurate representation of the observed values in an absolute sense (Hosmer and Lemeshow 2000).

Table 4.1.5 Classification table about the overall proportion of the predicted individuals as willing or unwilling to be involved in woody biomass-based activities.

			Predicted		
			V15w		
	Observed		0	1	Percentage Correct
Step 1	V15w	0	45	26	63.4
		1	20	56	73.7
	Overall Percentage				68.7
Step 2	V15w	0	48	23	67.6
		1	22	54	71.1
	Overall Percentage				69.4
Step 3	V15w	0	46	25	64.8
		1	21	55	72.4
	Overall Percentage				68.7
Step 4	V15w	0	40	31	56.3
		1	16	60	78.9
	Overall Percentage				68.0
Step 5	V15w	0	41	30	57.7
		1	15	61	80.3
	Overall Percentage				69.4

a. The cut value is .500

As can be seen from the classification table (Table 4.1.5), results of the logistic regression analysis indicated that the overall proportion of correctly predicted individuals as willing or unwilling to be involved in woody biomass-based activities is 69.4%. Out of 76 willing respondents the model predicted 61 respondents (80.3%) who are willing to become involved in woody biomass-based activities. Similarly, out of 71 respondents who indicated they were not willing, the model predicted 30 respondents (57.7%) who would not be willing to become involved in woody biomass-based activities (Table 4.1.5).

Another measure of how well the model fits is the goodness of fit statistic, which compares the observed probabilities to those predicted by the model (Norusis 1992). The goodness of fit statistic is defined as in equation (13):

$$Z^2 = \sum \frac{\mathrm{Re}\,sidual_i^{\,2}}{P_i(1-P_i)} \qquad [13]$$

Where, the Residual is the difference between the actually observed value and the predicted value. Results of the goodness of fit statistic are displayed in Table 4.1.5. It indicates the model fits all the variables. The results of the Hosmer and Lemeshow goodness of fit test provide that the model suits well the variables; it is acceptable at a 5% level of significance ($\alpha = 0.05$).

Finally, from equation (11) the value of $\chi^2 = 21.84$; df = 3; $p < 0.001$.

And from equation (12) the value of

Z = 1.267 - 0.712(Education) – 1.204(Sex) - 1.046(Environmental Factor)

Therefore, the results show that the factors of education, sex and environment (concern about surrounding environment) have significant effects ($\chi^2 = 21.84$; df = 3; $p < 0.001$) on the willingness of the respondents to be involved in the woody biomass bioenergy activities. It proves the goodness of fit of the model (equation 13).

4.1.2 Atikokan Area Survey Participants' Opinions on Important Factors of Community Development, Quality of Life and Woody Biomass Utilization

4.1.2.1 Opinions on Important Factors of Community Development

Atikokan area respondents identified seven factors they considered important for community development as a result of the APGS bioenergy project. Seven factors were provided in the questionnaire based on the literature of Dodge (1980) and Cook (1994). Of the 147 participants, 127 ranked the seven factors according to their importance. Among the seven categories (Appendix IV; Figure 4.1.2.1), the presence of facilities that provide employment in the community was identified as the most important category. This factor was identified by 79 respondents (62%). Thirty-seven percent of respondents (47 individuals) identified the natural environment as the most important factor.

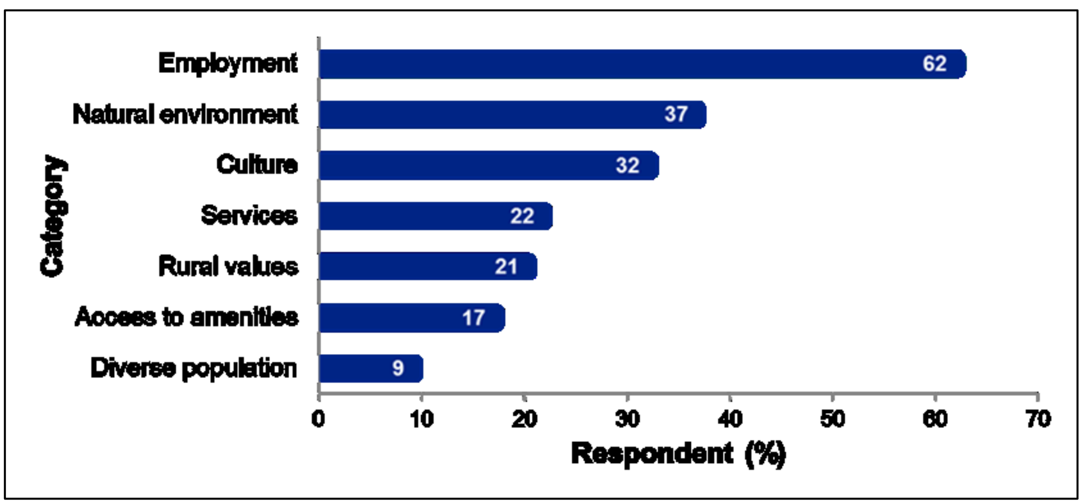

Figure 4.1.2.1 Most important factors in community development identified by survey respondents (the opinions are shown by number and percentage of respondents; total number of respondents = 127).

Culture was identified as most important by41 respondents (32%) (see Appendix IV; Figure 4.1.2.1). The presence of numerous rich natural resources surrounding of

Atikokan probably influenced the survey respondents (37%) to consider the natural environment as the most important factor of their community development. Only 22% of respondents identified services as a community priority, indicating that respondents were focused on other priorities (Appendix IV; Figure 4.1.2.1). Twenty percent of survey respondents identified rural values as the most important factor for community development, and the majority of them were Aboriginal people (Appendix IV; Figure 4.1.2.1). Access to amenities, defined as something that contributes to physical or material comfort, was identified as the most important factor for community development by 22 (17%) of survey respondents (Appendix IV; Figure 4.1.2.1). Diverse population is not perceived as a community priority as only 12 (9%) survey respondents identified diversity as the most important factor for community development (Appendix IV).

4.1.2.2 Opinions on Important Factors to the Quality of Life

Among the 147 participants of the survey, 131 persons gave their opinions on the important factors of quality of life, using six different categories (Appendix V).
In the quality of life category, the majority of respondents to the survey, 83 of 131 (63%), placed clean air and water as their most important quality of life factors; this attitude is also reflected in their choice of lifestyle as there is much less pollution in the area than in an urban environment.

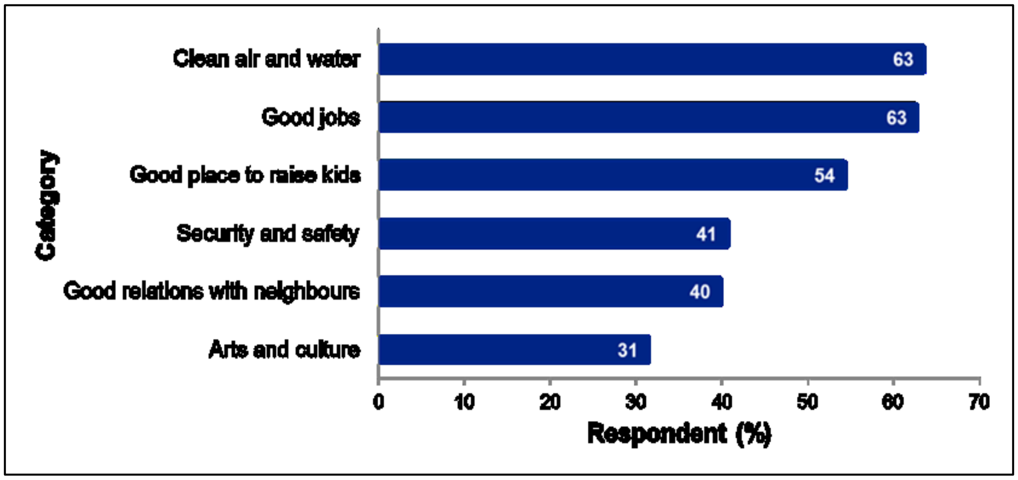

Figure 4.1.2.2 The opinions of respondents on the factor considering the most important to the quality of life in the community in different categories (the opinions are shown by number and percentage of respondents; total number of respondents = 131).

Slightly behind clean air and water, respondents (63%) identified good jobs as the most important factor to the quality of life in the Atikokan community (Appendix V). Based on answers from 71 (54%), 53 (40%), 52 (40%) and 41 (31%) respondents respectively (Appendix V; Figure 4.1.2.2), four factors affecting the quality of life in the community are that it is a good place to raise a family, it is secure and safe, it has good community relationships, and it has an arts and culture scene. However, among the six factors, clear air, clean water and good jobs are more highly rated other factors, with arts and culture scoring the lowest.

4.1.2.3 Opinions on the Purpose of Developing Woody Biomass-Based Bioenergy Projects

Among the 147 survey participants, 124 persons gave their opinions on the purpose of developing woody biomass-based bioenergy projects (Appendix VI). Out of 124 respondents, 86 (69%) identified woody biomass-based bioenergy in Atikokan as renewable energy (Appendix VI; Figure 4.1.2.3), indicating the respondents are knowledgeable about renewable energy options.

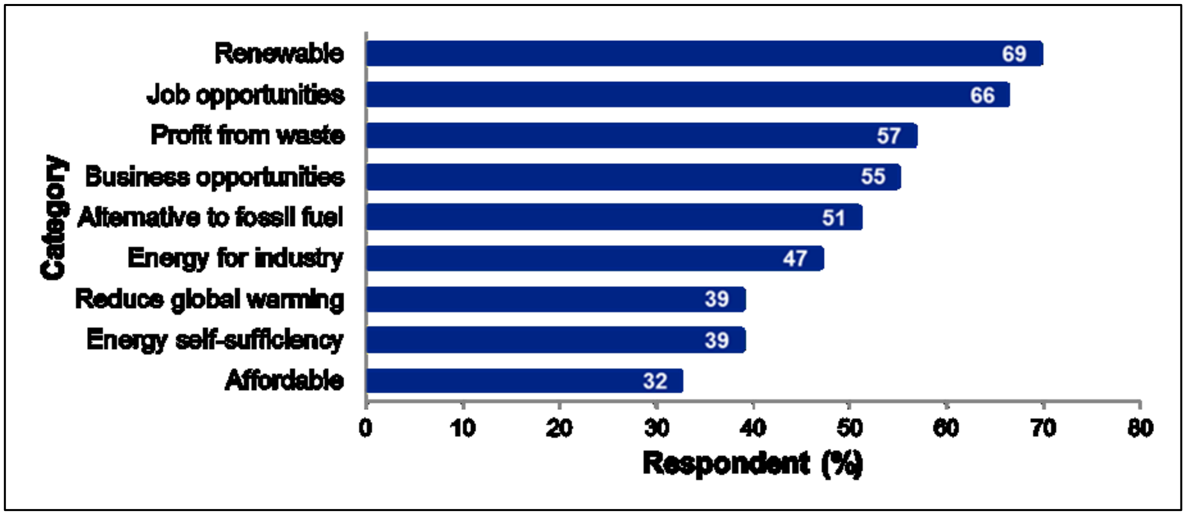

Figure 4.1.2.3 The opinions of respondents on the purpose of developing woody biomass based bioenergy projects as the most important in different categories (the opinions are shown by number and percentage of respondents; total number of respondents = 124).

Job opportunities were identified as the second most important factor for developing wood-based bioenergy projects, based on the opinions of 82 (66%) survey respondents (Appendix VI; Figure 4.1.2.3). Profit from waste was identified as the third most important factor by 70 (56%) survey respondents for the development of the APGS woody biomass-based bioenergy project (Appendix VI; Figure 4.1.2.3). Based on the opinions of 68 (55%) survey respondents (Appendix VI; Figure 4.1.2.3), business opportunities were identified as the fourth most important factor for developing woody biomass-based bioenergy projects. Biofuel as the alternative to fossil fuel was recognized as the fifth most important factor by 63 (51%) survey respondents (Appendix VI; Figure 4.1.2.3).

In the opinion of 58 (47%) survey respondents (Appendix VI; Figure 4.1.2.3), energy self-sufficiency for industry was identified as the sixth most important factor, and 48 (39%) identified rural energy self-sufficiency as the seventh most important factor for woody based bioenergy development (Appendix VI; Figure 4.1.2.3). The same number of respondents, 48 (39%), identified that reducing global warming is an important (7^{th}) factor for developing wood-based bioenergy projects (Appendix VI; Figure 4.1.2.3). Greenhouse gases produced by fossil fuels increase global warming (Gan and Smith 2006b). Using carbon neutral bioenergy instead of fossil energy will reduce greenhouse gases which will eventually reduce global warming (Gan and Smith 2006b; FERIC 2008).

According to 40 (32%) respondents, the eighth most important factor for developing the bioenergy projects APGS is that it is affordable (Appendix VI; Figure 4.1.2.3); in fact, it is more affordable than oil-based energy. However, it is much more expensive the coal-based energy. To build the woody biomass-based APGS bioenergy system, financial support has come from the Ontario provincial government and the Town of Atikokan for its development. In addition, a vast amount of biomass is available in FMUs in this region to supply the plant, and forest harvest residues can be used with very low cost. Finally, at the APGS, the test of combustion by using 100% pellet feedstock was successful. All of these factors have helped to make the project feasible and affordable.

4.2 FINDINGS FROM THE FOCUS GROUP DISCUSSIONS AND THUNDER BAY SURVEY

People's perspectives from the SWOT analysis for the APGS shifting to wood pellet feedstock are given in Table 4.2.1 to Table 4.2.9. The results from the SWOT analysis of the senior respondents on the utilization of woody biomass for bioenergy at the APGS are shown in Table 4.2.1. The senior respondents were 60 to 70 years old and from a variety of occupations: three retired school board members, a retired economic development commission member, a retired school teacher, a retired industry manager, an elderly librarian, an elderly Quetico Park manager, an elderly area forester from the MNR, an elderly doctor, three elderly loggers and an elderly business owner. Most of the senior respondents identified employment as the best strength (Table 4.2.1). They expressed concern about the cost of producing woody biomass-based energy and thought it was the main weakness since it is more costly than coal. Based on their responses, the economic opportunity is the best one from woody biomass-based electricity production at the APGS, and the seniors mentioned that government is the main threat.

Table 4.2.1 Top four SWOT points of seniors in Atikokan.

Strengths	**Weaknesses**
1. Employment 2. Demand for power 3. Tax base for Atikokan 4. Partnership with First Nations	1. Biomass energy is more costly than coal 2. Concern about the recovery of depleted areas 3. Weak government policy 4. Forest management is behind the times
Opportunities	**Threats**
1. Economic opportunity 2. Research opportunity 3. Possibilities of new biomass plant (e.g., pellet) 4. Minister of Northern Development, Mines and Forestry from NOW	1. Government 2. Escalating cost 3. Competition with other neighbouring provinces relating cheaper costs 4. Destruction of ecosystem

The results from the SWOT analysis of the young people respondents on the utilization of woody biomass for bioenergy at the APGS are shown in Table 4.2.2. There were 15 attendees in the group discussion, with ages ranging from 19-23 years. Most of them were female (11 of the 15). According to young people and similar to the seniors' group, the creation of job opportunities is the best strength (Table 4.2.2). They expressed that the primary weakness according to their understanding of the global economy was whether Canada would be left out if it stops using coal when other countries continue to use it for power and heat. They indicated that job creation is the best opportunity, while most of this group mentioned that over-harvesting is the main threat (Table 4.2.2).

Table 4.2.2 Top four SWOT points of young people in Atikokan.

Strengths	**Weaknesses**
1. Job opportunity 32. Renewable and clear energy 3. Leftover can be used 4. People are already trained and no cost to switch over	1. Canada loses out if it closes coal plants and other countries continue their use or even build new ones. What will be the consequences? 2. No international policy 3. Over-harvesting problem 4. At the APGS an explosion can happen using biomass, coal is safe to use
Opportunities	**Threats**
1. Job creation 2. Good for forest industries 3. More green thinking globally 4. Political support	1. Over harvesting 2. More stress on environment 3. Damage of water system and soil erosion 4. Biodiversity loss

The results from the SWOT analysis of the First Nations respondents on the utilization of woody biomass for bioenergy at the APGS are shown in Table 4.2.3. There were 19 attendees in the three group discussions. These group discussions were held at the Seine River First Nations community. According to First Nations people, employment is the greatest strength (Table 4.2.3) although they expressed land designation for biomass is a problem. According to most, the best opportunity is that bioenergy is renewable. Most of the respondents mentioned that emissions from biomass burning are the main threat (Table 4.2.3). During discussions First Nations people expressed their concerns about over-harvesting, residue removal and biomass transportation. They were also worried about the adverse effect of residue removal on soil erosion which can pollute water bodies and destroy fish habitat.

Table 4.2.3 Top four SWOT points of First Nation people in Atikokan area.

Strengths	**Weaknesses**
1. Employment 2. Government support 3. There are lots of trees in the north, i.e. biomass availability	1. Land designation for biomass is a problem 2. Not enough funding for the northern Ontario 3. Biomass-based electricity is not sustainable 4. There is no training 5. Capacity development is the major challenge 6. No monitoring of biomass resources
Opportunities	**Threats**
1. Renewable 2. Increase employment in Atikokan area 3. Self-sufficiency 4. Economic impact	1. Emission from biomass burning 2. Disturbing ecosystem 3. As trees are the sources for oxygen, biomass utilization for energy may create many penalties 4. Environmental effects (e.g., soil erosion)

The results from the SWOT matrix-based Thunder Bay survey by academic respondents on the utilization of woody biomass for bioenergy at the APGS are shown in Table 4.2.4. There were four participants in the group, three from Lakehead University and one from Confederation College. Most of the academics identified lower greenhouse gas emission as the greatest strength (Table 4.2.4). Uncertainties related to forest biomass production were identified as the main weakness of bioenergy. The best opportunity identified is that biomass is renewable. Academics identified the limited biomass capacity of the region as the most important threat when APGS starts electricity generation at its full capacity. They identified that this could result in limited supplies and a rise in electricity price for smaller consumers.

Table 4.2.4 Top SWOT points of academics in Thunder Bay.

Strengths	Weaknesses
1. Lower greenhouse gas emissions 2. Promotes energy security 3. Capable executive team 4. Creates employment 5. Utilization of the existing power plants, no re-establishment cost 6. Core business competence on logistics management 7. Development of infrastructure in rural areas	1. Uncertainties related to forest biomass production 2. Uncertain future of bioenergy markets 3. Reduced soil quality and fertility, for biomass collection from the forest floor 4. Biomass production business 5. Highly regulated industry
Opportunities	**Threats**
1. Renewable energy 2. Community development 3. Sustainability of feedstock 4. Favorable public opinion	1. Large users of biomass like Atikokan will consume a large amount of the regions biomass that could result in limited supplies and rising prices for smaller consumers 2. Competition from cheaper and cleaner sources of energy such as wind and hydro 3. Possible damage to forest ecology 4. Biomass & fossil fuel price fluctuations difficult to predict 5. Competition with existing biomass business holders

The opinions of college and university student respondents on the utilization of woody biomass for bioenergy production at the APGS are shown in SWOT Table 4.2.5. Five respondents were male and two were female. All of the university student were from Lakehead University. Most of the student respondents indicated that creating employment is the main strength (Table 4.2.5). Similar to the responses of academics, most of the student respondents indicated that uncertainties related to forest biomass production is the main weakness. As well, most respondents in this group mentioned that the main opportunity is that biomass is renewable. According to this group, the main threat is that it is more costly than coal-based energy generation.

Table 4.2.5 Important SWOT points of students in Thunder Bay.

Strengths	**Weaknesses**
1. Create employment 2. Lower greenhouse gas emissions 3. Develop infrastructure in rural areas 4. No competition with food production	1. Uncertainties related to forest biomass production 2. Uncertain future of bioenergy markets 3. Reduce biodiversity 4. Reduced soil quality and fertility, for biomass collection from the forest floor
Opportunities	**Threats**
1. Renewable energy 2. Community development 3. Clean air 4. Sustainability of feedstock	1. Costly 2. Possible damages to forest ecology 3. Overuse of biomass by Atikokan could result in limited supplies and rising prices for smaller consumers 4. Competition from cheaper and cleaner sources of energy such as wind, hydro and geothermal energy 5. Competition with conventional forest products industries

The results of the SWOT analysis of the NGO personnel on the utilization of woody biomass for APGS electricity are shown in Table 4.2.6. The group consisted of six NGO personnel: one was from Rainy River Future Development Corporation, and the others were from Thunder Bay and its surrounding communities. According to them rural economic development, with its impact on poverty reduction, is the main strength (Table 4.2.6). Similar to the responses of academics and student groups, most of the NGO respondents stated that uncertainties related to forest biomass production are the main weakness. Similarly, most of the respondents of the NGO personnel group mentioned that the main opportunity is that biomass is renewable. Similar to the academics, NGO personnel also mentioned the main threats will arise when APGS is running at full capacity with biomass feedstock, since it will consume a large amount of biomass of this region that could result in limited supplies and rising prices. This appears to be a misunderstanding on the part of the public since the plant will run at 10% of capacity normally. Even when the economy is running at full, the plant will operate at only 30% (OPG 2013).

Table 4.2.6 Top SWOT points by NGO personnel in Thunder Bay.

Strengths	**Weaknesses**
1. Rural economic development and contribution to poverty reduction 2. Closeness to source of feedstock 3. Promotes energy security 4. Utilization of the existing power plants, therefore no re-establishment cost	1. Uncertainties related to forest biomass production 2. Conversion technologies are still under trial 3. First project of full biomass-based renewable energy 4. Extensive pre-operating period
Opportunities	**Threats**
1. Renewable energy 2. Community development 3. Considerable dealings with local leaders, NGOs, financial institutions, local communities, farmers and other concerned stakeholders 4. Sustainability of feedstock 5. Presence of government support/commitment 6. Captive market of APGS	1. Large users of biomass like APGS will consume a large amount of the region's biomass that could result in limited supplies and rising prices for smaller consumers 2. Competition from cheaper and cleaner sources of energy such as wind, hydro and geothermal energy 3. Competes with conventional forest products industry 4. Competition with existing biomass business holders

The SWOT analysis of the business holders group for utilizing woody biomass for electricity at the APGS is shown in Table 4.2.7. There were three business holders in this group: a saw mill owner, an agriculture/wild blueberries business owner and a forest-based small business owner. Most of them mentioned that closeness of the feedstock is the strength. Similar to the responses of academics, student and NGO groups, most of the business holder respondents identified uncertainties related to forest biomass production as the main weakness. Similar to the responses of students and NGO groups, most of the business holder respondents mentioned that the main opportunity is that biomass is renewable. Similar to the responses of the student group, they identified high cost as the main threat.

Table 4.2.7 Top SWOT points of business holders in Thunder Bay.

Strengths	**Weaknesses**
1. Closeness to source of feedstock 2. Creates employment 3. Promotes energy security 4. Lowest tariff rate 5. Utilization of the existing power plants, therefore no re-establishment cost	1. Uncertainties related to forest biomass production 2. First project of full biomass-based renewable energy 3. Conversion technologies are still under trial 4. Costly to produce the feedstock and operate 5. Reduced soil quality and fertility from biomass collection from the forest floor
Opportunities	**Threats**
1. Renewable energy 2. Community development 3. Sustainability of feedstock 4. Favorable public opinion	1. Costly 2. Cheap imports from other provinces/countries 3. Large users of biomass like APGS will consume a large amount of the regions biomass that could result in limited supplies and rising prices for smaller consumers 4. Biomass & fossil fuel price fluctuations difficult to predict

The results of SWOT analysis of the opinions of government personnel respondents on the utilization of woody biomass for bioenergy production at the APGS are shown in Table 4.2.8. There were eight government personnel in this group: one was from Ontario Power Generation Thunder Bay, one from OMNR Thunder Bay, and the rest were economic development officers from Thunder Bay and surrounding communities. Based on most of the government personnel respondents the development of infrastructure in rural areas is the main strength (Table 4.2.8). They identified cost as the main weakness; compared to coal-based electricity, woody biomass-based bioenergy is costly to produce and operate. Government respondents cited community development as the main opportunity. Government personnel reported the competition from cheaper and cleaner sources of energy such as hydro energy as the main threats. Their views about APGS woody biomass-based electricity were oriented towards policy and local development.

Table 4.2.8 Top SWOT points of government personnel in Thunder Bay.

Strengths	**Weaknesses**
1. Development of infrastructure in rural areas. 2. Creates employment 3. Utilization of the existing power plants, therefore no re-establishment cost 4. Long-term power supply contract	1. Costly to produce the feedstock and operate 2. Extremely capital intensive 3. Uncertainties related to forest biomass production 4. First project of full biomass-based renewable energy
Opportunities	**Threats**
1. Community development 2. Renewable energy 3. Presence of government support/commitment 4. Considerable dealings with local leaders, NGOs, financial institutions, local communities, farmers and other concerned stakeholders	1. Competition from cheaper and cleaner sources of energy such as wind, hydro and geothermal energy 2. Possible damages to forest ecology 3. Competes with conventional forest products industry 4. Costly

Results of a SWOT analysis on the utilization of woody biomass for bioenergy production at the APGS that includes the opinions of respondents from the combined Thunder Bay professional groups (26 persons) are shown in Table 4.2.9. The highest number of respondents from all professional groups reported that job creation is the primary strength (Table 4.2.9). According to the groups, uncertainties related to forest biomass production are the main weaknesses. On the other hand, the fact that the woody biomass feedstock for the APGS as a renewable resource was selected as the main opportunity. Competition from cheaper and cleaner sources of energy such as wind, hydro and geothermal energy was listed as the main threat.

Table 4.2.9 Top important points of all professional groups (combined SWOT analysis).

Strengths	**Weaknesses**
1. Job creation 2. Development of infrastructure in rural areas. 3. Promotion of energy security 4. Closeness to source of feedstock	1. Uncertainties related to forest biomass production 2. Costly to produce the feedstock and operate 3. Reduced soil quality and fertility from biomass collection from the forest floor 4. Uncertain future of bioenergy markets
Opportunities	**Threats**
1. Renewable energy 2. Community development 3. Sustainability of feedstock 4. Favorable public opinion	1. Large users of biomass like Atikokan will consume feedstock at a rate that could result in limited supplies and rising prices for smaller consumers 2. Competition from cheaper and cleaner sources of energy such as wind, hydro and geothermal energy 3. More costly than coal to produce power 4. Competes with conventional forest products industry

4.3 FINDINGS FROM THE INTERVIEWS

4.3.1 General Overview

The objectives of this section are to: understand the views of individuals within Atikokan and its surrounding communities on converting woody biomass to energy at the APGS; identify, from the perspectives of individuals within Atikokan and its surrounding communities, the opportunities for and barriers to converting forest biomass to energy; and explore possible courses of actions to overcome those barriers. Biomass utilization is an issue that requires multiple people from a variety of fields and perspectives to implement projects successfully. A goal of this research section is to identify the key elements that must be considered for the development of the APGS bioenergy project.

4.3.2 Support for Bioenergy

Although numerous published definitions of woody biomass occur in reports, policies and forestry dictionaries, there is no one definition of forest business that research participants pointed to as being universally accepted. Many interviewees saw forest biomass as all the vegetation in the forest, but within the context of bioenergy, biomass is usually defined as the non-merchantable components of woody biomass, which could potentially be used for energy generation.

Generally there was a wide level of support among research participants for the idea of converting forest biomass to energy at the APGS. During interview, the Mayor of Atikokan, put it most directly when he said "We have to do this; we have to do something with our biomass reserve… it can create new economic opportunity and by this we can overcome our present economic downturn in Atikokan."

Individuals within government and non-profit organizations (i.e., MNR personnel, APGS personnel, elected leaders, local community organizations) gave the highest levels of support of the APGS project. When discussing opportunities that biomass utilization could provide, the majority of interviewees brought up job creation, renewable energy and rural economic development as their positives. Biomass utilization for energy seems to be a good solution for several different challenges. A member of provincial parliament (MPP), ministers and a local business developer, all of whom are involved with the Atikokan biomass utilization project, stated (MNDM 2011):

> The crisis in the North American forest industry has required new approaches to job creation in this industry. That's why we are taking steps to transform Ontario's forest sector, creating new jobs and attracting investment in a way that will ensure our forests continue to be managed sustainably. I am excited by today's announcement and the jobs that will be created in Atikokan and Northwestern Ontario. - MPP Thunder Bay-Atikokan
>
> Our government wants to support solid, innovative initiatives that will strengthen our forest industry. The allocations we're announcing in this first round of successful proposals will play a significant role in re-energizing Ontario's forest products sector.- Minister of Northern Development, Mines and Forestry
>
> This is an important milestone in Ontario's electricity history, and in the history of the northern Ontario economy, as we move to a coal-free province. By replacing dirty coal with cleaner renewable sources of power, we are bringing clean energy jobs to Ontario and giving future generations cleaner air to breathe. - Minister of Energy
>
> This announcement is an important step towards creating new forestry-based jobs in Atikokan and surrounding areas. …. ARF is proud to be working with the Rainy Lake Tribal Development Corporation on this project. - Owner, Atikokan Renewable Fuels (ARF)

During research interviews, participants agreed with statements by a local Member of Provincial Parliament, the Minister of Northern Development, Mines and Forestry (now Ministry of Northern Development and Mines), Minister of Energy and an owner of a local pellet plant (MNDM 2011), typically seeing more than one opportunity with the conversion of woody biomass to energy. In fact, the combination of potential benefits was often what excited interviewees most about woody biomass utilization. Some interviewees expressed hope that the potential opportunities of woody biomass utilization could overcome the present rural economic downturn, but despite their expressed anticipation, when asked what is driving this issue in Northwestern Ontario, almost all participants talked about forest utilization and job creation in a project that uses locally-produced resources in a region that needs economic activity. One interviewee from the small forest sector industry summarized:

> The forest products industries are helping to build our economy by providing a sustainable supply of wood products, jobs for rural communities and improved quality of life for many people. These industries add billions of dollars to the country's economy and provide a multi-million dollar tax base to support local schools, roads and other support services.

Still others emphasized the security of the biomass supply that exists in the Atikokan area. A MNR representative pointed out that there are "2 to 3 times more unmerchantable trees and abundant residual biomass in the area than needed for generating biomass power at APGS."

As well, interviewees considered woody biomass-based power as attractive since it is a source of renewable energy. For example, a representative from the APGS said that woody biomass "has significant environmental benefits compared to other forms of energy production" and a representative from the education sector observed: "Well-planned sustainable biomass power plant is a practicable source of clean renewable electricity, and thus it is useful for phasing out the coal-fired power plant of APGS." An elected leader's comments emphasized the advantages of a project that benefits both the forests and the region: the supply is sustainable and renewable and it provides "much-needed economic benefits to the forestry industries and communities." Interestingly, the same views were expressed by representatives from other sectors in addition to education, energy, forestry, community representatives and elected officials, showing a common perspective about the desirability of the bioenergy project at APGS.

Participants from local community organizations, elected leaders, small forest industry, MNR personnel and APGS personnel groups felt that new biomass-based market development in the form of pellets is equally driving the biomass utilization debate; however, this was not a majority opinion in the overall sample. Some respondents were not supportive of this idea and some were worried about its viability. As one Economic Development Officer (local community organization) pointed out:

> No sense to burn trees for electricity. No sense to cut standing trees for producing electricity. In Finland they use roots of the trees. Other countries of the European Union use waste materials (limbs, branches etc.) for this purpose. Taking all biomass from the stand is not good for soil also. But maybe ash can be recycled. Only a 100% natural pellet is allowed to be used in Canada. If there is 10% plastic inside the pellet, then USA can use it, not Canada.

A local resident who has worked in Atikokan for 40 years in both the small forest industry and social services also expressed his questionable support for biomass, but warns against a project that is focused on economics, without considering long term environmental effects: "… time will tell if it is a correct decision. The viability of a long-term, sustainable industry is questionable due to squandering of the resource. Research will allow us to overcome the barriers."

First Nations were the least supportive for reasons that include their lack of resource control, skill and financial capability. A previous Chief of Seine River First Nation broke down the main issues, emphasizing the lack of employment opportunities that has resulted in out migration from the community. This has resulted in the "sense of the community disappearing." As well, the problematic issues around land ownership where the federal government owns Indian reserve lands and the province all other publicly owned land result in First Nations communities having difficulty starting forest-based businesses because they do not own the resource. An individual First Nation responded stated: "Forest land use policy should be changed and new policy should be made considering Treaty 3." Furthermore, First Nation people feel they should not be cleaning up slash on the forest floor that has been made by the machinery of big industry. The interviewee's final comment points to a recommendation that is echoed by others: individuals who want to be involved in the bioenergy sector need "training and support from the government." These comments show the importance of open discussions with First Nation people so that they are assured of receiving the training required to benefit directly from any woody biomass-based project.

4.3.3 Barriers Relating Woody Biomass Utilization for Energy Production in Northwestern Ontario

Interviewees provided numerous comments on the barriers of woody biomass utilization for energy production in Northwestern Ontario. Among the nine groups of interviewees, three groups─42% from the social service sector, 30% from education institutions and 24% First Nation individuals─made no comment on barriers to woody biomass utilization for energy production in Northwestern Ontario. Respondents from the surrounding First Nation communities gave general comments, but were hesitant to voice their opinions on the APGS project development, saying they were not familiar enough with it specifically. It is important to make First Nations people aware of bioenergy benefits and the opportunities the project can provide to their communities. Interviewees made comments on different categories of barriers about woody biomass-based bioenergy production in this region. After coding, the responses were grouped into 10 categories of barriers: less government support, environmental factors, high cost, supply availability, sustainability of the woody biomass-based bioenergy production system, lack of policy support, lack of market facility, social acceptance, other and no barriers. In all, 304 responses about the barriers for the development of woody biomass-based bioenergy at APGS were made by the interviewees. Among the nine categories of interviewees, the small forest industry interviewees provided the highest number of comments (95). The numbers of responses by other categories of interviewees are: First Nation non-government organization 40, First Nation individuals 37, education institution 35, social service sector 30, MNR personnel 27, local community organization 19, APGS personnel 13 and elected leaders 8. Responses from the interviewees on the barriers are presented in Appendix VII. Figure 4.3.1 presents the responses of interviewees (percent) from nine categories in ten issues on the barriers of bioenergy systems in Northwestern Ontario. A brief description of the interview responses (percent) from different categories of interviewees on barriers for APGS bioenergy systems in Northwestern Ontario is presented below (also see Appendix VII for details).

Less government support: All interviewees (100%) from small forest industry mentioned that government is a barrier for woody biomass utilization for energy production in Northwestern Ontario (Figure 4.3.1). Most of the interviewees (75%) from First Nation non-government organizations mentioned they perceived government as a barrier. Half of the interviewees (50%) from local community organizations and MNR personnel, respectively, stated that government is a barrier for bioenergy development in this region. A substantial number of interviewees (40%) from the APGS personnel made similar comments. Some interviewees from First Nation individuals (24%), education institutions (20%) and elected leaders (20%) groups, respectively, said that government is a barrier. The least number of responses (8%) on government as a barrier came from social service sector interviewees (Figure 4.3.1 and Appendix VII).

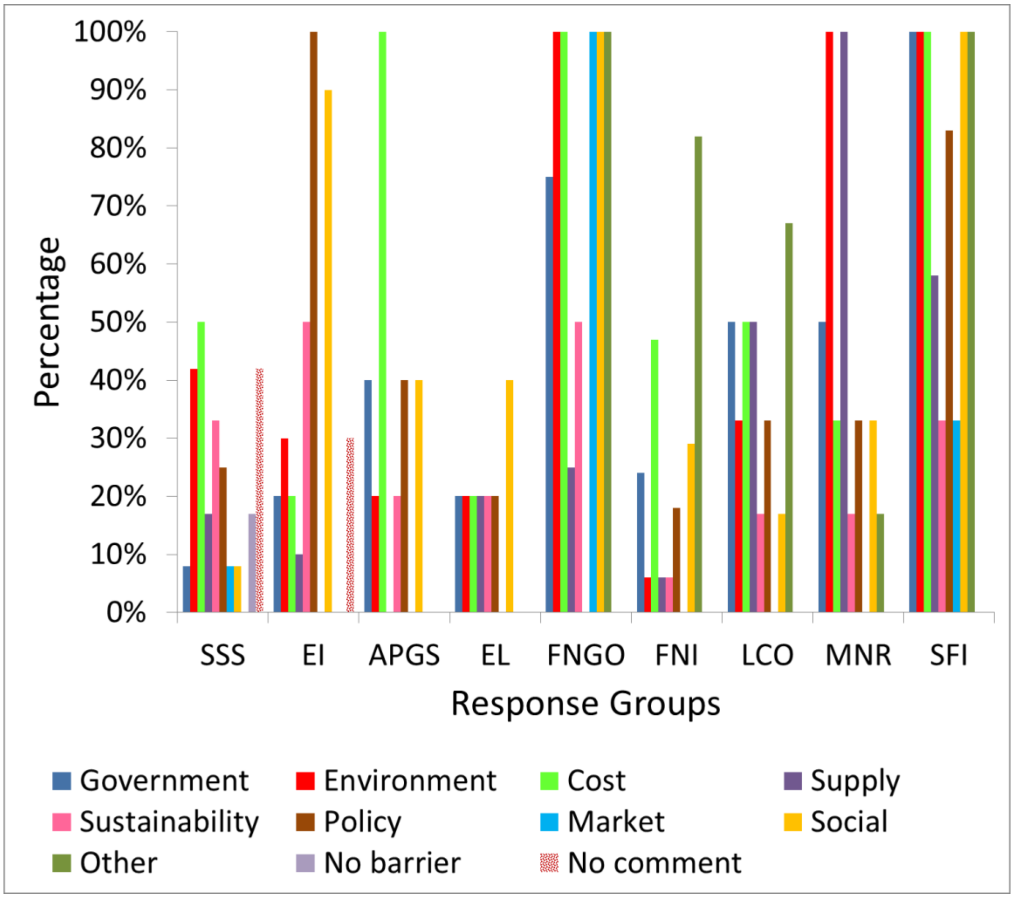

Figure 4.3.1 Comments on barriers according to interviewee groups.

Here response groups are: SSS−Social Service Sector (12), EI−Education Institutions (10), APGS − APGS personnel (5), EL−Elected Leaders (5). FNGO − First Nation Non-Government Organizations (4), FNI−First Nation Individuals (17), LCO−Local Community Organizations (6), MNR− MNR personnel (6) and SFI − Small Forest Industry (12).

Environment factors: All interviewees from First Nation non-government organizations, forest sector and small forest industry, respectively, raised the issue of environment as a barrier for woody biomass utilization for energy production in

Northwestern Ontario (Figure 4.3.1 and Appendix VII). Among the other categories of interview interviewees, 42% social service sector, 33% local community organization, 30% education institution, 20% APGS personnel, 20% elected leaders and 6% First Nation individuals interviewees, respectively, stated environmental issue as a barrier (Figure 4.3.1).

High cost: All interviewees from the APGS personnel, First Nation non-government organization and small forest industry, respectively, made comments that cost is a barrier for woody biomass utilization (Figure 4.3.1). Fifty percent in the social service sector, 50% in local community organizations, 47% First Nation individuals, 33% forest sector, 20% education institution and 20 % elected leaders interviewees, respectively, mentioned that cost is a barrier (Figure 4.3.1 and Appendix VII).

Supply availability: All interviewees from MNR made comments that lack of supply of woody biomass feedstock is a barrier for its utilization for energy production in Northwestern Ontario (Figure 4.3.1). Among the other categories, 58% small forest industry, 50% local community organizations, 25% First Nation non-government organization, 20% elected leaders, 17% social service sector, 10% education institution and 6% First Nation individuals interviewees, respectively, told supply of woody biomass as a raw material is a barrier. No interviewee from the APGS personnel made comments on supply as a barrier for woody biomass-based bioenergy production (Figure 4.3.1 and Appendix VII).

Sustainability of the woody biomass-based bioenergy production system: Half of the interviewees from education and First Nation non-government organization, respectively, mentioned that sustainability is a barrier for woody biomass-based bioenergy production (Figure 4.3.1). Thirty three percent social service sector, 33% small forest industry, 20% APGS personnel, 20% elected leaders, 17% local community organizations and 17% MNR interviewees, respectively, mentioned that sustainability is a barrier. The least number of responses (6%) on sustainability as a barrier for woody biomass-based bioenergy production came from First Nations individual's category (Figure 4.3.1and Appendix VII).

Lack of policy support: All interviewees from education institutions commented that lack of policy is a barrier for woody biomass utilization for energy production in Northwestern Ontario (Figure 4.3.1). Among other categories 83% small forest industry, 40% APGS personnel, 33% local community organizations, 33% MNR personnel, 25% social service sector, 20% elected leaders and 18% First Nation individuals, respectively, stated the issue of policy as a barrier. There was no comment from First Nation non-government organization on lack of policy as a barrier for woody biomass-based bioenergy production (Figure 4.3.1 and Appendix VII).

Lack of market facility: All interviewees from First Nation non-government organizations commented that an absence of market is a barrier for woody biomass utilization for energy production in Northwestern Ontario (Figure 4.3.1). Among other categories of interviewees, 33% small forest industry and 8% from social service sector interviewees reported that the market is a barrier. The interviewees from the other six categories, namely education institutions, APGS personnel, elected leaders, First Nation individuals, local community organizations and the MNR personnel did not make any comment on market as a barrier for woody biomass-based bioenergy production (Figure 4.3.1 and Appendix VII).

Social factor: Interviewees from all categories mentioned some social barriers to the project (Figure 4.3.1). For example, all interviewees from the categories of First Nation non-government organization and small forest industry, respectively, made comments that social factors such as social acceptability of the APGS project; a lack of communications between industry, First Nation communities and the people of the Atikokan area; and fear about loss of jurisdiction over traditional land use are barriers for woody biomass utilization for energy production in Northwestern Ontario. There were those who did not support woody biomass based bioenergy: they thought that hydroelectric power was more sustainable; others stated that clean coal technology was a better option than biomass use. The social concerns were raised by other interviewee groups: 90% of education institution, 40% APGS personnel, 40% elected leaders, 33% MNR personnel, 29% First Nation individuals and 17% local community organization interviewees identified social issues as barriers. The least number of responses (8%) about social factors as barriers for woody biomass-based bioenergy production came from social service sector category interviewees (Figure 4.3.1and Appendix VII).

Other: Interviewees also mentioned a number of other barriers for woody biomass utilization for energy production (Figure 4.3.1). All interviewees from the categories of First Nation non-government organizations and small forest industry, respectively, made comments that other issues are barriers for woody biomass utilization for energy production in Northwestern Ontario. Among other categories, 82% First Nation individuals, 67% local community organizations and 17% MNR interviewees, respectively, mentioned that other issues are barriers. There was no comment on this issue from the categories of social service sector, education institution, APGS personnel and elected leaders (Figure 4.3.1 and Appendix VII). Barriers grouped as other categories consist of lack of infrastructure, poor communication and education on biofuel and bioenergy, concerns about employment opportunities, lack of scientific research, and significant concerns about wood supply and sustainability. For example, interviewees expressed worries about supply from cheaper feedstock by countries like China, Brazil etc. competing with the locally produced feedstock, and whether there would be fewer jobs in bioenergy feedstock production than in the traditional managed forest (timber) industry. As well, people expressed concern about reduction of the wood supply for the other uses of small diameter trees (fuel wood, sports sticks etc.) because of demand for bioenergy fuel.

No Barrier: Except for the social service sector, interviewees from the other eight categories mentioned barriers for woody biomass-based bioenergy production in this region (Figure 4.3.1). Only 17% of the social service sector interviewees mentioned that there is no barrier for woody biomass utilization for energy production in Northwestern Ontario (Figure 4.3.1and Appendix VII).

4.3.4 Suggestions for Woody Biomass Utilization for Energy Production in Northwestern Ontario

During interviews interviewees from nine groups (social service sector, education institutions, APGS personnel, elected leaders, First Nation non-government organizations, First Nation individuals, local community organizations, MNR personnel and small forest industry) were asked for suggestions about developing woody biomass-based energy in Northwestern Ontario. Although 38% interviewees did not provide any feedback, 62% suggested considerations to improve and develop woody biomass-based energy in Northwestern Ontario. They also provided suggestions to overcome barriers to development, with some interviewees giving multiple comments on the issues. After coding the main themes and Axel coding within the themes, 10 categories emerged. These categories were: research, market development, supply availability, social acceptability, education and training, policy requirements, trust development, joint management, cost minimization, environmental aspects and jobs. The most frequent strategies suggested to overcome barriers to biomass utilization are described below.

Research: All First Nation non-government organizations commented on the importance of research to overcome barriers and improve systems for future development. Sixty seven percent mentioned that more research is needed and 33% suggested that get-rich-quick schemes should be avoided. Eighty-three percent of individuals working within local community organizations also suggested that more research is needed to overcome the barriers, identifying tools such as clean coal technology and smarter technology. They also emphasised more pilot projects should be taken for biomass energy development. Half of the APGS personnel emphasised research, specifically in technology development. Similarly, half of the elected leaders suggested more research for this purpose, and they also suggested more pilot projects should be taken. Forty percent of the education institutions group suggested research should be undertaken for woody biomass-based electricity generation and 20% of them also suggested to continue research to develop clean coal based technology for electricity generation. Thirty three percent of individuals within the social service sector group suggested that more research is needed for woody biomass-based energy development, also emphasizing more pilot projects for this purpose. First Nation individuals, MNR personnel and small forest industry groups did not provide any comments on research to overcome barriers.

Market Development: All First Nation non-government organizations interviewees suggested that new market development is necessary for developing woody biomass-based energy in Northwestern Ontario. Two-thirds of their responses proposed a new small biomass-based industry development in Atikokan and its surroundings. One-third of their responses proposed to develop grid lines for supplying electricity to Atikokan and other Northwestern Ontario communities. Some of them also suggested that plantations for bioenergy should be managed in such a way to encourage continued participation in the existing outdoors activities that attract tourism to this locality. Seventy-five percent of the APGS personnel responses proposed market development for new products, such as pellet and woody biomass-based electricity. As well, the APGS personnel recommended an increase the development of new bioenergy facilities (e.g., district heating). Half of the MNR personnel responses mentioned that new market development for energy is needed and indicated the importance of developing the pellet industry, biomass transportation and storage facilities, and markets for woody biomass-based electricity. Some of them also stated that markets should be found for Atikokan pellets for industrial use. The interviewees of the social service group did not think markets were an important issue to overcome the barriers. Only thirty-three percent of their responses concerned new market development, but they did emphasize development of new woody biomass-based products, such as woody pellets and woody biomass-based electricity. Some social service group interviewees suggested developing plantations for bioenergy feedstock that would incorporate a tourism aspect based at the locations. The First Nation individuals group also did not view markets as a solution to overcome the barriers for bioenergy development in this region. Only 29% of their responses mentioned that new market development is necessary, although interviewees suggested plantations on unutilized land should be raised and used for this purpose. Some suggested financial support was necessary to help new entrepreneurs of bioenergy. As with other interviewees, this group also thought that plantation development could be utilized for tourism. Of interviewee groups, only 17% of local community organizations interviewees mentioned that new markets are necessary for bioenergy development. They did, however, mention that waste heat from pellets used in electricity production should be used in a district heating system. Elected leaders, educational institutions and the small forest industry groups did not provide any suggestions for market development of woody biomass utilization for energy production.

Supply Availability: Among the First Nation non-government organizations group interviewees who provided suggestions for overcoming the barriers, 75% stated that a continuous supply of woody biomass feedstock should be ensured for woody biomass-based energy development. They suggested that all blow down, insect infested, dead and fire affected trees, residues, waste wood and unmerchantable tree species should be used for biomass-based energy production. Some of them emphasized that APGS should sign a long-term contract with biomass suppliers to supply wood pellets. They also suggested that long-term harvesting contracts should be provided by the government to APGS's feedstock producers, and that after harvesting for bioenergy, regeneration of that forest area should be audited in compliance to the legislation. Among the local community organization group 67% stated that a continuous supply of woody biomass feedstock should be ensured for woody biomass-based energy development. Nearly half of the social service interviewees suggested that continuous woody biomass supply availability is necessary for woody biomass-based electricity generation at the APGS. They emphasized the sustainability of the biomass feedstock, expressing that new plantations for bioenergy are necessary and emphasizing the requirement of a long-term contract by the APGS for buying pellets from the pellet suppliers. Half of the local MNR group interviewees also focused on supply availability, advising that over-harvesting for bioenergy generation should be avoided. Twenty percent of the APGS personnel, twenty percent of the elected leader personnel and 6% of the First Nation individuals groups specified that forest resources should be allocated to pellet producers using a long term contact, to develop woody biomass feedstock (pellets) and ensure sustainable supply of pellets to the APGS. Thirty three percent of interviewees from the small forest industry group mentioned that along with woody biomass, other alternative sources, such as agricultural residues, mill waste, switch grass and reeds should be considered for pellet production for bioenergy feedstock. Education institution groups did not make any comment on supply availability to overcome barriers.

Social Acceptability: Among the local community organizations group interviewees who provided suggestions for overcoming the barriers, 67% stated that social acceptance of woody biomass utilization is needed for woody biomass-based energy development. They mentioned that good communications and relationships should be developed among all stakeholders, and emphasized that benefits for all stakeholders (individuals, industries, institutions and organizations) should be considered at all stages of the project. Interviewees from the local community organizations group recommended that during conversion from coal to woody biomass, proper care enabled by modern technologies will help with social acceptance of the project. In the small forest industry group, 43% of interviewees made comments on the social acceptability of woody biomass utilization for energy production, suggesting that government needs to give incentives to bioenergy development. The small forest industry group also emphasized good communications and relationships among all stakeholders. Forty percent of interviewees from the educational institutions group mentioned that social acceptability is needed for woody biomass-based energy development. Some of them also proposed government incentives and recommended increasing communications and developing relationships among all stakeholders. A smaller percentage (one third) of the MNR personnel interviewees provided suggestions about developing social acceptance for woody biomass utilization for bioenergy. They also proposed to develop good communication and relationships between the stakeholders, suggesting publicity is needed on the benefits of woody biomass utilization for growing social acceptance of bioenergy production. One fourth (25%) of the APGS personnel interviewees suggested that public opinions on utilizing woody biomass for bioenergy should be considered and identified that public opinions on other alternative energies (e.g., wind, hydro and nuclear) should be measured. Interviewees of the social service sector and First Nations individuals groups proposed that government should provide incentives for woody biomass feedstock (e.g., pellets) production. Elected leaders and First Nation non-government organizations groups did not provide any suggestions on social acceptability.

Education and Training: All interviewees from the First Nation non-government organizations group suggested that education and training are needed for woody biomass-based bioenergy development. One third of them suggested the APGS should promote education about and awareness of the biomass development project. They also stressed that traditional knowledge from the Aboriginal elders should be considered for woody biomass utilization for energy production. Sixty percent of the educational institutions group interviewees indicated that training and education are needed, and recommended that training should be provided through small business development to the local people. Specifically, training is needed to improve biomass harvesting techniques, whereas mass education should focus on bioenergy. Forty-three percent of interviewees of the First Nation individuals' group suggested education and training for this purpose, emphasizing that training should be provided to increase the awareness on biomass utilization. As well, First Nation individuals pointed out the importance of the Aboriginal elders' traditional knowledge in this regard. A small portion of interviewees from the small forest industry group (29%), and interviewees of the APGS personnel (25%) included education and training in their comments; they emphasized providing mass education about woody biomass-based energy. Taking into account that electricity from woody biomass is more expensive than coal, 17% of local community organizations group interviewees suggested that proper publicity should be provided to encourage support for woody biomass-based electricity generation. The social service sector, elected leaders and MNR personnel did not comment on this issue.

Policy Requirement: All interviewees from the small forest industry group reported on the requirements of new policies and legislation to support woody biomass-based energy development. Nearly half of them (43%) suggested that the local resource management authority (such as local OMNR staffs) should be empowered to make timely decisions for the area. Some of them suggested that the government should help by providing policy support when needed. As well, the group emphasized the requirement of a Sustainable Forest Licence (SFL) for biomass utilization purposes should be provided to the woody pellet manufacturer in Atikokan. The group also proposed to cancel the unutilized annual harvest areas of the forest industries and suggested giving these uncut resources to new bioenergy entrepreneurs. Half of the social service sector group interviewees suggested policy requirements, emphasizing that more government help and policy support are needed for this development, especially when it comes to quick decision making. Forty percent of educational institutions group interviewees reported that policy support and new policy and legislation are needed for woody biomass-based energy development at APGS. They recommended that financial support from the government should be provided for woody biomass-based energy development which is needed to increase the growth of small communities like Atikokan. One third of the interviewees from the First Nation non-government organizations group stated that policy should be developed to utilize mature and insect affected park trees for bioenergy. One third of the interviewees of the local community organizations group suggested that government help and policy support is needed, emphasizing also that long-term licence should be provided to woody biomass developers. One third of the MNR personnel interviewees indicated that guidelines and legislation should be developed focusing on new biomass (energy) plantations, supporting the suggestion that new policies are needed to support this type of energy development. They also suggested that the harvesters of woody biomass should SFL holders. Policies and legislation are essential to support woody biomass-based energy development and should be developed and promoted by government. They pointed out that new rules are needed to overcome barriers for bioenergy development. One-fourth of the interviewees of the APGS personnel suggested that legislation should be changed to encourage the involvement of First Nation people in woody bioenergy development. Similarly, one-fourth of interviewees of the elected leaders group suggested that district cutting licences for firewood should be reissued in Atikokan.

Trust Development: One third of First Nation non-government organizations and 14% of First Nation individual group interviewees expressed that trust should be developed among government, different sectors and individuals for woody biomass-based energy production. They suggested that to gain support for any activity of woody biomass-based energy development, government and other sectors should acquire trust by respecting Aboriginal values. They suggested that to improve trust, government must first recognize the Aboriginality of the First Nation communities. Interviewees from the social service sector, educational institutions, APGS personnel, elected leaders, local community organizations, MNR personnel and small forest industry did not provide any suggestions to develop trust among different institutions, sectors and stakeholders.

Joint Management: Sixty-seven percent of the First Nation non-government organizations group suggested that partnerships between government, industries and First Nations should be developed for joint management of woody biomass supply in the feedstock development for bioenergy production. They suggested that all involved parties must benefit mutually by this relationship, and that First Nation communities should be involved from the planning stage of the biomass project. Forty-three percent of the First Nation individuals group also promoted partnerships among government, industries and First Nations for the joint management of this bioenergy project, expressing the view that governments, federal and provincial, should recognize the Aboriginal government as a partner, not as a stakeholder. Thirty-three percent of the MNR personnel interviewees pointed to partnership development for jointly managing the bioenergy project to reduce the barriers to woody biomass-based energy development. They suggested that partnerships must be developed with government, First Nations and industry where all mutually benefit. They also suggested that public opinion should be considered for bioenergy development. The elected leaders group interviewees and those from educational institutions, local community organizations and MNR personnel also emphasized partnership development among government, First Nations and industries that would be mutually beneficial. Interviewees from the social service sector and APGS personnel groups did not comment on joint management.

Cost Minimization: A number of interviewees mentioned that cost is an important barrier for bioenergy development in Northwestern Ontario (Figure 4.3.1). Sixty-seven percent of interviewees from the First Nation non-government organizations group suggested that the cost of bioenergy generation could be minimized by proper planning and applying suitable technology. Interviewees from remote First Nation communities that are rich in forest resources proposed that bioenergy plants, such as pellets and district heating should be developed in these communities for their energy self-sufficiency. Doing so would replace the current fossil fuel-based energy system where diesel oil is trucked for energy purposes. The First Nation organizations group expressed that numerous low cost hydro facilities in Northwestern Ontario challenge costly woody biomass-based electricity generation. Local community organizations group interviewees (17%) suggested that to minimize the cost of bioenergy generation, waste products from the community should be used as feedstock for bioenergy generation. They suggested that waste material from the communities could be burnt and heat used by a district heating system. MNR personnel interviewees (17%) mentioned that to minimize the cost of woody biomass-based electricity generation, care should be taken to maximize efficient utilization of the harvested natural resources and in value added products development. First Nation individual interviewees (14%) emphasized the importance of financial support, and small forest industry group interviewees (14%) supported this viewpoint, stating that easily procured business loans are needed for any successful business venture. The social service sector, educational institutions, APGS personnel and elected leaders did not provide any suggestion in this regard.

Environmental Aspects: All interviewees of the First Nation non-government organizations group said that the environmental aspects of woody biomass-based energy production should be considered. In fact, one third of these interviewees mentioned specifically that soil, water, air, wildlife and beneficial insects of the forest environment should be respected. Another one third of the First Nation non-government organizations group interviewees stated that bioenergy reduces the forest fire hazard; the rest of the interviewees in this group suggested that the forest fire hazard would be minimized by utilizing over-mature, dead and blown down trees. One-third of the interviewees of the social service sector group were concerned about the environmental aspects of woody biomass-based energy development. They suggested that proper measures should be taken for eliminating pollution, reducing inventory and ensuring long-term benefits in bioenergy production. One-third of the MNR personnel interviewees also expressed concern about the environmental effects of woody biomass-based energy production, making it clear that care should be taken to avoid any environmental degradation. They saw that removal of over-mature trees used for bioenergy would be a way to beautify parks. One-fourth of the elected leaders group commented on the value of leaving sufficient residues in the forest for soil enrichment. Interviewees from the educational institutions, APGS personnel, First Nation individuals, local community organizations and small forest industry groups did not provide any suggestions on environmental aspects.

Jobs: Interviewees considered jobs and job creation to be important to the community and the APGS project. Sixty percent of the interviewees of the educational institutions group focused on jobs in bioenergy development. They suggested that emphasis should be given to create more jobs for biomass development and proposed that subsidiary jobs should be created to support the biomass plant in the community. One third of interviewees of the social service group emphasized jobs in woody biomass-based bioenergy production, commenting that a steady workforce, hopefully local, is required for the new facility. They also mentioned that job creation should actually be part of the planning process for the plant since it is to be located in a community that had seen job losses and economic downturns. One-third of the MNR personnel interviewees predicted that new employment for the community would be created by bioenergy. First Nation individuals group interviewees (14%) mentioned that the underutilized work force should be involved in bioenergy production.

Interviewees of other groups, namely the APGS personnel, elected leaders, First Nation non-government organizations, local community organizations and small forest industry did not provide any suggestions in this regard.

CHAPTER 5

DISCUSSION

The Province of Ontario announced a ban on the use of coal to generate electricity by the end of 2014 (OME 2009). At the APGS, from 2005-2013 the Ontario government investigated the possibility of replacing lignite coal with renewable woody biomass, an Ontario-based resource, as feedstock. OPG has chosen wood-pellet biomass as the preferred fuel because the energy content is very similar to the lignite coal that APGS burned and much of the existing equipment can be adapted. Additionally, the APGS combustion test using 100% pellet feedstock was successful (Meadows 2008). OPG will buy wood-pellet biomass fuel for the station through a competitive process and will require that the wood-fibre is sourced from sustainably managed forests (OPG 2013). A vast amount of woody biomass is available in FMUs in the Atikokan region, and local forest harvest residues can be used for the low cost development of wood pellets (Alam *et al*. 2012). Additionally by converting coal to woody biomass-based feedstock at APGS for electricity generation a vast amount of greenhouse gas reduction could be obtained (OMAFRA 2011).

This study explores the social context of converting forest biomass to energy at the APGS, using qualitative research methods, including study instruments such as surveys, key informant interviews, semi-structured interviews and focus group discussions.This research explores the local public attitudes and opinions about woody biomass utilization for energy development at the APGS, and explores the major socio-economic characteristics that influence people’s decisions to join in the project’s woody biomass-based activities.

According to Domac *et al.* (2004), biomass utilization, bioenergy technologies, market share and research interests vary considerably among different countries. The authors reported that in most countries, the social and economic benefits of bioenergy use can be identified as a significant driving force in increasing the share of bioenergy in the total energy supply. In other countries, regional employment creation and economic gains are the two most important issues regarding biomass use for energy production (Domac *et al.* 2004). The introduction of a wood pellet production plant for supplying bioenergy production at APGS could help to stem adverse social and cohesion trends such as high levels of unemployment and rural depopulation in Atikokan. The scope of this study is regional, but the findings of the study may be applicable for other regions facing similar situations. The literature does not report many studies about perceptions of local communities regarding biomass utilization for energy production. The only studies that were found related to this topic were from the United States (Bradbury *et al.* 2009) with some from European countries. However, to our knowledge no such study has been conducted in Ontario.

5.1 DISCUSSION OF ATIKOKAN SURVEY RESULTS

5.1.1 Factors Affecting Involvement in Woody Biomass Production Activities in the Atikokan Area

The socio-economic conditions of potential woody biomass entrepreneurs have influenced their decision to become involved in woody biomass-based activities. The willingness of respondents to be involved in woody biomass-based activities in this area is the function of their education, sex and environmental opinions. Furthermore, the surrounding environmental conditions of Atikokan have substantial effects on the survey participants' decisions to become involved in woody biomass-based activities. In fact, a higher percentage of Aboriginal people are interested in becoming involved in this sector than non-Aboriginal people. Other findings show that males expressed more interest in involvement than women did. Those who want to be involved in biomass-based activities are over 40 years old and are educated (their education level is higher than grade 12). As the major forest-based industries have been closed in Atikokan for the last five years, a number of jobless, but forest-experienced people currently live in this area, and they might show interest in becoming involved in woody biomass-based activities.

People who are involved in forest related occupations at present are more interested than those who are in non-forest related occupations in any woody biomass-based activities in the future. As woody biomass-based energy development is a forest-based initiative, forest-based professionals might be more interested than non-forestry professionals to become involved in this sector. Among the respondents who have been in this region for 20 years or less, more are willing to be involved in biomass-based activities in future than those who have been in this region for a longer period of time. It is possible that those who have been in this region for longer are financially more established than those who migrated to this locality over the past 20 years. The established people do not need any new jobs/businesses. Economics is also a factor for respondents whose monthly expenditure for energy is more than $500 CDN – they are more willing to become involved in woody biomass-based activities in the future than those whose expenditure is less. The risk involved in new woody biomass-based energy development also requires substantial financial support for the initial stages of business development. High income earners showed their interest more than those who earn less. Surprisingly, respondents who are not members of local volunteer and professional organizations showed more interest in becoming involved in woody biomass-based activities than people who are members of local organizations. It might be that people who do not have other community commitments think that woody biomass-based activities open an opportunity to become involved. Not surprisingly, people who have their own businesses showed more interest in becoming involved in woody biomass-based activities than people who do not have their own business. This could be due to their willingness to take risks and their familiarity with business practices. As well, respondents who have access to credit are also more interested in woody biomass-based activities than the respondents who do not have access to credit, due to their strong financial position in the community.

Furthermore, those who indicated that the surrounding environmental condition of Atikokan has improved over the last five years also expressed more willingness to become involved in woody biomass-based activities than people who mentioned the environment has worsened over the last five years. People who have a positive outlook about the environment of Atikokan showed more interest and optimism about joining a new woody biomass initiative. Respondents who are concerned about cutting unmerchantable trees showed more interest in woody biomass-based activities than respondents who are not concerned about cutting unmerchantable trees. This perception is controversial, and those who have concerns about cutting unmerchantable trees but who also have an interest in biomass activities should be provided with more information about the adverse effects of woody biomass-based bioenergy on the environment. Respondents who are not concerned about using forest harvest residues showed more willingness to be involved in woody biomass-based activities than respondents who are concerned about using forest harvest residues. As the main issue of woody biomass-based electricity generation at APGS is woody biomass utilization for energy, people who are not concerned about forest harvest residues are more interested in being involved in biomass activities in the future than who have concerns about it.

From this study it was observed that a number of people showed their interest in woody biomass-based activities in the future. Currently there are no training facilities for the interested people and to ensure success in woody biomass-based activities, people should be provided with training or an extension program to attract public interest and involvement. As well, access to low interest rate capital and incentives for new business development would help encourage investment. Creating a positive perception and image of this type of forest resource utilization is important for this new technology to succeed. Therefore, more communication and publicity about the benefits of woody biomass utilization need to be provided to the people who live in the Atikokan area. Provincial government representatives and APGS authorities could set up public communications opportunities to increase awareness of utilizing woody biomass for bioenergy, and disseminate information on the direct and indirect benefits of woody biomass utilization. The above factors that influence the future development of the woody biomass-based bioenergy should be considered by the people who formulate the policies and the executive authorities of the APGS.

5.1.2 Opinions on Important Factors of Community Development

At the time of the survey in 2009-2010, employment insurance for the people whose jobs had been impacted by the local mill closures was nearly finished, people had moved away and were dislocated from the community, children suffered as a result of their parents' out migration, and families were facing difficult financial situations (Atikokan Info 2013). In Atikokan, the APGS provides 90 good paying jobs to the community and a significant amount of taxes to the municipality. If APGS cannot be converted from coal to biomass or a natural gas feedstock-based plant, the government of Ontario will close it by 2014. The people of Atikokan are concerned about the potential job losses in future. Probably this factor influenced them to elect employment as the most important factor for their community improvement and development.

The natural environment includes climate, weather and natural resources that affect human survival and economic activity. It includes all living and non-living things occurring naturally on Earth and encompasses the interaction of all living species. It includes all vegetation, microorganisms, soil, rocks, atmosphere, air, water, and climate, as well as energy, radiation, and electric charge not originating from human activity. The natural environment was selected as the most important factor for community development by 37% of survey respondents. Atikokan has been a natural resource-based community since its beginnings (Town of Atikokan 2012) with the region's most important natural resources listed as minerals, forests, tourism, wildlife and numerous water bodies. In the past Atikokan was an iron ore mine based community; after mining, forestry took over the economy. Since the shutdown of the two major forest mills, APGS, tourism and other jobs (hospital, municipality, retailers, pellet plant, small forest-based entrepreneurs, etc.) currently support the community economy.

Forests are an important asset for the Atikokan region. Vast areas of Crown forests surround (i.e., the Sapawe, Crossroute and Dog River-Matawin forests) the community. The net volume of standing timber in the productive forest is approximately 110 m^3/ha (Reynolds *et al.* 2008), and the availability of forest harvest residue and underutilized wood is 60 m^3/ha, respectively (Alam *et al.* 2012). Saw logs, pulpwood and biomass are supplied from these forests to Resolute Forest Products at its Fort Frances and Thunder Bay mills. A number of community people are involved in forest harvesting and wood supply activities to mills. Other regional natural resources development includes the OSISKO Hammond Reef Gold Project, which opened in February 2013 and started gold mine activities in the Atikokan region.

The natural environment itself is a major asset in the area; Atikokan is famous for canoeing and other outdoor activities including hunting and fishing. Quetico Park, the largest natural wilderness park of Canada, is located at the boundary of Atikokan. The forests of Atikokan and its surrounding are rich in game wildlife such as moose, deer, bear, rabbit, grouse, geese and otter. The water bodies (lakes, river etc.) support a number of fish species such as northern pike, bass, white fish and lake trout. The presence of numerous rich natural resources surrounding Atikokan probably influenced the survey respondents (37%) to consider the natural environment as the most important factor for their community development.

Culture is concerned with the integrity of languages, health beliefs, family relationships, sexuality and gender roles, spirituality and religion, and politics and social concerns (NNAAPC 2013). Survey respondents belong to both Aboriginal and non-Aboriginal people who have different ethnic, language, family relationships, health beliefs, religious and spiritual beliefs. Aboriginal people value their traditional lifestyles and spiritual beliefs: they regularly hunt, fish, trap and harvest wild blueberries. They do not support the clear cutting system as they perceive clear cutting hampers their traditional lifestyle. Most of the Aboriginal respondents supported culture as the most important factor for their community development.

The main public services of the research area are banking, transportation, healthcare, law enforcement and education, which are all local services that are important for the development of the community. At present there is no public mass transit available in the Town of Atikokan or the surrounding region so the population is dependent on private automobiles for travel. Still, only 22% of respondents identified services as a community priority, indicating that respondents were focused on other priorities such as employment (Appendix IV; Figure 4.1.2.1).

Values can be defined as broad preferences concerning appropriate courses of action or outcomes that is comprised of a set of consistent values and measures. Traditional values refer to those beliefs, moral codes and mores that are passed down from generation to generation within a culture, subculture or community (Rokeach 1973). According to Farmer (2003), the rural value system is primarily communitarian and rational and these values are found in peasant villages, agricultural communities, ethnic neighborhoods or tribal communities. Farmer (2003) also points out that the personal benefits of the rural value system include belonging, emotional support, security and predictability. The way people relate to others in rural communities is more personal, emotional, direct and socially supportive. Twenty percent of survey respondents identified rural values as the most important factor for community development, and the majority of them were Aboriginal people (Appendix IV; Figure 4.1.2.1).

Access to amenities, defined as something that contributes to physical or material comfort, was identified as the most important factor for community development by 22 (17%) of survey respondents (Appendix IV; Figure 4.1.2.1). Access to amenities is a feature that increases the value of a piece of real estate or a geographic location. Access to social infrastructure and basic amenities such as drinking water, sanitation, electricity, housing, and drainage/sewage are crucial to the community's wellbeing as they contribute to material comforts and quality of life. They also ensure better health and improve the environment.

A diverse population includes immigrants and refugees, persons with disabilities, persons with low literacy skills, gender and sexually diverse persons, persons living in poverty, and persons experienced in homelessness. Currently, the population of Atikokan is a mixture of individuals of Aboriginal and non-Aboriginal descent and the town's population is more diverse than it was 10 years ago. The original inhabitants of the Atikokan area were First Nation people, but historically, Atikokan also has diverse settlers from Fort Frances and surrounding First Nation communities. People migrated because of railway development, mining operations, commercial forestry and tourism businesses. For example, people moved to Atikokan in 1899 to work on the construction of the Canadian Northern Railway Line. In the 1950s, they came to Atikokan to work in the iron mines and in 1980s to work at APGS. Diverse population is not perceived as a community priority: it was identified as the most important factor for community development by only 12 (9%) survey respondents (Appendix IV). With the introduction of APGS, it is anticipated that the Atikokan Township would become more diverse as it would attract both social and economic migrants, such as business owners, consultants and contractors.

5.1.3 Opinions on Important Factors for the Quality of Life

Forests renew our air supply by absorbing carbon dioxide and producing oxygen. Trees also clean our atmosphere by intercepting airborne particles and by absorbing ground level ozone, carbon monoxide, sulfur dioxide and other greenhouse gases. For example, a single tree can absorb 4.5 kg of air pollutants a year, and produce nearly 118 kg of oxygen (Dwyer *et al.* 1992; Hastie 2003; McPherson *et al.* 2006). Forests act as natural reservoirs, treatment plants and storm water management systems. Forests provide natural filtration and riparian forests help to keep the water in streams clear. The ability of forest vegetation and soil to absorb and filter water also increases ground water. As such, the majority of respondents to the survey, 83 of 131 (63%), placed clean air and water as their most important quality of life factors; this attitude is also reflected in their choice of lifestyle as there is much less pollution in the area than in an urban environment. Also, the majority of the Atikokan area survey respondents identified good jobs as the most important factor; other four factors affecting the quality of life in the community are that it is a good place to raise a family, it is secure and safe, it has good community relationships, and it has an arts and culture scene.

A healthy and supportive work environment, which includes physical, social and psychological aspects of the workplace, is a vital factor in creating strong employment relationships (Lowe and Schellenberg 2001). Individuals with strong employment relationships tend to have reasonable jobs, enjoy supportive co-workers, perform interesting work, occupy a workplace that is both healthy and safe, and are able to balance work with their personal lives. High levels of employee trust and commitment, in particular, are linked to the perception that their employer cares about them (Lowe and Schellenberg 2001).

Atikokan is a small town, but it has good schools, a hospital, libraries, an art center, golf courses and parks. According to the key informants, there are a lot of advantages to living in a small town like Atikokan. Here, people enjoy a better quality life than most people in large cities. They are able to avoid the frustration of dealing with large volumes of traffic. They can get closer to nature. They can enjoy hunting, fishing, hiking, canoeing and cycling on a regular basis because living in a small town makes it easier for them to enjoy these hobbies. The crime rate in Atikokan is less than in surrounding large cities, and people can walk down the street feeling safe and secure. In this locality people know one another, creating a tighter sense of community. For example, parents have the chance to know their children's social circle. Students have the benefit of being able to get more feedback from their teachers, and parents also know all the school teachers and can consult about their children.

5.1.4 Opinions on the Purpose of Developing Woody Biomass-Based Bioenergy Projects

Participants noted that the first four most important factors for developing woody biomass-based bioenergy in the Atikokan area included that it is renewable energy, it provides job opportunities, it allows for profit from waste, and it creates business opportunities. In order of their importance, the other four encouraging factors for developing woody biomass based bioenergy were related to energy self-sufficiency: biofuel is an alternative to fossil fuel, it provides energy self-sufficiency for industry, it allows for rural energy self-sufficiency and reduces global warming, and biomass-based energy is affordable for APGS.

Among the Atikokan area survey respondents, 69% identified woody biomass-based bioenergy in Atikokan as renewable energy indicating the respondents are knowledgeable about renewable energy options. Developing a woody biomass-based bioenergy plant requires a number of steps that involve job creation in all phases, including tree harvesting, pellet production, pellet supply and plant operation. All biomass production systems require people to procure the feedstock and to operate the plant, thus creating jobs. A study by FERIC (2008) found that for generating 1MW bioenergy, two new jobs will be created. Since the impact on employment is primarily in rural areas, these factors affect survey respondents to rank creating job opportunities as an important factor for converting the APGS to bioenergy; as well, those who work in the current coal-powered plant could look forward to keeping their jobs. Atikokan might also follow the European model where biomass from intensive silviculture is commonly used for combined heat and power production.

Forest harvest residues are treated as waste, but for woody biomass-based bioenergy development these wastes are used as feedstock. The current practice of burning forest harvest residues at the harvesting site involves costs and there is a risk of forest fire; both cost and fire hazard can be minimized by utilizing forest harvest residues as bioenergy feedstock (Alam *et al.* 2012). Besides forests and mill wastes, areas devastated by mortality due to fire, insects, diseases and wind throw are excellent sources of feedstock for bioenergy. These issues might have influenced the respondents to choose to generate profit from wastes as an important driver for bioenergy development.

Since wood pellets will be used in the APGS as feedstock instead of coal, different types of businesses will be created by the development of the bioenergy projects and pellet industry, such as biomass operations that specialize in harvesting, communition and hauling. Fossil fuel creates greenhouse gases, but biofuel is carbon neutral, and so the use of forest biomass for electricity generation instead of fossil fuel can reduce greenhouse gas emissions (Keith and Rhodes 2002; Gan and Smith 2006b). Furthermore, coal use at the APGS comes via rail from western Canada, but a huge amount of biomass is available in FMUs that are close by the APGS (Alam *et al.* 2012). Industries can use biomass in their own combined heat and power (CHP) plants to produce heat and power. After fulfilling their own energy demands, they can also sell the surplus power to the grid.

By installing woody biomass-based electricity plants and CHP plants in remote rural areas, the energy and heat demands of the community can be fulfilled, thus reducing the dependency of remote communities on oil and gas imports from the other places. Ultimately, rural communities could become energy self-sufficient. Greenhouse gases produced by fossil fuels increase global warming (Gan and Smith 2006b). Using carbon neutral bioenergy instead of fossil energy will reduce greenhouse gases which will eventually reduce global warming (Gan and Smith 2006b; FERIC 2008).

Development of woody biomass-based bioenergy at the APGS is more affordable than oil-based energy. However, it is much more expensive than coal-based energy. To build the woody biomass-based APGS bioenergy system, financial support has come from the Ontario provincial government, with the support for its development also coming from the Town of Atikokan. Since a vast amount of biomass is available in FMUs in this region to supply the plants, forest harvest residues can be used with very low cost. Most important, the APGS test of combustion by using 100% pellet feedstock was successful. All of these factors have helped to make the project feasible and affordable.

5.2 DISCUSSION OF FOCUS GROUP DISCUSSIONS AND THUNDER BAY SURVEY RESULTS

People’s perspectives from the SWOT analysis for the APGS shifting to wood pellet feedstock are given in Table 4.2.1 to Table 4.2.9. The scope of this study is regional, but the findings of the study may be applicable for other regions facing similar situations. Creating employment is the greatest strength of woody biomass-based energy production at the APGS, and a number of local situations may influence a group’s selection of ‘Create Employment’ as the most important function (Table 4.2.1; 4.2.2; 4.2.3; 4.2.5; and 4.2.9). Atikokan is suffering from the closing of its main forest industries, and this reality might have influenced respondents’ perceptions. Normally, the quantity and quality of employment in the bioenergy sector mainly depends on the overall bioenergy system cycle: i.e., production, conversion and end use (Dwivedi and Alavalapati 2009), as it is a labour-intensive process. At the APGS, pellet-based bioenergy is being promoted due to its potential contribution to energy security, environmental appropriateness and ease of plant conversion. It is hoped that deployment of bioenergy has the potential for job creation in the community, improved industrial competitiveness, regional development and the development of a strong export industry. Elsewhere, the findings support the view that bioenergy improves local economies. The Ministry of New and Renewable Energy (MNRE 2013) study conducted by the Indian Government on biomass-based plants in India reported:

> Biomass power generating units produce a significant economic benefit to the area surrounding the plant. A 10 MW biomass power project can create approximately employment for 100 workers during the 18-month construction phase, 25 full-time workers employed in the operation of the facility, and 35 persons in the collection, processing and transportation of biomass material (MNRE 2013).

A study in the U.S. by American Renewables (2013) found that during peak construction, a 100-MW biomass power facility can create approximately 400 construction jobs. When operational, the facility will create approximately 40 direct full-time positions at the site, and will also generate approximately 700 indirect jobs throughout the region (American Renewables 2013).

Among the opportunities of woody biomass utilization for bioenergy production at the APGS, renewable energy was selected by the highest number of the professional groups respondents of Thunder Bay. Biomass is considered a renewable energy source because the carbon in biomass is regarded as part of the natural carbon cycle: trees take in carbon dioxide from the atmosphere and convert it into biomass and when they die, it is released back into the atmosphere (Gan 2007; IISD 2008). Whether trees are burned or whether they decompose naturally, they release the same amount of carbon dioxide into the atmosphere. The idea is that if trees harvested as biomass are replanted as fast as the wood is burned, new trees take up the carbon produced by the combustion. Therefore, the carbon cycle theoretically remains in balance, and no extra carbon is added to the atmospheric balance sheet – so biomass is considered “carbon neutral” (Gan 2007; IISD 2008). Since nothing offsets the CO_2 that fossil fuel burning produces, replacing fossil fuels with biomass supposedly results in reduced carbon emissions (Cho 2011). If the forest harvest residues and unmerchantable trees are not used for biomass-based electricity production, they will naturally decompose, releasing CO_2 into the atmosphere without the benefit of electricity production (MNRE 2013).

Development of infrastructure in rural areas was selected as the second main strength by the second highest number of respondents (Table 4.2.9). New industry and roads will be created due to the development of the biomass-based energy plant. For example, a pellet industry was created in Atikokan due to the requirement of pellet feedstock by the APGS. One more pellet industry will also be created in Atikokan soon, and real estate, schools and markets will be developed to provide services to the APGS operating environment.

Promotion of energy security was selected as the third main strength for by all professional group respondents. The Canadian Security Intelligence Service (CSIS) (2013) reported that energy security is a complex concept. Canada is rich in energy resources and the Canadian society depends on its diverse energy inputs to function. Securing the processes through which that energy is produced, delivered and consumed is important. The free market nature of the Canadian energy sector is its strength, enabling energy security through increased trade and growth, and ensuring that Canadian resources are developed and extracted (CSIS 2013). The main risk to Canada's energy security, as realized by the Fraser Institute (2013), is the need for high levels of domestic energy consumption, comparatively low levels of energy efficiency, and a lack of access to diverse markets (Fraser Institute 2013). The federal government is adversely affected by the drive for energy in Canada. Although the country is currently energy secure, woody biomass utilization for energy could also help Canada by promoting energy security for the future (Heinberg 2007b; CSIS 2013). Hoogwijk *et al.* (2003) identified six biomass resource categories for the future world potential of biomass for energy, and among them woody biomass was identified as an important resource. But the authors suggested that bioenergy should not be relied upon in a large scale as the land is also needed for other important uses (e.g., food production) as land resources are limited.

Closeness to source of feedstock is recognized as the primary strength by focus groups respondents and surveyed professional group respondents. APGS is situated in the midst of a productive forest area: forest harvest residues (FHR) and underutilized wood (UW) are abundant in forest management units surrounding the APGS. The nearby forest management units involved are Sapawe Forest, Crossroute Forest and Dog River Matawin Forest. A study conducted by the Ontario Ministry of Energy (FBI 2006) found that within a 500 km radius of the APGS, approximately 2.7 million ODt of woody biomass feedstock are available annually from FHR, UW and mill wood waste. In Northwestern Ontario, the actual annual amounts of biomass available by distance from the APGS: within 0-100 km is 130,000 ODt; within 100-200 km is 418,500 ODt; within 200-300 km is 436,100 ODt; within 300-400 km is 234,400 ODt; within 400-500 km is 149,000 ODt; and from more than 500 km is 456,900 ODt (FBI 2006). Furthermore, Alam *et al.* (2012) found that by using a harvesting factor of 0.67, the annual average technical availability of FHR and UW in Northwestern Ontario was about 2.1 million gt and 7.6 million gt, respectively.

Normally, biomass energy yields local economic benefits (Domac and Segan 2005). In a study in Minnesota, Zerbe (1988) noted that each dollar spent on biomass energy resulted in US$1.50 of additional economic activity, compared to only US$0.34 for each dollar spent on oil. Harris *et al.* 2004 estimated the impacts of biomass utilization for bioenergy production instead of coal in South Carolina. The annual feedstock was estimated to be 20.9 million ODt of woody biomass, which consisted of logging residues, thinning, scrub wood cuttings, mill residues and urban wood residue. The study reported that biomass electricity is more expensive than coal-based electricity: the estimated biomass electric production cost was US$.084/kWh and coal-based electric production cost was US$.039/kWh (Harris *et al.* 2004). In Ontario, the current Feed-in Tariff for biomass produced electricity is $0.138/kWh (CAD), as the production of wood bioenergy is more expensive than fossil fuel (coal) based energy. However, when the environmental and social benefits of wood bioenergy are accounted for, utilization of woody biomass for bioenergy production becomes environmentally, economically and socially justifiable (Dwivedi and Alavalapati 2009).

By comparing the focus group discussions in Atikokan, it was observed that the senior focus group emphasized local issues and local development. Strength issues include local tax generation, partnership with First Nations and the possibilities of new biomass business, i.e., a pellet plant. Weaknesses raised include environmental concerns about the recovery of harvested/depleted areas, CO_2 emission from pellet-based electricity, and resource depletion. Respondents from the seniors group also had concerns about less government representation in the North and weak environmental policies, as well as the complexity of using woody biomass in a sustainable way. Finally, seniors perceived that the present transmission lines from the Atikokan community are not sufficient for the projected supply coming from APGS. They identified government threats and weak policies as the external weaknesses. The seniors group proposed that the Ministry of Northern Development and Mines; and the Ministry of Forestry should be permanently located in the Thunder Bay area (near Atikokan). Seniors viewed the current MNR minister being from Northern Ontario as an opportunity. This group also identified the benefits of using woody biomass to heat houses and create a district heating system in the Atikokan area. Economic and research opportunities and the development of new pellet plants were also identified by the group. According to the senior respondents, destruction of the ecosystem and threats to wildlife, e.g., moose, deer and bear, are the main local threats.

The First Nations group, similar to the seniors, also gave preference to local issues as they are concerned about the adverse effects on their local environment. Similar to the seniors and young people groups, the First Nations group indicated that employment is the best strength. Both the First Nations and the young people groups reported that the renewability of biomass as an opportunity. All three groups placed emphasis on local environmental issues (Tables 4.2.1, 4.2.2 and 4.2.3).

Compared to young people group in Atikokan and the Seine River First Nation group, the senior groups of Atikokan and the professional groups of Thunder Bay discussed regional and national issues more than local issues. The participants in both the focus group discussions and survey respondents mentioned that creating employment is the main strength. Similarly, all groups in these two localities mentioned “biomass is renewable” as an important opportunity. Other than employment, the main regional issues mentioned by the professional groups were rural infrastructure development, community development through biomass use and favorable public opinion. The main social issues by professionals were community development, closeness to feedstock sources to APGS, competition with conventional forest products industry and favorable public opinion. The professional groups’ main economic issues were employment opportunities, the high cost of woody biomass-based electricity (as compared to coal), the uncertainty of future markets, and competition from cheaper and cleaner sources of energy such as hydro and geothermal energy. Professionals identified environmental issues such as renewable energy, reduced soil quality, energy security, and the sustainability of feedstock as being part of their concerns about the project.

The main social issues for the seniors’ group are potential conflicts between federal and provincial governments, and partnerships with First Nations. As well, the seniors’ group worried about the demand for electricity, good access to the Atikokan plant (waterways, road and rail), having an experienced and skilled workforce, closeness to the biomass feedstock source from the plant, unclear bioenergy policy, and a lack of government legislation. The main economic issues for seniors concerned employment opportunities, royalties for the Municipality of Atikokan, and the possibility of new biomass plants, i.e., a pellet plant and district heating by waste heat. The main environmental issues for seniors included renewable energy, possible damage to the environment by residue removal, CO_2 emission by woody biomass-based energy, the complexity of using biomass for bioenergy in a sustainable way, resource depletion, destruction of the ecosystem, and threats to wildlife habitat.

The main social issues for the First Nation discussion group also included environmental concerns about biomass availability and allocation of land for biomass use, along with the perceived lack of capacity development, training and government support. As well, First Nation respondents indicated the project to switch from coal to biomass was a time consuming and complex process. The main economic issues for the First Nation discussion group were employment opportunities, economic impacts, energy self-sufficiency at a provincial level, the project's cost to implement and the continuing economic crisis in First Nation communities. Environmental issues identified included resource renewability, possible damage to the environment by overharvesting, emissions from biomass burning, ecosystem disturbance and its environmental effects, and threats to their traditional lifestyle based on hunting and fishing.

The main social issues for young people are renewable resources, opportunities for training workers, the availability and ease of access to local resources, and political support. Young people expressed the desire to see more research and global green thinking to identify what is good for forest communities. They are also interested in developing international consequences for countries (such as Canada and the US) that neighbour each other, where one burns coal and one bans coal. If Canada ends coal burning and its neighbour the USA does not cease to use it, the young persons group wondered if an international policy exists that would protect against environmental damage. The main economic issues raised by young people are job opportunities in the region, the cost to switch over from coal-based to biomass-based energy production and the size of the boost to forestry this conversion will bring about. The main environmental benefits young people identified were that the project would use leftover litter from the forest, it is a clean energy (less emission), and one that is safe to extract. On the other hand, they considered overharvesting problems, safety (in the plant) and environmental degradation as important issues. Finally, young people saw certain environmental effects such as soil erosion, the adverse effects of logging, the loss of natural habitat and biodiversity also as being important to them.

5.3 DISCUSSION OF INTERVIEW RESULTS

The interviews and the literature gave insight into the key issues that the interviewees identified as important in the development of bioenergy from woody biomass at the APGS; the issues will be instrumental in determining social acceptance of bioenergy at APGS. In Northwestern Ontario, for example, the cost of producing woody biomass-based electricity is an issue because it is higher than coal-based electricity. Also there are abundant supplies of hydro-power in Northern Ontario, which makes it difficult for woody biomass energy to compete on the electricity market. The findings of the interviews are discussed in this section of the thesis under three topics: Economic Issues, Environmental Issues and Social Issues.

5.3.1 Economic Issues

The majority of interviewees (50%) identified the economic aspects of using woody biomass as most important. Many MNR personnel interviewees and small forest industry holders saw biomass markets as opportunities to utilize wood that is unused due to the poor current markets. Some identified woody biomass markets as ways to offset the high costs of forest and park management. Others saw biomass from Crown forests becoming an important revenue stream for government. Unfortunately, the high costs associated with the harvest, collection and transport of woody biomass often make bioenergy unprofitable (field data; Li *et al.* 2006). These costs increase with longer transportation distances, rough terrain, expensive harvesting equipment and handling by inexperienced operators. Besides, collection costs associated with the harvesting of small-diameter, low grade trees and logging residues are higher, as they are very bulky and thus transport cost is very high. These barriers hamper the wider use of bioenergy (GAO 2006; Mayfield *et al.* 2007; McCormick and Kaberger 2007), and according to the interviewees, the technologies for collection, storage and conversion of biomass into energy should be improved.

A number of American and international studies (e.g., Resource Systems Group and Energetics Inc. 1994; Harris *et al.* 2004) have examined the regional economic impacts of using woody biomass energy. They found utilizing woody biomass creates more total employment than fossil fuels in energy generation. In 1994, Resource Systems Group and Energetics Inc. (1994) spent US$29 million for a biomass home heating fuel program and obtained direct and indirect economic activity worth US$74.8 million and 1,482 jobs. However, a South Carolina study (Harris *et al.* 2004) estimated that biomass electric production cost was US$ 0.084/kWh, compared to coal-based electric futures which at the time averaged about US$ 0.039/kWh.

Wood fiber supply was also identified as important by many research interviewees. Currently a number of products, such as particleboard, pulp and paper, animal bedding, and a number of other light manufactured wood products are made from sawdust, wood residues and low-grade timber. There is concern that high demand from a growing bioenergy sector could increase feedstock costs for these existing industries, closing some of them and driving others abroad. Rafferty (2012) also expressed this concern. From a sustainability perspective, many interviewees are worried that an additional fiber demand could result in unsustainable levels of harvesting, especially where two or more wood-using enterprises are operating in the same forest area. Most members of the MNR personnel and some members from the small forest industry group stressed the importance of an appropriate scale for biomass harvesting. They suggested that an economically viable scale should be developed by considering community need and the quantity of biomass from the local forest resource that can be produced without compromising other management objectives. According to Gan and Smith (2007), economies of scale tend to reward larger energy producers with low per unit operating costs. Some education institutions interviewees indicated that government incentives for woody biomass-based energy could play an important role in improving the production of pellets or electricity from the woody biomass.

Woody biomass needs to be available to the APGS energy plant. Over half of the education institutions participants, including at least one person from each of the other groups, brought up the cost of transporting biomass as being an important issue. Many education institutions interviewees, because of high transportation costs, suggested that biomass could be gathered only within a 100 km radius of the APGS. This limits how much supply would actually be accessible to the plant. Similarly, the majority of participants from the local community organizations, MNR personnel, APGS personnel, educational institutions and First Nation non-government organization groups mentioned that the supply must be economical and continuous. A majority of participants from the small forest industry, APGS personnel and MNR personnel also said that the supply must be long-term, which is normally 20-25 years. It was thought that if these criteria were not met, then companies interested in building a woody biomass-based energy facility would not be able to secure the financing necessary to cover the capital costs of development. Since the supply will largely be coming from Crown forest lands, in addition to being actually available, a number of participants questioned whether the necessary supply would be politically supported in future. Atikokan Renewable Fuels (now taken over by Rentech Inc.) has accepted one of Ontario's first new wood supply offers, which is to produce wood pellets for domestic and international customers that can be used for heating and electricity. This will create up to 150 jobs, help sustain other jobs in the forestry sector and support the local economy.

A majority of participants in the MNR group, small forest industry and APGS personnel groups suggested a contract ensuring a known quantity of supply over a long time period is the most effective tool for woody biomass based bioenergy development at APGS. Participants indicated that using long term contracts would help to assure the sustainability of the biomass supply. In February 2011, Atikokan Renewable Fuels was awarded an OMNR wood supply offer of 179,400 m^3 per year of poplar and birch fibre, which is in addition to an existing allotment of 100,000 m^3 per year. Ontario is investing $1 million (CAD) in the Atikokan Renewable Fuels (now Rentech Inc.) plant conversion through the Northern Ontario Heritage Fund Corporation's (NOHFC) Enterprises Northern Job Creation Program, and $250,000 (CAD) toward converting the plant's existing natural gas heating system to woody biomass-based heat through the Northern Energy Program. The Ontario government states that one of its important goals is to help build a stronger forest industry and create jobs and economic opportunities in Northern Ontario (OPG 2013).

Even if supply is made available, it is currently very expensive to harvest biomass and transport it to a processing plant. Interviewees debated the use of subsidies to help offset these costs, with some people in support and others against. A majority of participants in the small forest industry, APGS personnel, local community organizations and MNR personnel groups thought that some form of subsidy would be necessary to make biomass utilization projects viable; however, no one from the elected leaders group suggested this strategy. A Quetico Park employee wondered why Northwestern Ontario, which is rich in potential hydroelectric power, would pursue biomass-based energy projects. He points out that bioenergy is expensive to produce: "Wood is far more expensive to handle, far more expensive to use for electricity production." He views hydroelectricity as the best option because it "is more affordable," and the energy is cleaner than biomass: "Burning wood is not economically sound and has no environmental benefits." Finally, with hydroelectricity, the work can be done by people in Atikokan because of their past experience with APGS: "the Atikokan community has a very close link with the power plant."

An Economic Development Officer agrees that economics is the driver for the project, but that biomass falls short because it is expensive to produce and the project has not finalized markets for the feedstock produced:

> … it cannot be produced economically. It is more expensive than coal. The pellet company needs a guarantee by OPG to buy a certain percent of pellets before they start to produce pellet. It is essential to find a good and profitable market for pellets, and a guarantee by OPG to purchase it.

At the time of writing, the situation for the pellet market has changed, and the provincial government allotted wood for pellet production to a local pellet plant to produce woody pellet (feedstock) for supplying APGS. In the discussions it is clear that tension exists between those who think the environmental and job creation advantages are worth the higher production costs and those who think that the cost of biomass energy production is prohibitive.

5.3.2 Environmental Issues

Progressive technological development and continually rising energy consumption cause a gradual worsening of environment quality. Energy industries that mainly use fossil fuels contribute to environmental degradation by discharging carbon, sulphur and nitrogen oxides into the atmosphere (FERIC 2008). Carbon dioxide has an enormous influence on the greenhouse effect (Cline 1991). Sustainability and environmental issues were found to be the second most important for the majority of interviewees. They considered that woody biomass for energy would provide plenty of environmental advantages such as better living conditions for local communities. The interviewees identified that decreases in greenhouse gas emissions, wind, soil and surface erosion, and wastes produced by the fossil fuel-based energy industry were all positive effects of woody biomass based bioenergy. As well, they saw advantages resulting from a secure CO_2 flow and an increase in biodiversity through the growing of new species of trees for woody biomass energy.

They also mentioned that the use of forest biomass should not negatively impact forest soils, biodiversity, ecosystem integrity or water resources. In addition, many of them felt that forest biomass must be developed as a positive tool for achieving the objectives of forest habitat management, fire reduction, and other activities intended to improve forest structure or ecological functions. Some of them suggested that increased biomass utilization could and would contribute to these objectives. On the other hand, a small number of individuals felt that biomass harvesting is not a correct management tool and that increased harvesting poses a risk to a number of forest values, including biodiversity, recreation, water quality and wildlife habitat. Robinson (personal communication, March 26, 2011) argued that sustainability is possible only through proper planning and tenure policies that encourage growth. This includes local access to resources as well as locally produced power, low-cost infrastructure and facilities that can be converted cheaply to new uses.

Many interviewees identified that the old growth forest and lands designated as wilderness, such as Quetico Park, are unsound for biomass harvesting; they feel these lands should be excluded from the practice. In addition, interviewees also mentioned that biomass harvesting should not be allowed in wetlands, national parks, roadless areas, and forests containing endangered species in this category. In fact, their feelings were strong as they expressed that the suitability of biomass harvesting would be determined on a case-by-case land use basis. Domac and Segan (2005) also suggested the same. The use of forest biomass should not reduce the ability of forested landscapes to sequester carbon nor should it cause carbon losses from standing trees or forest soils. Though woody biomass provides a renewable substitute for fossil fuels, the carbon emissions resulting from the uses of heavy equipment and petroleum fuels should be considered. Biomass must be produced through a network of low or no carbon impact systems (van den Broek 2000; Domac *et al.* 2004; Finkral and Evans 2007; Morris 2008; MTC 2009).

To assess forest sustainability, market-based voluntary forest certification systems are the most accepted and practiced approaches in Canada. They include the Forest Stewardship Council system (FSC) (FSC 2006, 2012), the Sustainable Forestry Initiative (SFI) and the Canadian Standards Association (CSA) Sustainable Forest Management Standard. FSC standards are based on 10 principles associated with social, economic and ecological factors, which are considered for the assessment of sustainable forest management (FSC 2006, 2012). In Canada, the Sustainable Forestry Initiative (SFI) is the largest certification system, with an area comprised of 57.6 million ha as compared to the FSC system, which covers 54.1 million ha. Two-thirds of the forests of the world (253 million ha) are certified (PEFC 2013).

While sustainable forest management (SFM) certification is one mechanism for applying and monitoring standards to forest management systems to ensure ecological sustainability (Lattimore *et al.* 2009; 2013), other approaches have been suggested. Lattimore *et al.* (2009; 2013) proposed a set of principles, criteria, indicators and verifiers of sustainable forest management by first considering the issues related to producing and harvesting forest bioenergy feedstock and reviewing current internationally recognized certification frameworks and scientific literature. The authors suggested that these principles, criteria, indicators and verifiers are adaptable to local conditions and can be incorporated into existing sustainable forest management and green energy certification schemes to ensure the sustainability of wood fuel production systems. These proposed standards could be considered for sustainable woody biomass-based bioenergy development at APGS. McDonald and Lane (2004), Lattimore *et al.* (2009; 2013) reviewed the main environmental risks to forest ecosystems that can arise from household-to-industry wood fuel production systems, including forest soil quality and site productivity, water resources, biodiversity, and carbon budgets. The principles of FSC, SFI and CSA should be considered for sustainable woody biomass-based bioenergy development at APGS.

5.3.3 Social Issues

Although forest enterprises and rural communities of Northwestern Ontario can benefit economically from the utilization of woody biomass for bioenergy production, the social ramifications of development are well-known when public forests are involved (Becker *et al.* 2009; Schindler 2007). Social buy-in is also important when there are competing interests, as seen in the Brazilian clash between industry and conservationists over the scale of bioenergy projects (Ceccon and Miramontes 2008) or the Australian conflicts between industry and conservationists over bioenergy projects that use native forests (Raison 2006). The importance of social acceptability takes on a new context when public forests are involved. Woody biomass utilization is socially accepted in Northwestern Ontario, but social acceptability is not the only issue, and although projects are more likely to succeed with social acceptability, that alone will not lead to success. There are still a number of technical barriers to biomass utilization that must be addressed, such as the cost of production.

During the recent past, Northwestern Ontario's forest enterprises have faced declining pulpwood markets that use small diameter and low value trees. As a result of this declining market, forest harvesting is often delayed. In addition, about 2.1 million gt of logging residues are available annually across Northwestern Ontario for bioenergy production (Alam *et al.* 2012). Using these materials as feedstock for bioenergy production creates additional markets and provides additional income to forest enterprises. For communities that depend on timber, market changes can have dramatic impacts on employment stability and viability. Many of these rural communities need additional markets to trade timber products. Utilizing logging residues, building processing facilities and marketing the products created can bolster economic conditions in the rural communities of Northwestern Ontario (OMNR 2013).

According to the research findings, job creation was found to be the prime social issue for the majority of the interviewees that would lead them to support using woody biomass for energy generation in Atikokan. At the APGS, woody biomass-based energy development can become an important source of forest-based income and a significant driver for enterprises that specialize in woody biomass-based energy feedstock processing. In addition, plantation establishment, harvesting and transport will create new workplaces. As a local Community Economic Development Adviser observed:

> The community is becoming prosperous at present. The community normally relies on industry, trade, international market, etc. In Atikokan it is also happening. Community change/attitude is relative to the expectation of different types of people. Most of the people are familiar with the APGS's announcement of biomass utilization for energy. Biomass is a positive driver as a part of the energy solution. …… There

> is a way for employment, but from the environmental point of view, we should be careful. Economic benefits and environmental impacts should be taken into consideration. The long-term impact of biomass is a concerning issue. We need to try and see how it works. At this point there is nothing to lose. After 30-40 years what will happen? We need to think/consider, and make a right plan. Many people have many political views. Overcoming the political mindset is important.

Local sources of energy increase economic efficiency of resources management on a regional scale and stimulate local entrepreneurship, especially within small and medium companies, and help to prevent unemployment (Domac *et al.* 2005). For local governments, the APGS bioenergy development means extra revenue from taxes. In the USA and other parts of the world a number of studies have examined the regional economic impacts of using biomass energy. For example, in east Texas, a study by Smith and Gan (2005) shows that the development of a bioenergy industry created 1,338 jobs. An economic analysis from Georgia demonstrated that a biorefinery using 440 tonnes of biomass daily would generate 95 jobs and state tax revenue of US$991,000 per year. Direct and indirect impacts from the goods and services produced at the plant would be about US$33 million (Gan and Smith 2007).

Public trust is also considered an important issue for both the development of woody biomass-based energy at Atikokan and in the public lands debate. All participants of the educational institutions and First Nation non-government organization groups along with the majority of participants in the local community organizations and small forest industry groups mentioned lack of trust between parties as a barrier to biomass utilization. Some small forest industry group interviewees indicated that the lack of enthusiasm from federal and provincial forest field personnel is a barrier to the development of the bioenergy projects. Interviewees attributed some of this unwillingness to the deep-rooted management culture of government forestry personnel that emphasizes a conservative management approach which focuses mainly on timber production. Interviewees suggested that field personnel fear too much personal risk to carry out public-private partnerships because of the present government's top-down working procedures. In Northwestern Ontario, most of the forests are on Crown land and the OMNR is responsible for the allocation of wood for biofuel production. According to a logger of the small forest industry group, the allocation of wood for biofuel production is a long bureaucratic process. One such entrepreneur stated:

> We have been sitting here for two years now waiting for authorization to proceed. The heat and taxes on the building [are] killing us because we have no income. The Ministry, still to this day, cannot tell us when a time-frame might happen as to when we are going to receive even a yes or no. I can't explain in words how perturbed we are.

Public trust is integral to the success of public-private partnerships, as well as biomass harvesting on public lands (Raison 2006). One interviewee in the First Nation non-government organization group suggested that public lands should be managed in a way that is not directly influenced by human activities. The majority of the persons in this particular interviewee group thought that habitat, biodiversity, old growth preservation, wilderness protection, water resources and recreation were the most appropriate uses of public lands, whereas commercial logging, road building, mining, grazing, and other economic uses were the least appropriate for public lands. In contrast, most personnel in the MNR and small forest industry groups felt that public lands should be managed for a multitude of social, economic and ecological objectives, including the production of wood products, recreation and wildlife management. A First Nation individual suggested that forest land use policy should be changed and new policy should be made that considers Treaty 3. Grand Council Treaty #3 is the traditional government of the Anishinaabe Nation and represents 26 member First Nation communities in Northwestern Ontario. The Ministry of Northern Development and Mines, the Ministry of Natural Resources and Grand Council Treaty #3 signed a letter of commitment on October 25, 2012, to help find practical approaches to economic development and the management of natural resources. Grand Council Treaty #3 and the province meet annually in Treaty #3 territory to continue discussions and review progress (Hicks 2012; National Talk 2012).

Through collaborative efforts, trust can be improved among government, small forest industry, APGS personnel, MNR personnel, First Nation communities and other stakeholders. Collaborations can be very useful in breaking down barriers between different view and value systems (Moote and Becker 2003; Moote and Lowe 2007; Itaoka *et al.* 2009). According to the interviewed individuals, good communication and transparency are the main components of a successful collaboration process. Collaborative projects on bioenergy will give an opportunity to grow sustainable bioenergy projects that will be socially acceptable, economically viable and environmentally sound.

Nearly half of the interview participants, including all of the participants in the First Nation non-government organization and the majority of participants in the local community organization and elected leaders groups, suggested taking a joint approach to overcome barriers. By "joint approach," most participants were referring to a process by which community members would work together toward a common goal. A second suggestion to improve social acceptability was to develop a small pilot project. The participant who mentioned a pilot project thought that the debate over forest biomass utilization would be more productive if everyone could see the action on the ground and what the effects are.

Just over a third of participants, including all interviewees within the First Nation non-government organization group and a majority within the local community organization group, mentioned that using sound science in the planning and implementation of woody biomass projects would build social acceptability. This refers to scientific management of the forest from harvesting to regrowth. Although there is extensive and in-depth scientific knowledge on forest management and ecology, participants pointed out that the scientific and practical knowledge about using woody biomass for energy is poor. The same problem was described by Hacker (2005). Furthermore, there are few studies on how removal of small diameter or unmerchantable trees could impact wildlife habitat, soil structure or nutrient cycling in Northwestern Ontario. In addition, some research participants within the small forest industry group questioned the provincial government's ability to offer or follow through on long-term supply contracts.

Finally, the Ministry of Energy investigated the conversion of coal-based electricity to woody biomass-based electricity at the APGS and found the project was technically feasible. This research offers one of the first looks at the social, economic and environmental acceptability as perceived by individuals and groups on converting woody biomass to energy at the APGS. Though there are some areas of conflict, local support for the APGS conversion does exist. Most of the interviewees supported the idea of woody biomass utilization at the APGS because they recognized it will bring socio-economic benefits to their community.

5.4 OVERALL DISCUSSION

By analyzing research findings obtained in interviews, surveys and focus group discussions, it was observed that participants support the utilization of woody biomass at the APGS for bioenergy. While groups identified similar factors, the importance placed on each factor differed. Participants identified a number of factors for their positive support of woody biomass-based bioenergy at APGS, but out of the responses, all categories of participants observed that creating employment is a primary strength of the APGS project. Furthermore, participants from professional groups surveyed in Thunder Bay identified the importance of economic and environmental spinoffs from the APGS bioenergy plant, including the potential contribution to local resource-based renewable bioenergy, CO_2 emissions reduction, environmental appropriateness and ease of plant conversion. All groups also expressed hope that the deployment of wood pellets and bioenergy will improve industrial competitiveness, regional development and promote a strong export industry in the community. This information aligns with what Faaij *et al.* (1998) found when they examined the externalities of biomass-based electricity production in the Netherlands. Faaij *et al*. (1998) found that the most important factors between biomass and coal in electricity production were their impacts on gross domestic product (GDP) and CO_2 emissions. Furthermore, McCallum (2001), Remedio (2003), Domic *et al.* (2004, 2005), Reynolds *et al.* (2008) and Dwivedi and Alavalapati (2009) suggested that creation of jobs and income are the most significant socio-economic benefits of woody biomass-based bioenergy. Faaij *et al.* (1998) also reported that in woody biomass-based electricity production, the use of locally produced feedstock has a greater impact on local income and job creation than power generation using coal. These positive socio-economic impacts are also supported by the research participants' views about the benefits that the development of woody biomass-based energy in APGS will bring to Atikokan and the surrounding communities.

Among the opportunities of the bioenergy project at the APGS, biomass as a source of renewable energy was the second factor identified by the highest number of the research participants selected from surveys in Atikokan area, and in surveys at the Grassroots Approach Conference in Thunder Bay. Since nothing offsets the CO_2 that fossil fuel burning produces, replacing fossil fuels with woody-biomass at APGS supposedly results in reduced carbon emissions (Cho 2011), thus helping to reduce global warming. Ediger and Kentel (1999), Ushiyma (1999), Nagel (2000), Pari (2001), Berndes *et al.* (2003), Gan and Smith (2006b), and Smith and Web (2013) also reported that woody biomass has the best potential to be converted into renewable bioenergy since it has the advantage of reducing greenhouse gas (GHG) emissions while being a sustainable energy source. Hall (1997), IEA Bioenergy (2005), DeYoe (2007) and Stupak *et al.* (2007) reported that unlike fossil fuels, biomass can be replaced within a harvest cycle.

Responses were influenced by participants' connection to their geographical location. Focus group respondents in Atikokan emphasized local issues and development in contrast to the Thunder Bay professional group who identified more national and regional issues connected to woody biomass-based energy development. Thunder Bay professionals identified development of infrastructure in rural areas as the second main strength whereas participants from Atikokan and its surrounding communities recognized job opportunities as the second most important. Where Thunder Bay respondents chose the promotion of energy security as the third main strength, the Atikokan group ranked profit from waste as the third strength for woody biomass-based bioenergy development.

The senior focus group emphasized local issues and local development. Strengths the group identified include local tax generation, partnership with First Nations and new biomass business development. As well, the senior group was concerned about the complexity of using biomass in a sustainable way, the CO_2 emissions from pellet-based electricity, and resource depletion. According to the senior respondents, destruction of the ecosystem and threats to wildlife are the main local threats. Similarly, First Nations group responses indicated preference for local issues, identifying that the renewability of biomass is an opportunity and that employment is the project's best strength. However, like the seniors' group, First Nations respondents were concerned about possible adverse effects on their local environment, especially overharvesting of the resource resulting in loss of habitat. Their concerns reflect what Domac *et al.* (2005) reported: that adoption of the new technology is a challenge to institutional conventions and traditional First Nations practices. Another group of participants, the young people's group, was in agreement about the employment advantages of the project, but respondents were concerned that environmental degradation would threaten the local ecosystem. Departing from responses obtained in the seniors' and First Nations groups, the young people's group was outward looking, interested in developing international consequences to encourage countries to stop burning coal.

By investigating a number socio-economic factors that are commonly recognized as key points in socio-economic impact assessment studies, the survey provides interesting insights regarding two groups of participants: those who are willing and those who are unwilling to be involved in woody biomass-based activities at APGS. The results point to significant differences between the two groups with respect to their education levels, gender and attitude toward environmental issues even though other differences between the two groups were insignificant (with respect to ethnicity, age, income, occupation, length of residence, monthly household expenditure of energy, organizational membership, business owners, access to credit, concern about cutting unmerchantable trees for energy, and concern about harvesting forest residues for bioenergy production). The similarities that influence decisions about becoming involved in the APGS project may result from the fact that the survey participants are from the same small geographical area and so share characteristics that influence their decisions. For instance, Atikokan area respondents identified the high cost of starting the project-related activities was the most important barrier to their being involved in woody biomass based activities at APGS. Moreover, they reported that the present subsidy awarded for starting a biomass-based business is not sufficient as the initial establishment and installation costs of wood pellets are very high, and that people's willingness to be involved in woody biomass-based activities would increase if the existing government subsidy would also increase. A number of research interviewees and the Atikokan area survey participants also identified a lack of information about woody biomass-based (wood pellets) energy development in the study areas as a barrier to their becoming involved in biomass-based activities at APGS in the future.

A number of social, organizational and infrastructure impediments to widespread adoption of bioenergy production from woody biomass exist. In fact, Rosch and Kaltschmitt (1999) identified five categories of challenges to bioenergy production: lack of knowledge; funding, financing, and insuring; administrative conditions; organizational difficulties; and perception and acceptance. All of these issues were described as barriers by the many research interviewees of this study. Interviewees mentioned specifically that the existing local administrative conditions of OMNR, Ministry of Energy and OPG were typically developed without attention to creating a sustainable woody biomass-based bioenergy production. This lack of focus can make the APGS's ongoing process confusing, accompanied by uncertainties about the requirements for issues related to bioenergy production (e.g., ash disposal). The impacts of legislative and administrative rules on feedstock supply are difficult to predict because many of the rules have only been proposed at this time, and the definitions of qualifying material of Ontario Forest Management Directives and Procedures (OMNR 2013) for forest biofibre on allocation and use are unclear.

Although not a focus of legislative and administrative representatives in the Atikokan area, the literature supports the identified silvicultural benefits associated with producing biomass from conventional forests. Manley and Richardson (1995) describe the increased opportunities for thinning, intermediate cuttings, and stand and site rehabilitation. Research interviewees in this study mentioned that a number of challenges exist with the use of small-diameter trees from forests for bioenergy production, information that is supported in the literature (Hjerpe *et al.* 2009). First, infrastructure may be limited for harvesting, transporting, and processing small-diameter material that has resulted from the partial dismantling of the harvesting infrastructure following reductions in timber harvest from Crown lands. Furthermore, the remaining infrastructure capacity may not be well suited to handling small-diameter material efficiently. Second, the supply of wood in the Atikokan area may vary, depending on harvesting policies and regulations, particularly on Crown land, where different companies are given permission to cut small diameter trees for uses other than woody biomass feedstock for APGS, for example, aspen for furniture production. Finally, some research interviewees have concerns about thinning activities due to the possibility of damaging or harvesting trees that are planned to make up the future forest composition.

Significant challenges to identify the public perceptions of biomass use have been confirmed through this study and in the literature. As identified by Rosch and Kaltschmitt (1999), this study found that while there is general approval for renewable energy production, there is also uncertainty about generating energy from woody biomass. Interviewees also confirmed what Rosch and Kaltschmitt identified as a significant barrier, which is a lack of quality information related to woody biomass-based energy. Monroe and Oxarart (2009), and Puddister *et al.* (2011) also reported the similar findings. In this dissertation nine categories of research interviewees identified nine common themes (little government support, biodiversity, high production cost, long term supply availability, sustainability of resource, lack of policy, lack of marketing, social factors and other factors) related to social, economic and environmental barriers of APGS woody biomass-based energy development. It is important to mention that each category of interviewees also identified specific actions for their respective comments. These common themes are: research, market development, supply availability, social acceptability, education and training, policy requirements, trust development, joint management, cost minimization, environmental aspects and job creation. These themes have the potential to make significant impacts on woody biomass-based energy production at APGS.

In the Atikokan area survey, focus group discussions and in interviews (mainly MNR personnel and small forest industry), many of the research participants saw biomass markets as opportunities to utilize wood that is unused due to the poor current markets. Some identified the markets as ways to offset the high costs of forest and park management. Others saw biomass from Crown forests becoming an important revenue stream for government although the high costs associated with the harvest, collection and transport of woody biomass often make bioenergy unprofitable. Faaij *et al.* (1998) also reported that in woody biomass-based electricity production, the initial investment cost is relatively high in comparison with power generation using coal. Gan and Smith (2007), and Kumar *et al.* (2003) also reported that electricity from forest biomass is generally not cost competitive with fossil fuels under current technology and market conditions in the United States.

Some research interviewees and focus group participants are concerned that high demand from a growing bioenergy sector could increase feedstock costs for existing wood-based industries, and that an additional fiber demand could result in unsustainable levels of harvesting. This is especially possible where two or more wood-using enterprises are operating in the same Crown forest land. During focus group discussions, members of the professional group in Atikokan reported these concerns. Members of the MNR personnel and some members from the small forest industry group also stressed ensuring an appropriate scale for biomass harvesting, suggesting that an economically viable scale is needed that does not compromise other management objectives.

To assure the sustainability of the biomass supply, a majority of research interviewees in the MNR, small forest industry and APGS personnel suggested that long term contracts are required to ensure supply. Interviewees in these groups thought that some form of subsidy would be necessary to make biomass utilization projects viable. In Ontario, the current Feed-in Tariff for biomass produced electricity is $0.138/kWh, as the production of wood bioenergy is more expensive than fossil fuel (coal) based energy. However, when the environmental and social benefits of wood bioenergy are accounted for, utilization of woody biomass for bioenergy production becomes environmentally, economically and socially justifiable (Stone *et al.* 2002; Dwivedi and Alavalapati 2009; Hackett 2009).

The majority of interviewees identified that sustainability and environmental issues were the second most important concerns. Positive impacts that bioenergy is thought to provide include a decrease in greenhouse gas emissions and an increase in biodiversity of new tree species. However, research interviewees and focus group discussion participants also emphasized that the use of forest biomass should not negatively impact forest soils, biodiversity, ecosystem integrity or water resources. In Sweden, local environmental benefits that have occurred from bioenergy projects include a reduction of soil acidification, improved nitrogen balance and reduction of nutrient leaching by recirculation wood ash (Borjesson 2000). Research interviewees pointed out that forest biomass harvesting should be developed as a positive tool for achieving improved forest structure or ecological functions. Only a few individuals from the focus groups and interviews felt that biomass harvesting is not an effective management tool because increased harvesting could make forest values such as biodiversity, recreation, water quality and wildlife habitat vulnerable. They also indicated that although woody biomass provides a renewable substitute for fossil fuels, the carbon emissions resulting from the use of heavy equipment are one environmental factor that works against the reputation of carbon neutrality. It is therefore important, as Domac *et al.* (2004), Finkral and Evans (2007), UN-Energy (2007) and Morris (2008) have explained that wood pellets produced for bioenergy must adhere to a network of low or no carbon impact systems. They suggest that forests for bioenergy should be in proximity to the production facilities.

Rural communities of Northwestern Ontario can benefit economically from the utilization of woody biomass for bioenergy production. But studies done in the United States by Schindler (2007) and Becker *et al.* (2009) showed that the social corollaries are well-known when public forests are involved for bioenergy development. In Australia (Raison 2006) and Brazil (Ceccon and Miramontes 2008), industry clashes with indigenous peoples and conservationists over the scale of bioenergy projects show the importance of social buy-in when there are competing interests over bioenergy projects that use native forests. Social acceptability is one factor that will lead to success of a project. According to the research findings, APGS's woody biomass energy is socially accepted; however, as Hall 1991, Perlack *et al.* 2005, OPG 2011 suggested, groups commented that technical barriers to biomass supply and the cost of production must be addressed to assure success for the APGS bioenergy project.

As a result of declining forestry markets, Northwestern Ontario's woody feedstock is in good supply for APGS. Unused wood as feedstock supply for bioenergy production creates additional markets and provides additional income to forest enterprises. A rural community like Atikokan requires additional markets for its timber products, so using logging residues, building processing facilities and marketing manufactured products can bolster economic conditions (OMNR 2013). Since job creation is a primary concern for people of the region, the APGS biomass-based energy development project will become a significant driver for enterprises that specialize in wood pellet processing. A local source of energy increases economic efficiency of resources management on a regional scale and stimulates local entrepreneurship, especially within small and medium forest based companies. Industry spin-offs such as plantations, harvesting and transport will reinvigorate and increase traditional forestry jobs. All these developments originating from bioenergy means extra revenue from taxes, which allows for a broader municipal tax base to fund other local initiatives.

Like social acceptability, public trust is important to the development of woody biomass-based energy both for Atikokan and in the public lands debate. All interviewees from educational institutions and First Nation organization groups, and the majority of those from local community organizations pointed out lack of trust as a barrier in the APGS project. As the APGS conversion coal to biomass depends on Ontario's political decisions and policies, the interviewees are unsure of the project's long lasting stability. Most of the forests are on Crown land where the OMNR is responsible for the allocation of wood for biofuel production. According to interviewees from the small forest industry group, the allocation of wood for biofuel production is a long bureaucratic process. Some of this may be alleviated as, during the writing of this thesis, the OMNR settled some of the forest allocations that are to be used for pellet production to supply APGS. First Nation non-government organization interviewees think that any use of public land should protect habitat, resources and the environment rather than for commercial uses. Stakeholders in the MNR personnel and small forest industry groups agreed that public lands should be managed for a multitude of social, economic and ecological objectives.

By examining all research findings of this study along with the literature, it appears that using woody biomass (wood pellets) to create bioenergy in the APGS is a viable option for increasing value to unmerchantable small diameter trees, providing a renewable energy source and giving needed economic development opportunities for the Atikokan area. The woody biomass-based energy of APGS has strong support from government, local institutions and local people. Interviewees from elected leaders and personnel from the MNR, APGS and small forest industries agree that woody biomass-based energy at APGS has the potential to alleviate local problems of the Atikokan area. Bradley (2006) and Borsboom *et al.* (2006) also reported that replacing fossil fuels with bioenergy provides an excellent opportunity to increase rural economic activities. Reynolds *et al.* (2008) reported that as a result of mill closures and production reductions, abundant unutilized forest resources exist in Northwestern Ontario, which leave them vulnerable to pest attack and wildfire. Harvesting this supply of biomass while it is still usable will benefit the Atikokan community and its Crown forest land.

Interviewees in these groups also advised that using sound science would build social acceptability of the woody biomass project from forest harvesting to regrowth.

According to Sundstrom *et al.* (2012), woody biomass utilization trends, barriers and strategies vary considerably from region to region. This variation is likely a reflection of local contextual differences in forest products and energy sectors, land tenure, historic context, and social concerns. Regional differences in both barriers and solutions suggest that successful woody biomass use efforts will need to be aware of and able to adapt to local and regional circumstances. The variation also suggests that relevant national policies, such as the definition of woody biomass allowed under a renewable energy standard, need to be flexible enough to be adapted to local conditions. Ultimately, fostering appropriate use of woody biomass requires a number of strategies rather than a single approach to meet the diverse challenges and needs across the country.

However, a number of research interviewees agree that there is a lack of cohesion and collaboration among different level of governments (federal, provincial and First Nations) and woody biomass stakeholders (small industry contractors, workers, and developers). Personnel from all the responding groups (small forest industry, MNR personnel, APGS personnel, education and social services, along with First Nation individuals, First Nation Non-Government Organizations, local community organizations and elected leaders) should collaborate to support research, policy issues and educational programs that enhance the efficiency of current forest biomass operations and promote the use of woody biomass for bioenergy. Cooperation as a tool to overcome barriers was mentioned by nearly half of all interviewees, including all of those in the First Nation non-government organization, and the majority of interviewees in local community organizations and elected leaders groups. Collaborative action by these individuals would be an important step in ensuring the proper development of the woody biomass-based bioenergy at APGS.

This research discovered that respondents' views about biomass utilization for energy mainly focused on forest-related issues rather than on energy, and in Atikokan, public opinion was directly linked to the bioenergy sector providing job creation and community well-being. Given this, it will be important first to inform the communities about bioenergy, and next develop policies and initiatives from a community development perspective.

This research offers one of the first looks at the perspectives of different individuals and groups on converting woody biomass to energy at APGS. Findings indicate that the people of Atikokan are open about their support for the APGS project because of the perceived socio-economic benefits to their community. Though some research interviewees from the surrounding First Nation communities gave general comments, but a number of them were hesitant to voice their opinions on the APGS project development, saying they were not familiar enough with it specifically. It is important to make First Nations people aware of bioenergy benefits and the opportunities the project can provide to their communities.

This study explores the major socio-economic characteristics that influenced people who decided to join in woody biomass-based activities at APGS in the future. It evaluates the probable impacts of APGS' woody biomass-based bioenergy systems on the community. Furthermore, the suggestions and recommendations provided by the research participants of different categories should be incorporated into the present biofuel policies and literature that have been mentioned in this dissertation for developing a management plan for woody biomass-based bioenergy, which would lead to better management of the APGS bioenergy project.

CHAPTER 6

CONCLUSION

6.1 CONCLUSION AND POLICY DIRECTION

The Ontario provincial government has invested in a number of programs to achieve energy self-sufficiency, combat climate change, and promote development of renewable energy from low-carbon woody feedstock. At the APGS, the Ministry of Energy has been investigating the conversion of coal-based electricity to woody biomass-based electricity. This research offers one of the first looks at the perspectives of different individuals and groups on converting wood biomass to energy at APGS.

Given Ontario's huge and sustainably managed forest resource, forest biomass is expected to be a major component of renewable energy production in Ontario. The move towards renewable energy production that will replace fossil fuels with forest-based biomass will have considerable socio-economic implications for local and First Nation communities living in and around the bioenergy power generating station. However, the views and concerns of the local communities dependent on the forest resources have generally been overlooked during the decision-making process about the conversion. A number of studies have been done to evaluate the technological feasibility of forest biomass energy, but none of them have focused on social aspects, which is an important factor in projects involving public forests. This research explores the local public attitudes and opinions about woody biomass utilization for energy development at the APGS, and explores the major socio-economic characteristics that influence people's decisions to join in the project's woody biomass-based activities. The study's objectives are three-fold: to assess the project's socio-economic impacts on the Atikokan community; to identify what influences people to get involved in the project; and to explore public perspectives about the project. As well as cataloguing local responses, this research presents the probable impacts of APGS' woody biomass-based bioenergy systems on the community. By using formal and informal interviews, surveys, and focus group discussions, this study communicated with the general population, people working in bioenergy development, community organizations and local industry to identify the factors that could help to design a holistic management plan for the APGS bioenergy project.

The social effects of developing woody pellets and their utilization in APGS' electricity generation benefit Atikokan and its surrounding small forest-based rural communities in direct and indirect ways. The best technology does no good unless people use it. Therefore, the future of Atikokan and other Northwestern Ontario biofuel/bioenergy initiatives depends not only on the development of effective and efficient technologies but also on the social, economic, and political climate within which people decide to develop, use or avoid these new fuel sources and technologies (Evans and Durant 1995). On a social-psychological level, individual behaviours are often guided by people's attitudes toward the behaviour or objects involved and by the norms established by others within a social setting (Wegener and Kelly 2008). Therefore, an understanding about how public attitudes and beliefs are formed or changed and, in particular, how the public perceives the Atikokan woody biomass-based power plant and the development of wood-based pellet operations to supply the power plant is important to determine the community's social acceptance of the project.

The arrival of a new technology such as woody biomass-based bioenergy at APGS signals the beginning of a period of change, conflict and uncertainty. It is also the beginning of a process where individuals and society struggle to understand the new technology and cope with the implications of the accompanying changes. The outcome of that effort determines the degree of society's acceptance of the technology (Wartburg and Liew 1999). The degree to which society accepts a new technology depends on two types of factors: rational and emotional (Evans and Durant 1995). Rational factors include the degree of public understanding, the amount of social control over the technology, the decision-making process behind it, and the conviction that the technology will be of practical use to society and individuals (Evans and Durant 1995). Emotional factors are responses to the uncertainty that the technology will bring and that both individuals and society must deal with (Evans and Durant 1995; Wartburg and Liew 1999; Wegener and Kelly 2008). Emotional factors in this context include lack of knowledge, level of anxiety and degree of distaste to a risk, all of which were mentioned by research participants of this study. The synthesis of rational and emotional factors results in society's acceptance of a new technology, but that acceptance also requires another element—trust (Chiao *et al.* 2009). Trust depends on the perceptions of the public and the institutions involved with the technology; building trust requires the elements of openness and willingness to share knowledge and experience (Evans and Durant 1995; Wegener and Kelly 2008; Chiao *et al.* 2009). According to research participants, a strong relationship between the public, industry and government representatives will promote a better understanding, develop trust in the new woody biomass-based bioenergy technology at APGS, and increase local support.

Control of the technology falls into two categories: technical control, which focuses on risk prevention and damage control, and social control, which uses legislative measures and public decision-making processes to control the non-technical aspects of a technology. New technology, e.g., woody biomass-based bioenergy, sometimes causes anxiety because it is a change and because people lack experience with it (Evans and Durant 1995). Most will probably accept the risk of doing something if the risk of not doing it is greater. The challenge of a new technology is not in controlling the technical risks, but in dealing with the changes and impacts of the changes that the technology introduces into people's lives (Evans and Durant 1995; Wartburg and Liew 1999). Individual well-being is an important factor of woody biomass-based bioenergy technology development at APGS. According to Faaij (2006), local socio-economic impacts are diverse and will differ accordingly by factors such as the nature of the technology used, local economic structures, social profiles and the production processes of bioenergy. These impacts are also mirrored in the research findings of this dissertation.

In addition to technology, the primary external factors affecting industries include demographics, government, and social changes. Demographic shifts are often considered relevant to long-term trends. For instance, the large surge in population due to the baby boom has led to industry success depending on the boomers' life stage (Domac *et al.* 2004). Government plays a large role in industry, especially through regulations, and laws can change over time, altering the competitive dynamics. Social changes are the result of attitudinal shifts among the population (Wegener and Kelly 2008). Social features are well-known factors when public forests are involved, such as in the United

States (Becker *et al.* 2009; Schindler 2007). This research shows that APGS will receive a major portion or all of its woody biomass supply (for wood pellet and electricity production) from Crown forests. These forest harvesting areas are covered by environmental laws that permit citizen appeals and litigation, which will lead to public discussions. Ensuring public involvement takes time, effort and trust. In particular, regions with high levels of doubt between parties (e.g., First Nation communities and the provincial government) must build trust before any collective effort is likely to be successful. Though there are some areas of conflict, most of the interviewees and survey respondents supported the idea of biomass utilization at the APGS because they recognized the project will benefit their community economically. Given that the knowledge of First Nation individuals in the study area about the utilization of woody biomass-based bioenergy at APGS is reported as inadequate, it is important to make First Nation people aware of bioenergy benefits and the opportunities the project can provide to their communities.

In addition, according to the interviewees, the most important barrier to biomass utilization is the cost of harvest and transport of materials. Aguilar and Garrett (2009), Becker *et al.* (2009) and Guo *et al.* (2007) also reported similar findings. Respondents indicated that government support to facilitate finances should be offered so that biomass entrepreneurs can recover their investments and biomass business start-up costs. Finally, the decision-making and planning processes of any biomass-based projects for energy in this region must be transparent, and the local natural resources management organizations should be involved in this process from the initial stage.

The connection of the APGS woody biomass-based project and rural community development provides opportunities and challenges for Atikokan's economic development. As demand for forest harvesting increases for developing wood pellet and bioenergy, special attention is needed to ensure and maintain the social, economic and environmental sustainability of biomass use at APGS. In this research, respondents' views about biomass utilization for energy focused mainly on forest-related issues rather than energy. Research findings in the Atikokan area indicated that respondents' opinions were directly linked to job creation resulting from APGS woody biomass-based energy production. Given this, it will be important to develop policies and projects that enhance and protect the resource. Policies that promote community projects, public-industry-community partnerships and joint collaboration (government, industry, First Nations and other stakeholders) will be necessary to achieve social acceptance for the APGS plant. Furthermore, building public trust and developing the APGS bioenergy project will be beneficial to Northwestern Ontario's forests, climate, communities and economy.

The Atikokan area survey model provides interesting insights regarding two groups of participants: those who are willing and those who are unwilling to be involved in woody biomass-based activities at APGS. Although the two groups are significantly different with respect to their education levels, gender and attitude toward environmental issues, other factors such as age, ethnicity and occupation are not significant in members' decisions to be involved in woody biomass-based activities at APGS. The similarities that influence decisions about becoming involved in the APGS project may result from the fact that survey participants are from the same small geographical area and so share characteristics that influence their decisions.

This study observed that a little more than half of the people (52%) surveyed are interested in becoming involved in woody biomass-based activities at APGS in future. The research also indicated that most respondents are not concerned about harvesting unmerchantable trees and utilizing forest harvest residue for bioenergy production at APGS. A number of local situations may influence the research respondents' (equally respondents from surveys, focus group discussions and interviews) selection that employment is the number one strength of this project. Atikokan is suffering from the closure of its main forest industries, and this reality might have influenced respondents' perceptions. Normally, the quantity and quality of employment in the woody biomass-based bioenergy sector mainly depends on the overall bioenergy system cycle, i.e., production, conversion and end use (Dwivedi and Alavalapati 2009). It is a labour-intensive process. At the APGS, pellet-based bioenergy is being promoted due to its potential contribution to energy security, environmental appropriateness and ease of plant conversion. It is hoped that deployment of bioenergy has the potential for job creation in the community, improved industrial competitiveness, regional development and the development of a strong pellet export industry.

In addition to economic development, community self-reliance, provincial energy self-sufficiency and job creation, woody biomass utilization for energy could also help in responding to ecological challenges including climate change, insect and disease threats, storm events, natural disasters and wildfire concerns. The advantages of bioenergy as outlined by respondents indicate the potential for the development of higher valued products. There are a number challenges to achieve these opportunities, however. Biomass harvesting and residue removal of wood-based energy raise social concerns about esthetics and potential conflicts with other perceived forest values and benefits, such as Atikokan's reputation for outdoor recreation and tourism. For this reason, it is important to develop a holistic management plan for APGS's wood-based bioenergy. Careful monitoring and precautionary guidelines, as well other policy and planning actions, are needed to ensure that wood-based pellet investments, including pellet-based bioenergy initiatives, do not negatively impact biodiversity, soil productivity and ecosystem health in Atikokan and its surrounding forest communities.

Sustainability and environmental issues were found to be important concerns for the majority of the research interviewees. Currently, market-based voluntary forest certification systems are the most accepted and practiced approaches to assessing forest sustainability. Other Sustainable Forest Management Standards are the Forest Stewardship Council system (FSC) (FSC 2006), the Sustainable Forestry Initiative (SFI) and the Canadian Standards Association (CSA). The principles of FSC, SFI and CSA would provide a solid foundation for the practice of sustainable woody biomass-based bioenergy development at APGS.

Lattimore *et al.* (2009; 2013) proposed a set of principles, criteria, indicators and verifiers of sustainable forest management by reviewing current internationally recognized certification frameworks and scientific literature that could be used for sustainable woody biomass-based bioenergy development at APGS. The Forest Guild (2009) (Evans 2008a; 2008b) compiled a collection of woody biomass removal case studies from throughout the United States. This report concluded that biomass harvesting guidelines should address six areas of potential biomass harvesting impacts, including: dead wood; wildlife and biodiversity; water quality and riparian zones; soil productivity; silviculture ; and disturbance. Reports assessing biomass harvesting guidelines for Maine, Minnesota, Missouri, Pennsylvania and Wisconsin have been released by Evans and Perschel (2009), Minnesota Forest Resources Council (MFRC)(2007a, 2007b, 2007c), Pennsylvania Department of Conservation and Natural Resources (2008), and Wisconsin Council on Forestry (2008). McDonald and Lane (2004), Lattimore *et al.* (2009; 2013) reviewed the main environmental risks to forest ecosystems that can arise from woody biomass-based bioenergy production systems, including forest soil quality and site productivity, water resources, biodiversity, and carbon budgets. Recommendations provided by the research respondents and in the Forest Guild report, along with other literature on biomass harvesting (e.g., Titus *et al.* 2013; Lattimore *et al.* 2013) should be used as a baseline for developing biomass harvesting guidelines for Ontario.

Bayless (2007) reported that the Province of Ontario does not actively incorporate an Ontario-based bioenergy strategy that would see the phasing in of woody biomass as a fuel in existing coal plants and the adding in of appropriate pollution control equipment. He suggested that Ontario Power Generation (OPG) requires a clear mandate to invest in the entire supply chain. To ensure appropriate policy development, more research is required on these issues.

6.2 SIGNIFICANCE OF THE RESEARCH AND LIMITATIONS

Northwestern Ontario, especially Atikokan, has been suffering from an aging population, unemployment, youth out-migration, mill closures and layoffs. Atikokan is representative of the overall unstable economic structure of rural Northwestern Ontario.

As a way to stabilize rural northern economies, woody biomass could be a major component of the renewable energy and fuels picture across Canada. The transition from fossil fuels to woody biomass alternatives for electricity generation at APGS will extend the life of the plant and save the jobs of its current employees. It is also hoped that adopting woody biomass-based energy will result in a number of permanent and seasonal jobs for people in Atikokan, and will alleviate the present unsteady economy of the community. At the same time, the unused unmerchantable trees and forest harvest residues of its surrounding forests will be used as a feedstock (pellets) for APGS. This will also improve the socio-economic status of Atikokan and its surrounding communities through job creation, small business development, and income improvement, all of which promote the well-being of the population and community's development.

As the aim of research is to assess the probable impacts of APGS' woody biomass-based bioenergy system on Atikokan and its surroundings, only the view, attitudes and opinions of local people were assessed. The local focus could be a limitation of this study since the attitudes and opinions of other groups such as governmental policy makers, private sector personnel, environmental non-government organizations outside the community are not included, although they may be involved in the decision making process for policy development of woody biomass-based bioenergy. At the APGS the success of the plant conversion has been tested and is expected to work, but there are no long-term data to confirm its ongoing success, making the socio-economic effects difficult to assess. Time and financial constraints to collect time sensitive data were also limitations since research was being done while the project was moving forward.

Biomass utilization for bioenergy development is a complex and challenging issue that requires the collaboration of many people from a variety of fields and perspectives to implement projects successfully (Richardson 2006; Buchholz *et al.* 2007). In most instances, the failure to listen to and address concerns expressed by the local people and stakeholders has resulted in the failure of bioenergy projects (Upreti and van der Horst 2004; Banerjee 2006). Local people and stakeholders' views and opinions obtained by this study can help the APGS bioenergy system to adapt to its new setting.

This research focused on respondents' feedback about biomass utilization for energy, especially as their viewpoints pertained to forest related issues. The people of Atikokan gave support to the APGS project because the community would benefit economically, and respondents saw economic improvement as a forerunner of community well-being. Policies that include a community development perspective should be created for the APGS bioenergy project. Although the scope of this study applies to the Northwestern Ontario region, the findings of the study may be applicable for other regions facing similar situations.

6.3 FUTURE RESEARCH DIRECTIONS

The results from this study are relevant to the theme of the socio-economic impacts of wood biomass utilization for energy production on small rural communities in Northwestern Ontario. However, to our knowledge no such study has been conducted in Ontario. Information provided by this research creates a base for discussions as woody biomass energy becomes an important issue in Ontario, Canada and other regions of the world. This research provides a look at a community's views, using methods that provide a breadth of information, but that is limited in scope. The findings can serve as a starting point for advanced discussion on biomass utilization in different arenas: within mutual groups involved in a specific project; among policy makers at the local, federal or provincial level; and with researchers interested in understanding public acceptance of biomass utilization in other regions of Canada and around the world. As the public's attention turns towards woody biomass bioenergy as a renewable energy source, this research provides knowledge about the Atikokan project and the community's response to it. Further research will be required to determine the reach of the public's perspectives and opinions on woody biomass utilization for bioenergy within the stakeholder groups, Aboriginal communities, the general public and across different regions.

REFERENCES

Abbas, D., D. Current, M. Phillips, R. Rossman, K.N. Brooks and H. Hoganson. 2011. Guidelines for harvesting forest biomass for energy: A synthesis of environmental considerations. Biomass and Bioenergy 35:4538-4546.

Abbasi, T. and S.A. Abbasi. 2010. Biomass energy and the environmental impacts associated with its production and utilization. Renewable and Sustainable Energy Reviews 14(3):919-937.

Aboriginal Justice Implementation Commission (AJIC). 2013. Aboriginal and Treaty Rights. Chapter 5: Aboriginal and Treaty Rights. In: The Justice System and Aboriginal People. The Aboriginal Justice Implementation Commission. http://www.ajic.mb.ca/volumel/chapter5.html#1. November 5, 2013.

Abraham, S. 2004. Climate: The Bush Administration's approach to climate change. Science 305(5684):616.

Abramson, J.J. and Z.H. Abramson. 1999. Survey Methods in Community Medicine: Epidemiological Research, Programme Evaluation, Clincal Trials. 5th edition, Churchill Livingstone, London.

Adams, T. 2007. Cleaning up Coal's Act. Presented in the Conference on the Future of Coal in Ontario: Towards a Clean, Secure and Competitive Energy Portfolio; Toronto, Ontario, May 10, 2007. 1-23 pp. http://www.queensu.ca/qieep/events/coal.html. June 27, 2011.

Agrawal R, N.R. Singh, F.H. Ribeiro and W.N. Delgass. 2007. Sustainable fuel for the transportation sector. Proc Natl Acad Sci USA 104(12):4828-4833.

Aguilar, F. and H.E. Garrett. 2009. Perspectives of woody biomass for energy: Survey of state foresters, state energy biomass contacts, and National Council of Forestry executives. Journal of Forestry 107(6):297-306.

Alam, M.B., R. Pulkki and C. Shahi. 2012. Woody biomass availability for bioenergy production using forest depletion spatial data in northwestern Ontario. Canadian Journal of Forest Research 42(3):506-516.

Alcantara, C. 2003. Individual property rights on Canadian Indian reserves: the historical emergence and jurisprudence of certificates of possession. The Canadian Journal of Native Studies XXIII 2:391-424.

American Renewables. 2013. Benefits of Biomass Energy. American Renewables, Gainesville, Florida, USA. http://www.amrenewables.com/biomass-energy/biomass-energy-benefits.php. July 1, 2013.

Andersson, G., A. Asikainen, R. Bjoerheden, P. Hall, J. Hudson, R. Jirjis, D. Mead, J. Nurmi and G. Weetman. 2006. Production of Forest Energy. Springer Netherlands 71:49-123.

Astley, W.G. 1985. The Two Ecologies: Population and Community Perspectives on Organizational Evolution. Administrative Science Quarterly 30(2):224-241.

Atikokan Info. 2013. 2012 Annual Report. Atikokan Economic Development Corporation. http://atikokaninfo.com/aedc/annualReports/acrobat/annualReport2012.pdf. June 15, 2013.

Australian Government. 2005. Socio-economic Impact Assessment Toolkit: A guide to assessing the socio-economic impacts of Marine Protected Areas in Australia. Australian Government Department of the Environment and Heritage. http://www.dcita.gov.au/cca. Sept. 15, 2010.

Banerjee, R. 2006. Comparison of options for distributed generation in India. Energy Policy 34(1):101-111.

Baten, C.S. 1998. Rehabilitation of the Denuded and Encroached Government Sal Forests of Bangladesh, Involving Encroachers and Local Poor People: A Socio-economic Study in Vannara. M.Sc. Thesis, Faculty of Forest, Geo and Hydro Sciences, University of Dresden, Germany. 98 pp.

Baten, C.S. 2005. Participatory Forestry in Bangladesh: Agroforestry Projects, Policy and Poverty Alleviation. M.Sc. Thesis, Faculty of Forestry, University of Toronto, Toronto, Canada. 224 pp.

Bauen, A. 2006. Future energy sources and systems – acting on climate change and energysecurity. Journal of Power Sources 157(2):893-901.

Baumann, P., M. Bruno, D. Cleary, O. Dubois and X. Flores. 2004. Applying people centered development approaches within FAO some practical lessons. LSP Working Paper 15, Food and Agricultural organization of the United Nations (FAO).

Bayless, D. 2007. Future of Coal: Emissions, Energy, Fuels and Chemicals. Presented in the Conference on the Future of Coal in Ontario: Towards a Clean, Secure and Competitive Energy Portfolio; Toronto, Ontario, May 10, 2007. 1-18 pp. http://www.queensu.ca/qieep/events/coal.html. June 27, 2011.

Bazeley, P. 2004. Issues in Mixing Qualitative and Quantitative Approaches to Research *in* R. Buber; J. Gadner and L. Richards (eds) 2004. Applying qualitative methods to marketing management research. Palgrave Macmillan, UK. 141-156 pp.

Becker, D.R., C.C. Harris, E.A. Nielsen and W.J. McLaughlin. 2004. A comparison of a technical and participatory application of social impact assessment. Impact Assessment and Project Appraisal 22(3):177-189.

Becker, D.R., D. Abbas, K.E. Halvorsen, P.J. Jakes, S.M. McCaffrey and C. Mosely. 2009. Conventional wisdoms of woody biomass utilization. Final report; Boise (ID), Joint Fire Sciences Program.

Becker, H.A. 2001. Social impact assessment. European Journal of Operational Research 128:311-321.

Beckley, T.M. 1999. Forest community sustainability: Introduction to the theme. The Forestry Chronicle 75(5):745-746.

Beckley, T.M. and W. Reimer. 1999. Helping communities help themselves: Industry-community relations for sustainable timber-dependent communities. The Forestry Chronicle 75(5):805-810.

Benoit, L. 2008. Canada's Forest Industry: Recognizing the Challenges and Opportunities. Report of the Standing Committee on Natural Resources. 39th Parliament, 2nd Session, June 2008.

Benoit, L. 2009. Combining our energies: integrated energy systems for Canadian communities. Report of the Standing Committee on Natural Resources. 40th Parliament, 2nd Session, Ottawa.

Berndes G, M. Hoogwijk and R. van den Broek. 2003. The contribution of biomass in the future global energy supply: A review of 17 studies. Biomass Bioenergy 25(1):1-28.

Bhatti, J.S., N.W. Foster, T. Oja, M.H. Moayeri and P.A. Arp. 1998. Modeling potentially sustainable biomass productivity in jack pine forest stands. Canadian Journal of Soil Science 78:105-113.

Borjesson, P. 2000. Economic valuation of the environmental impact of logging residue recovery and nutrient compensation. Biomass and Bioenergy 19:137–152.

Borsboom, N., B. Hektor, B. McCallum and E. Remedio. 2006. Social Implications of Forest Energy Production. Bioenergy from Sustainable Forestry: Guiding Principles and Practice. Springer Netherlands 71:265-297.

Botkins, J.W., E. Mahdi and M. Mircea. 1979. No Limits to Learning. Pergamon Press, New York.

Bouma, G.D., R. Ling and L. Wilkinson. 2009. Qualitative or Quantitative Research? Where do I begin? Chapter 4 *in* The Research Process, Canadian Edition; Oxford University Press, Toronto. 41-47 pp.

Bradbury, J., I. Ray, T. Peterson, S. Wade, G. Wong-Parodi and A. Feldpausch. 2009. The role of social factors in shaping public perceptions of CCS: Results of multi-state focus group interviews in the U.S. Energy Procedia 1:4665-4672.

Bradley, D. 2006. Climate Change Solutions. Canada Biomass-Bioenergy Report. http://www.climatechangesolutions.net/pdf/canada_country2006.pdf. March 10, 2010.

Bradley, R.L. 2012. The Increasing Sustainability of Conventional Energy. Policy Analysis, No. 341.

Bratkovich, S. 2009. Community-Based Bioenergy and District Heating: Benefits, Challenges, Opportunities and Recommendations for Woody Biomass. Dovetail Partners, Inc. http://www.dovetailinc.org/files/DovetailDistHeat0409.pdf. August 5, 2013.

Braun, V. and V. Clarke. 2006. Using thematic analysis in psychology. Qualitative Research in Psychology, 3:77-101.

Brown, M., H. Odum and S. Jorgensen.2004. Energy hierarchy and transformation in the universe. Ecological Modeling 178:17-28.

Bryman, A. 2006. Integrating quantitative and qualitative research: how is it done? Qualitative Research 6(1):97-113.

Buchholz, T.S., T.A. Volk and V.A. Luzadias. 2007. A participatory systems approach to modeling social, economic, and ecological components of bioenergy. Energy Policy 35:6084-6094.

Bureau du forestier en chef. 2010. Bilan d'aménagement forestier durable au Québec 2000-2008. Gouvernement du Québec, Roberval, Québec. 290 p.

Campbell, D.A. and S.C. Barker. 1998. Selecting appropriate content and methods in program delivery. Chapter 8 of: Improving agricultural extension: A reference manual. Food and Agriculture Organization of the United Nations, Rome.

Canadian Forest Service. 2012. Total growing stock by Eco zone. http://cfs.nrcan.gc.ca/pages/354. July 15, 2012.

Canadian Security Intelligence Service (CSIS). 2013. What Does Energy Security Mean for Canada? Canadian Security Intelligence Service. http://www.csis-scrs.gc.ca/pblctns/cdmctrch/cnd_nrg_scrt_rprt-eng.asp. July 4, 2013.

CANBIO. 2009. Benefits of Bioenergy to Canada. Canadian Bioenergy Association. www.canbio.ca. Nov. 1, 2009.

CanmetENERGY. 2011. Bioenergy Systems. http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/bioenergy.html. August 30, 2011.

Catania, A., R. Revetria, F. Oliva, and L. Cassettari. 2008. An integrated model for evaluating self sustainability of bio-energy settlements: Technological, economic and social aspects *in* S.J. Mason; R.R. Hill; L. Mönch; O. Rose; T. Jefferson and J.W. Fowler (eds.) 2008. Proceedings of the Winter Simulation Conference.

CBC News. 2012. $200M conversion coming for Atikokan coal plant. Biomass plant expected to be up-and-running by 2014. CBC News, July 20, 2012. http://www.cbc.ca/news/canada/thunder-bay/story/2012/07/19/tby-biomass-plant.html. November 10, 2012.

Ceccon, E. and O. Miramontes. 2008. Reversing deforestation? Bioenergy and society in two Brazilian models. Ecological Economics 67(2):311-7.

CENBIO. 2005. Renewable Energy. National Biomass Reference Center. http://www.cenbio.org.br/in/index.html. Oct. 13, 2009.

Center for International Forestry Research (CIFOR). 2012. Adaptive Collaborative Management Methods and Tools. http://www.cifor.org/acm/beyond/index.htm. Jan. 10, 2012.

Centre for Research and Innovation in the Bio-Economy (CRIBE). 2013. Biomass Solutions for our Future. http://www.cribe.ca/home. June 9, 2013.

Charmaz, K. 1988. Contemporary field research: A collection of readings. Prospect Heights, Illinois: Waveland Press. 109 p.

Charmaz, K. 2006. Grounded theory: A practical guide through qualitative analysis. Thousand Oaks, California: Sage.

Chiao, C., V. Mishra and W. Sambisa. 2009. Individual- and community-level determinants of social acceptance of people living with HIV in Kenya: Results from a national population-based survey. Health & Place 15(3):742-750.

Cho, R. 2011. Is Biomass Really Renewable? State of the planet: Blogs from the Earth Institute, Columbia University. http://blogs.ei.columbia.edu/2011/08/18/is-biomass-really-renewable/. May 22, 2013.

Christensen, R. 1990. Log-Linear Models. Springer Texts in Statistics. Springer Verlag, Berlin and Heidelberg, Germany.

Cline, W.R. 1991. Scientific basis for the greenhouse effect. The Economic Journal, 101(407):904-919.

Cook, J.B. 1994. Community Development Theory. Department of Community Development, University of Missouri. pp. 1-15.

Corder, G.W. and D.I. Foreman. 2009. Nonparametric Statistics for Non-Statisticians: A Step-by-Step Approach. Wiley, ISBN: 9780470454619.

Costanza, R. 1996. Ecological economics: reintegrating the study of humans and nature. Ecological Applications 6:978-990.

Costanza, R. and B.C. Patten.1995. Defining and predicting sustainability. Ecological Economics 15:193-196.

Creswell, J.W. 2003. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Second Edition. SAGE Publications, Thousand Oaks. California. 246 pp.

Creswell, J.W. 2007. Qualitative Inquiry and Research Design: Choosing Among Five Approaches. Second Edition. SAGE Publications, Thousand Oaks. 395 pp.

Daily G.C. and P.R. Ehrlich. 1996. Socio-economic equity, sustainability, and earth's carrying capacity. Ecological Applications 6:991-1001.

Daly, K. and Gliksman. 1997. The public health researcher: A methodological approach. Melbourne, Australia: Oxford University Press. 611–618 pp.

Department of Environmental Affairs and Tourism (DEAT). 2006. Socio-Economic Impact Assessment. Integrated Environmental Management Information Series 22, Department of Environmental Affairs and Tourism (DEAT), Pretoria. 18 pp.

Dewees, D. 2007. Pricing Ontario Coal Emissions. Presented in the Conference on the Future of Coal in Ontario: Towards a Clean, Secure and Competitive Energy Portfolio; Toronto, Ontario, May 10, 2007. 1-23 pp. http://www.queensu.ca/qieep/events/coal.html. June 27, 2011.

DeYoe, D. 2007. Use and Utility of Forest Biomass: Benefits to the Forest, the Community and Economic Development. Canadian Silviculture, May 2007.

Dietz, T. 1987. Theory and methods in social impact assessment. Sociological Inquiry 57(1):54-69.

Dodge, W.K. 1980. Ten Commandments of Community Development or one Middle Aged Graduate's Advice to New Graduates. Journal of the Community Development Society Spring: 49-57.

Domac, J., K. Healion, A. Lunnan, R. Madlener, S. Nilsson, K. Richards, B. White, T. Yagishita and V. Segon. 2004. Educational Work of Iea Bioenergy Task 29: Socio-Economic Drivers in Implementing Bioenergy Projects. 2nd World Biomass Conference - Biomass for Energy, Industry and Climate Protection; Rome, Italy 10.-14. May 2004.

Domac, J. and V. Segan. 2005. Socio-economic drivers in Implementing Bioenergy Projects. Technology Report: Bioenergy and Job Creation. IEA Bioenergy Task 29. ExCo56, Dublin, Ireland, October 12-13, 2005.

Domac, J., K. Richards and S. Risovic. 2005. Socio-economic drivers in implementing bioenergy projects. Biomass and Bioenergy 28(2):97-106.

Dwivedi, P. and J. R.R. Alavalapati. 2009. Stakeholders' perceptions on forest biomass-based bioenergy development in the southern US. Energy Policy 37(5):1999-2007.

Dwyer, J.F., E.G. McPherson, H.W. Schroeder and R.A. Rowntree. 1992. Assessing the benefits and costs of the urban forest. Journal of Arboriculture 18(5):227-234.

Ediger, V.S. and E. Kentel. 1999. Renewable energy potential as an alternative to fossil fuels in Turkey. Energy Conversion and Management 40(7):743-755.

Edward Hoshizaki Development Consulting. 2008. Investment Readiness Projects: Atikokan Economic Development Corporation, Township of Atikokan, Unincorporated Township of Upsala, Lac La Croix First Nation, and Seine River First Nation. Asset Inventory Report (Draft), March 2008. Edward Hoshizaki Development Consulting, 135 N. Syndicate Avenue, Suite 400, Thunder Bay, Ontario, Canada P7C 3V6.

Elghali L., R. Clift, P. Sinclair, C. Panoutsou and A. Bauen. 2007. Developing a sustainability framework for the assessment of bioenergy systems. Energy Policy 35(12):6075-6083.

Ellington, R.T., M. Meo and D.A. El-Sayed. 1993. The net greenhouse warming forcing of methanol produced from biomass. Biomass and Bioenergy 4:405-418.

ENCANA. 2006. Socio-Economic Impact Assessment. EnCana Corporation, Calgary, Alberta, Canada. http://www.encana.com/. Nov. 02, 2009.

Energy Information Administration (EIA). 2008a. Annual Energy Outlook 2008. US Department of Energy, Washington, DC. www.eia.doe.gov/oiaf/aeo. Nov. 15, 2011.

Energy Information Administration (EIA). 2008b. International Energy Outlook 2008. US Department of Energy, Washington, DC. www.eia.doe.gov/oiaf/ieo. Nov. 25, 2011.

Engineering and Physical Sciences Research Council (EPSRC). 2009. Bioenergy Benefits: Cheap, sustainable energy could be growing all round us. http://www.epsrc.ac.uk/default.htm. Oct. 3, 2009.

Environment Canada. 2013. National Climate Data and Information Archive. http://www.climate.weatheroffice.gc.ca/climate_normals/station_metadata_e.html June 20, 2013.

Eppen, G.D., F.J. Gould, C.P. Schmidt, J.H. Moore and L.R. Weatherford. 1998. Introductory Management Science: Decision Modeling with Spreadsheets. Prentice Hall, Inc. Upper Saddle River, NJ 07458. 25 p.

Etcheverry, J., P. Gipe, W. Kemp, R. Samson, M. Vis, B. Eggertson, R. McMonagle, S. Marchildon, and D. Marshall. 2004. Smart Generation: Powering Ontario with Renewable Energy. The David Suzuki Foundation, Vancouver, BC, Canada. www.davidsuzuki.org/files/Climate/Ontario/Smart_Generation_full_report.pdf. Sept. 20, 2010.

Ettarh R. 2004. Common descriptive and analytical statistics in investigative studies. Radiography 10(4):299-302.

Evans A.M. and A. J. Finkral. 2009. From renewable energy to fire risk reduction: a synthesis of biomass harvesting and utilization case studies in US Forests. Blackwell Publishing Ltd, GCB Bioenergy 1:211–219.

Evans, A.M. 2008a. Synthesis of Knowledge from Woody Biomass Removal Case Studies. Forest Guild; US Forest Service. http://biomass.forestguild.org/. September 3, 2013.

Evans, A.M. 2008b. Woody biomass removal case studies: Lessons learned and strategies for success. Forest Wisdom 11:1-10.

Evans, A.M. and R.T. Perschel. 2009. An Assessment of Biomass Harvesting Guidelines. Forest Guild. http://www.forestguild.org. September 5, 2013.

Evans, A.M., R.T. Perschel and B. Kittler. 2010. Revised assessment of biomass harvesting and retention guidelines. Forest Guild, Sante Fe, NM.

Evans, G. and J. Durant. 1995. The Relationship Between Knowledge and Attitudes in the Public Understanding of Science in Britain. Public Understanding of Science 4:57-74.

Faaij, A., B. Meuleman, W. Turkenburg, A. Wijk and A. Bauen. 1998. Externalities of biomass based electricity production compared with power generation from coal in the Netherlands. Biomass and Bioenergy 14(2):125–147.

Faaij, A.P.C. 2006. Emerging international bio-energy markets and opportunities for socio-economic development. Energy for Sustainable Development. Volume X No. 1, March 2006.

FAO. 2008. UNECE/FAO Forest Products Annual Market Review, 2007-2008. http://www.unece.org/timber/docs/fpama/2008/FPAMR2008.pdf. October 11, 2013.

Farley, J., J.D. Erickson and H.E. Daly. 2005. Ecological Economics - A Workbook for Problem-Based Learing. Island Press Washington, Covelo, London.

Farmer, D. 2003. Urban, Rural Differences Interesting. The Kiowa County Press. July 25, 2003. http://www.kiowacountypress.com/2003-07/07-25/Urban,%20Rural%20Differences%20Interesting.htm. June 25, 2013.

Felix, E. 2009. Bioenergy in context: lessons learned from the Food and Agricultural Organization of the United Nations on Sustainability Food security and Environment. Bioenergy and Food Security Workshop, Santo Domingo 11-12 March 2009.

Fereday, J. and E. Muir-Cochrane. 2006. Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. International Journal of Qualitative Methods, 5 (1):4.

Ferguson, A. 2003. Implications of the USDA 2002 update on ethanol from corn. The Optimum Population Trust, Manchester, U.K., in press.

FERIC. 2008. FPInnovation: FERIC. http://www.feric.ca/. Aug. 01, 2008.

Fernholz, K., S. Bratkovich, J. Bowyer and A. Lindburg. 2009. Energy from woody biomass: a review of harvesting guidelines and a discussion of related challenges. Dovetail Partners Inc., Minneapolis, USA. 4-11 pp. http://www.dovetailinc.org/files/DovetailBioGuides0709.pdf. November 3, 2013.

Finkral, A.J. and A.M. Evans.2007. The effects of a thinning treatment on carbon stocks in a northern Arizona ponderosa pine forest. Unpublished manuscript. 26 p.

Food and Agricultural Organization of the United Nations (FAO). 1990. Women in agricultural development. FAO's plan of action. Food and Agriculture Organization of the United Nations, Rome.

Food and Agricultural Organization of the United Nations (FAO). 2008. Forestry and energy. FAO Forestry Paper 154, Food and Agriculture Organization of the United Nations, Rome.

Food and Agricultural Organizations (FAO). 2009. Do Sustainable livelihoods approaches have a positive impact on the rural poor? Economic and Social Development Department, Food and Agricultural Organizations of the United Nations (FAO). www.fao.org. Nov. 15, 2009.

Forest BioProducts Inc. (FBI). 2006. An Assessment of the Viability of Exploiting Bio-Energy Resources Accessible to the Atikokan Generating Station in Northwestern Ontario. Ontario Ministry of Energy: Final Report. Forest BioProducts Inc., 645 Queen Street East, 2nd Floor, Sault Ste. Marie, Ontario, Canada.

Forest Stewardship Council (FSC). 2006. A universal set of 10 principles of social, economic, and ecological factors for sustainable forest management. http://www.fsc.org/. Dec. 20, 2011.

Forest Stewardship Council (FSC). 2012. FSC Principles and Criteria for Forest Stewardship. Forest Stewardship Council, FSC-STD-01-001 V5-0 EN.

https://ca.fsc.org/download.fsc-principles-and-criteria-v5.129.pdf. Accessed on December 15, 2013.

Forman, G. 2011. Coal is a killer. Ontario Nature. Spring 2011. http://onnaturemagazine.com/coal-is-a-killer.html. Oct. 21, 2011.

FPAC. 2012. Certification in Canada. http://www.certificationcanada.org/english/status_intentions/status.php. Nov. 14, 2012.

Fraser Institute. 2013. Risks to Canada's energy security. http://www.fraserinstitute.org/research-news/research/topics.aspx. July 2, 2013.

Gan, J. 2007. Supply of biomass, bioenergy, and carbon mitigation: method and application. Energy Policy 35: 6003-6009.

Gan, J. and C.T. Smith. 2006a. Availability of logging residues and potential for electricity production and carbon displacement in the USA. Biomass and Bioenergy 30(12):1011-1020.

Gan, J. and C.T. Smith. 2006b. A comparative analysis of woody biomass and coal for electricity generation under various CO2 emission reductions and taxes. Biomass and Bioenergy 30(4):296-303.

Gan, J. and C.T. Smith. 2007. Co-benefits of utilizing logging residues for bioenergy production:The case for East Texas, USA. Biomass and Bioenergy 31:623-630.

Gibbons, J.D. and S. Chakraborti. 2003. Nonparametric Statistical Inference. 4th Ed. CRC, ISBN: 0824740521.

Gowdy, J.1999. Hierarchies in human affairs: microfoundation and environmental sustainability. J. Kohn, Editor, et al. Sustainability in Question: The Search for a Conceptual Framework, Edward Elgar, Northampton, MA. 67-84 pp.

Guest, G. K., M. MacQueen and E.E. Namey. 2012. Introduction to Applied Thematic Analysis. SAGE Publications Inc., Thousand Oaks, Callifornia.

Guo, Z., C. Sun and D.L. Grebner. 2007. Utilization of forest derived biomass for energy production in the USA: Status, challenges, and public policies. International Forestry Review 9(3):748-758.

Hacatoglu, K. 2008. Bioenergy Systems in Canada: Towards Energy Security and Climate Change Solutions. M.Sc. Thesis, Queen's University Kingston, Ontario, Canada. 149 pp.

Hacker, J.J. 2005. Effects of logging residue removal on forest sites: A literature review. Resource Analysitics and West Central Wisconsin Regional Planning Commission, Eu Claire, WI.

Hackett, P. 2009. Growing Pains: The Possibilities and Problems of Biofuels. A Christian Aid report, August 2009. www.christainaid.org.uk. Nov. 10, 2009.

Hakkila, P. 2002. Operations with reduced environmental impact. In: Richardson J., R. Björheden, P. Hakkila, A.T. Lowe, C.T. Smith, Eds. Bioenergy from Sustainable

Forestry: Guiding Principles and Practice. Dordrecht: Klewer Academic Publishers. 244-261 pp.

Hall, C.A.S. 2000. Quantifying Sustainable Development: The Future of Tropical Economies. Academic Press, San Diego.

Hall, D. 1991. Biomass energy. Energy Policy 19(8):711–739.

Hall, D.O. 1997. Biomass energy in industrialized countries: a view of the future. Forest Ecology and Management 91(1):17-45.

Hall, H.E. and S. Helynen. 2006. Rationale for Forest Energy Production. Springer Netherlands 71:1-17.

Hammond, D. 2003.The Science of Synthesis, Exploring the Social Implications of General Systems Theory. University Press of Colorado, Boulder, CO.

Harris, R.A., T. Adams, V. Hiott, D. Van Lear, G. Wang, T. Tanner and J. Frederick. 2004. Potential for biomass energy development in South Carolina, South Carolina Forestry Commission. http://www.state.sc.us/forest/prod1004.pdf. Oct. 10, 2008.

Hastie, C. 2003. The benefits of urban trees: A summary of the benefits of urban trees accompanied by a selection of research papers and pamphlets. 2-5 pp. http://www.naturewithin.info/UF/TreeBenefitsUK.pdf. September 3, 2013.

Heinberg, R. 2007a. Bridging peak oil and climate change activism *in* Gonick, C. (eds.) 2007. Energy Security and Climate Change: a Canadian Primer. Fernwood Publishing, Black Point, NS. 108-117 pp.

Heinberg, R. 2007b. Responding to the challenge of peak oil *in* Gonick, C. (eds.) 2007. Energy Security and Climate Change: a Canadian Primer. Fernwood Publishing, Black Point, NS. 31-36 pp.

Hektor, B. 2001. Socio-Economic Management Models for the Bioenergy Sector. IEA Bioenergy Task 29 Workshop, Alberta, Canada, May 28-31, 2001.

Heller, M.C., G.A. Keoleian and T.A. Volk. 2003. Life cycle assessment of a willow bioenergy cropping system. Biomass and Bioenergy 25(2):147-165.

Heller, M.C., G.A. Keoleian, M.K. Mann and T.A. Volk. 2004. Life cycle energy and environmental benefits of generating electricity from willow biomass. Renewable Energy 29(7):1023-1042.

Helmisaari, H.S. and E. Vanguelova. 2013. Proceedings of the Workshop W6.1 Forest bioenergy and soil sustainability at EUROSOIL Congress, July 2-6, 2012, Bari, Italy. 72 p. www.helsinki.fi/forestsciences/eurosoil/index.html. June 5, 2013.

Hicks, D. 2012. Ties that bind - Treaty #3 reaffirms agreements. http://fftimes.com/node/255570. January 15, 2014.

Hill, S. 2007. Emission pricing: Reframing coal and climate policy in Ontario. Presented in the Conference on the Future of Coal in Ontario: Towards a Clean, Secure and Competitive Energy Portfolio; May 10, 2007, Toronto, Ontario; 1-16 pp. http://www.queensu.ca/qieep/events/coal.html. June 27, 2011.

Hill, T. and P. Lewicki. 2007. STATISTICS Methods and Applications. StatSoft, Tulsa, OK.

Hjerpe, E., J. Abrams and D.R. Becker,. 2009. Socio-economic barriers and the role of biomass utilization in southwestern ponderosa pine restoration. Ecological Restoration 27(2):169–177.

Holling, C.S. 1978. Adaptive Environmental Assessment and Management. International Institute for Applied Systems Analysis, Wiley, Chichester, New York.

Holling, C.S.2001. Understanding the complexity of economic, ecological, and social systems. Ecosystems 4:390-405.

Hoogwijk M., A. Faaij, R. Van den Broek, G. Berndes, D. Gielen and W. Turkenburg. 2003. Exploration of the ranges of the global potential of biomass for energy. Biomass and Bioenergy, 25(2):119-133.

Hosegood, S.I. 2010. Fuel characteristics of northwestern Ontario tree species and their components. M.Sc. Thesis, Lakehead University, Thunder Bay, Ontario. 133 pp.

Hosmer, D.W. and S. Lemeshow. 2000. Applied Logistic Regression: Second Edition. John Wiley and Sons, Inc.: A Wiley-Interscience Publication. Toronto, Ontario. 1-397 pp.

Hoyle, R.H., M.J. Harris and C.M. Judd. 2002. Research Methods in Social Relations. USA: Wadsworth.

Hugo, M.L., A.T. Viljoen and J.M. Meeuwis. 1997. The Ecology of Natural Resource Management: The Quest for sustainable living. Kagiso Tertiary, South Africa.

IEA Bioenergy. 2005. Benefits of Bioenergy. www.ieabioenergy.com. Nov. 03, 2009.

International Energy Agency (IEA). 2006. IEA Energy Statistics. International Energy Agency (IEA). www.iea.org. March 20, 2009.

International Energy Agency (IEA). 2007. Bioenergy project development and biomass supply: good practice guidelines. International Energy Agency (IEA), Paris, France. pp. 43-59.

International Energy Agency (IEA). 2012. Mobilizing Sustainable Supply Chains for Forest Biomass for Energy. IEA Bioenergy Task 43 workshop: Biomass Feedstock for Energy Markets. February 21, 2012, Charleston, South Carolina, USA. http://www.ieabioenergytask43.org/. June 14, 2013.

International Institute for Sustainable Development (IISD). 2008. Global Renewable Energy Forum. May 18-21, 2008. http://www.iisd.ca/ymb/greb2008/html/ymbvol128num2e.html. September 23, 2013.

Isokun, M.I. 1985. Administration of Justice: A Study of Nigerian System of Justice with Special Reference to the Informal Justice System in Bendel State, Nigeria. Ph.D. Thesis, Center for Development Studies, University of Wales, Swansea.

Itaoka, K., Y. Okuda, A. Saito and M. Akai. 2009. Influential information and factors for social acceptance of CCS: the 2nd round survey of public opinion in Japan. Energy Procedia 1:4803-4810.

Itaoka, K., A. Saito and M. Akai. 2011. A study on roles of public survey and focus groups to assess public opinions for CCS implementation. Energy Procedia 4:6330-6337.

Janowiak, M.K. and C.R. Webster. 2010. Promoting Ecological Sustainability in Woody Biomass Harvesting. Journal of Forestry 108:16-23.

Johnson, B. and L. Christensen. 2004. Educational Research: Quantitative, Qualittive and Mixed Approaches. Second Edition, Pearson Education, Inc., Boston, USA. 564 pp.

Johnston, M. and B. Lorch. 1996. Community distinctiveness and company closure in a northern Ontario mining town. The Great Lakes Geographer, 3(1):39-52.

Kabzems, R. 2012. Aspen and white spruce productivity is reduced by organic matter removal and soil compaction. For. Chron., 88: 306-316.

Kalich, C. and A. Utilities. 2011. Capabilities of Electric Power Resources. http://pnucc.org/sites/default/files/CapabilitiesofResourcesReportandMemoweb.pdf. Oct. 25, 2011.

Karekezi,S. 2001. Renewables in Africa-Meeting the Energy Needs of the Poor. African Energy Policy Research Network (AFREPREN), Nairobi.

Keith, D. 2007. Coal, Wind & Nuclear: Trade-offs and options in Ontario. Presented in the Conference on the Future of Coal in Ontario: Towards a Clean, Secure and Competitive Energy Portfolio; Toronto, Ontario, May 10, 2007. 1-30 pp. http://www.queensu.ca/qieep/events/coal.html. June 27, 2011.

Keith, D.W. and J.S. Rhodes. 2002. Bury, burn or both: a two-for-one deal on biomass carbon and energy. Climatic Change 54(3):375-377.

Kimmins, H. 2008. Carbon and Nutrient Cycling: Is Forest Bioenergy Sustainable? Canadian Silviculture, May 2008.

Kishore, U. 2013. Techno-commercial analysis of integrating vam with smaller biomass power plant. Project report 2013. Center for Advanced Management and Power Studies, National Power Training Institute, Maharshi Dayanand University, Rothak, India. p.49.

Klein, K.K., R. Romain, M. Olar and N. Bergeron. 2004. Ethanol and Biodiesel in Canada: Can They Help Meet Canada's Kyoto Commitment? CAFRI Number.5. 2004. 221-237 pp. www.CAFRI.org. Nov. 13, 2009.

Korey, J.L. 2009. Introduction to Research Methods in Political Science: The POWERMUTT Project (SPSS Version). http://www.csupomona.edu/~jlkorey/POWERMUTT/Topics/control_variables.html. Nov. 23, 2009.

Kumar, A., J. Cameron and P. Flynn. 2003. Biomass power cost and optimum plant size in western Canada. Biomass and Bioenergy 24:445-64.

Kvale, S. 1996. Interviews: An Introduction to Qualitative Research Interviewing. Sage Publications.

Lake Abitibi Model Forest Network (LAMFN). 2009. Sustainable Communities: A Community Development Impact Model (CDIM). www.lamf.net. Aug. 12, 2009.

Lattimore, B., C.T. Smith, B. Titus, I. Stupak and G. Egnell. 2013. Woodfuel Harvesting: A Review of Environmental Risks, Criteria and Indicators, and Certification Standards for Environmental Sustainability. Journal of Sustainable Forestry 32(1-2):58-88.

Lattimore, B., C.T. Smith, B.D. Titus, I. Stupak and G. Egnell. 2009. Environmental factors in woodfuel production: Opportunities, risks, and criteria and indicators for sustainable practices. Biomass and Bioenergy 33:1321-1342.

Layzell, B.D., J. Stephen and M. Susan. 2006. Wood Exploring the Potential for Biomass Power in Ontario. BIOCAP Canada Foundation. www.biocap.ca. Feb. 23, 2008.

Layzell, D. 2007. Biomass as an Alternative to Coal in Ontario. Presented in the Conference on the Future of Coal in Ontario: Towards a Clean, Secure and Competitive Energy Portfolio; Toronto, Ontario, May 10, 2007. 1-17 pp. http://www.queensu.ca/qieep/events/coal.html. June 27, 2011.

Layzell, D. and A. Pollard. 2008. Towards a Sustainable Bioeconomy: A Great Lakes / St.Lawrence Bioenergy Corridor. Energy 2100 – Making the Lakes Great, MaRS Discovery Centre; Toronto, Ontario, April 24, 2008.

Lee, R.G., D.R. Field and W.R. Burch. 1990. Community & Forestry: Continuities in the Sociology of Natural Resources. Social Behavior and Natural Resources Series, West view Press, Boulder, San Francisco & London.

Lee, H., W.C. Clark and C. Devereaux. 2008. Biofuels and Sustainable Development: Report of an Executive Session on the Grand Challenges of a Sustainability Transition. San Servolo Island, Venice, Italy, May 19-20, 2008.

Lemelin, R.H. 2009. Class Note of the course "Qualitative Methods for Research and Inquiry" Winter 2009 (OUTD 5050). Lakehead University, Thunder Bay, Ontario.

Lewandowski, I. and A.P.C. Faaij. 2006. Steps towards the development of a certification system for sustainable bio-energy trade. Biomass and Bioenergy 30(2):83-104.

Li, X., J. Wang, G. Miller and J. McNeel. 2006. Production economics of harvesting small-diameter hardwood stands in central Appalachia. Forest Products Journal 56(3):81-86.

Licht. F.O. 2005. Biofuels and the international development agenda. World Ethanol and Biofuels Report,Volume 3, No. 21.

Lovins, A.B.2002. Small is Profitable - The Hidden Economic Benefits of Making Electrical Resources the Right Size, Rocky Mountain Institute, Boulder, CO.,

Lowe, G.S. and G. Schellenberg. 2001. What's a Good Job? The Importance of Employment Relationships. CPRN Study No. W|05, Renouf Publishing Co. Ltd., 5369 Canotek Road Ottawa, ON. vii-xv pp.

Ludwig, D., R. Hilborn and C. Walters. 1993. Uncertainty, resource exploitation, and conservation: lessons from history. Science 60:17-36.

Mackenzie Valley Environmental Impact Review Board (MVEIRB). 2009. Socio-Economic Impact Assessment Guidelines. Mackenzie Valley Environmental Impact Review Board, Yellowknife. http://reviewboard.ca/upload/ref_library/SEIA_Guidelines_Contents_and_Chapter_1.pdf. Nov. 13, 2009.

Madlener, R. and J. Domac. 2007. Introduction to the special section "Modeling socio-economic aspects of bioenergy use: methodologies, case studies, and policy evaluation and guidance." Energy Policy 35(12):e1-e4.

Management Study Guide (MSG). 2013. SWOT Analysis. Management Study Guide. http://www.managementstudyguide.com/swot-analysis.htm. June 29, 2013.

Manley, A. and J. Richardson. 1995. Silviculture and economic benefits of producing wood energy from conventional forestry systems and measures to mitigate negative impacts. Biomass and Bioenergy 9(1–5):89–105.

Markel, K.E.J. 2007. Coal in the US. Presented in the Conference on the Future of Coal in Ontario: Towards a Clean, Secure and Competitive Energy Portfolio; May 10, 2007, Toronto, Ontario; 1-52 pp. http://www.queensu.ca/qieep/events/coal.html. June 27, 2011.

Marshall, L., C. Fralick and D. Gaudry. 2010. OPG Charts Move from Coal to Biomass. POWER: Business and Technology for the Global Generation Industry. April 1, 2010. 6 pp.

Mary, E. 2009. Community Guide to Development Impact Analysis. www.lic.wisc.edu. Oct. 29, 2009.

Massachusetts Environmental Energy Alliance (MEEA). 2013. The harmful impacts of biomass energy generation: undermining the fight against global warming. www.massenvironmentalenergy.org. November 14, 2013.

Massachusetts Technology Collaborative (MTC). 2009. Bioenergy Benefits and Barriers. http://www.masstech.org/index.asp. Nov. 5, 2009.

Mayfield, C.A., A.D. Foster, C.T. Smith, J. Gan and S. Fox. 2007. Opportunities, barriers, and strategies for forest bioenergy and bio-based product development in the Southern United States. Biomass and Bioenergy 31:631-637.

McCallum, B. 1997. Small-Scale Automated Biomass Energy Heating Systems: A Value Option for Remote Canadian Communities? Natural Resources Canada; Ontario Ministry of Natural Resources. NODA Note No. 30.

McCallum, B. 2001. Opportunities and benefits of integrated forest harvesting operations in Canada's remote northern communities. Presented at the IEA Bioenergy Task 29 Workshop in Alberta, Canada, 28–31 May 2001. http://www.iea-bioenergy task29.hr/pdf/canada_papers/McCallum_2001.pdfS. July 15, 2012.

McCarthy, S. 2009. Ottawa takes aim at coal-fired power plants. Toronto Globe and Mail International, April 29, 2009.

McCormick, K. 2005. Sustainable Bioenergy Systems: Experiences from Sweden. Proceedings of the Asia Pacific Roundtable on Sustainable Consumption and Production; Melbourne, Australia, Oct. 10-12, 2005.

McCormick, K. and T. Kaberger. 2007. Key barriers for bioenergy in Europe: Economic conditions, know-how and institutional capacity, and supply chain co-ordination. Biomass and Bioenergy 31:443-452.

McDonald, G.T. and M.B. Lane. 2004. Converging global indicators for sustainable forest management. Forest Policy and Economics, 6: 63-70.

McFadden, D. 1981. Econometric models of probabilistic choice *in* Manski, C.F. and D. McFadden (eds.) 1981. Structural analysis of discrete data with econometric application. The Mit Pree, Cambridge, MA.

McKinnon, M. 2013. Rentech jumps into wood pellet business in a big way. Atikokan Progress, May 7, 2013. http://atikokanprogress.ca/2013/05/07/rentech-jumps-into-wood-pellet-business-in-a-big-way/. November 2, 2013.

McKitrick, R. 2007. Emission Pricing: Some Implication Issues. Presented in the Conference on The Future of Coal in Ontario: Towards a Clean, Secure and Competitive Energy Portfolio; Toronto, Ontario, May 10, 2007. 1-19 pp. http://www.queensu.ca/qieep/events/coal.html. June 27, 2011.

McLoughlin, J., J. Kaminski and B. Sodagar. 2008. A multi-level approach to the study of the socio-economic impact of ICT at cultural heritage sites. In: David Arnold, Franco Niccolucci, Daniel Pletinckx, Luc Van Gool (Editors) EPOCH Conference on Open Digital Cultural Heritage Systems.

McPherson, E.G., J.R. Simpson, P.J. Peper, S.L. Gardner, K.E. Vargas, S.E. Maco and Q. Xiao. 2006. Piedmont Community Tree Guide, Benefits, Costs, and Strategic Planting. USDA Forest Service, Pacific Southwest Research Station, United States Department of Agriculture, Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-200; Center for Urban Forest Research, One Shields Avenue, UC Davis, Davis, California.

Meadows, B. 2008. Power plant finds success with biofuel testing. The Chronicle Journal, Thunder Bay, Ontario, Canada. Saturday, August 23, 2008. http://www.chroniclejournal.com/stories_local.php?id=130188. June 15, 2011.

Mendoza, G.A. and R. Prabhu. 2003. Qualitative multi-criteria approaches to assessing indicators of sustainable forest resource management. Forest Ecology and Management 174(1-3):329-343.

Michael S. and Kievelitz, U. 1994. Participatory Learning Approaches. Rapid Rural Appraisal Participatory Appraisal. An Introduction Guide. GTZ, GmbH, Eschborn, Germany. pp. IX-106.

Midgley, J. 1999. Growth, Redistribution and Welfare: Toward Social Investment. Social Service Review, March 1999. 3-21 pp.

Millet, I. and W. Wedley. 2002. Modelling risk and uncertainty with the analytic hierarchy process. Journal of Multi-criteria Decision Analysis 11:97-107.

Ministry of New and Renewable Energy (MNRE). 2013. The first Biogas Bottling Plant towards commercialization in India – A success story. Ministry of New and Renewable Energy, Government of India. http://mnre.gov.in/file-manager/UserFiles/success_story_bgfp.htm. May 15, 2013.

Ministry of Northern Development and Mines (MNDM). 2011. Creating Jobs And Clean Energy In Atikokan. http://news.ontario.ca/mndmf/en/2011/01/creating-jobs-and-clean-energy-in-atikokan.html. Oct. 20, 2011.

Minnesota Forest Resources Council (MFRC). 2007a. Biomass harvesting on forest management sites. Minnesota Forest Resources Council, St. Paul, Minnesota. 42 p.

Minnesota Forest Resources Council (MFRC). 2007b. Woody biomass harvesting for managing brushlands and open lands. Minnesota Forest Resources Council, St. Paul, Minnesota. 55 p.

Minnesota Forest Resources Council (MFRC). 2007c. Biomass harvesting guidelines for forestlands, brushlands, and open lands. http://www.frc.state.mn.us/Info/MFRCdocs/forest%20biomass%20harvesting.pdf. August 5, 2013.

Minnesota IMPLAN Group Inc. (MIG). 2004. IMPLAN Professional Version 2.0: Social Accounting and Impact Analysis Software. Stillwater, Minnesota 55082. 414 pp.

Miranowski, J.A. 2007. Biofuel Incentives and the Energy Title of the 2007 Farm Bill. http://www.aei.org/research/farmbill/publications/pageID.1476,projectID.28/default.asp. July 15, 2013.

Moazzami, B. 2006. An Economic Impact Analysis of the Northwestern Ontario Forest Sector. Department of Economics, Lakehead University; Northern Ontario Forest Council. 1-5 pp.

Mog, J.M. 2004. Struggling with sustainability - a comparative framework for evaluating sustainable development programs. World Development 32(12):2139-2160.

Monroe, M. and A. Oxarart. 2009. Final Report Wood to Energy: An Outreach Program for Utilizing Interface Fuels for Bioenergy Outreach Program, SRS 05-CA-11330150-105, Martha Monroe and Annie Oxarart with contributions from Alan Hodges, Matthew Langholtz, Todd LeVasseur, Lauren McDonell, Christie Staudhammer, & Jessica Tomasello .School of Forest Resources and Conservation Institute of Food and Agricultural Sciences .University of Florida June 2009.

Moote, A. and D. Becker. 2003. Exploring Barriers to Collaborative Forestry. Ecological Restoration Institute at Northern Arizona University. 28 p.

Moote, A. and K. Lowe. 2007. What to Expect from Collaboration in Natural Resources Management: A Research Synthesis for Practitioners. Ecological Restoration Institute at Northern Arizona University. 20 p.

Morris, G. 1999. The Value of the Benefits of U.S. Biomass Power. National Renewable Energy Laboratory, 1617 Cole Boulevard, Golden, Colorado, USA.

Morris, G.M. 2008. Bioenergy and Greenhouse Gases. Pacific Institute. 43 p.

Mulholland, R. and C. Vincent. 2007. The State of Small- and Medium-Sized Enterprises in Northern Ontario. Government of Canada; FedNor.

Muth, K. 2012. Factors to consider in power plant decision. The Chronicle Journal, Monday, Nov. 26, 2012.

Myles, H. 2001. Socio-Economic Modelling of Bioenergy Systems. IEA Bioenergy Task 29 Workshop; Alberta, Canada, May 28-31, 2001.

Nachmias, C.F. and Nachmias, D. 1992. Research Methods in Social Sciences, Fourth Edition, Edward Arnold (a division of Hodder and Stoughton), London, Melbourne and Auckland.

Nagel, J. 2000. Biomass in energy supply, especially in the state of Brandeburg, Germany. Ecological Engineering 16:103-110.

Nancy, R. 2004. Tague's The Quality Toolbox. Second Edition, ASQ Quality Press. 487-494 pp.

National Energy Board (NEB). 2007. Canada's Energy Future. Calgary, AB. www.neb-one.gc.ca. Jan. 15, 2011.

National Forestry Database. 2012a. http://nfdp.ccfm.org/data/compendium/html/comp_41e.html#bookMark_Ha. Aug. 15, 2012.

National Forestry Database. 2012b. http://nfdp.ccfm.org/data/compendium/html/comp_31e.html. Sept. 5, 2012.

National Forestry Database. 2012c. Silviculture Statistics. http://nfdp.ccfm.org/data/compendium/html/comp_61e.html. Nov. 15, 2012.

National Forestry Database. 2012d. Area of Stand Tending. http://nfdp.ccfm.org/data/compendium/html/comp_69e.html. Dec. 14, 2012.

National Native American AIDS Prevention Center (NNAAPC). 2013. HIV prevention online toolkit for native communities. The National Native American AIDS Prevention Center. http://www.nnaapc.org/resources/toolkit/images/traditionalism_chart.jpg&imgrefurl. June 25, 2013.

National Talk. 2012. Ontario and Grand Council Treaty #3 Renew Commitments. http://nationtalk.ca/story/ontario-and-grand-council-treaty-3-renew-commitments/. January 20, 2014.

Natural Resources Canada (NRCan). 2006. Powerful Connections: priorities and directions in energy science and technology in Canada. Ottawa, ON. www.nrcan.gc.ca/es/oerd. Dec. 15, 2010.

Natural Resources Canada (NRCan). 2009. Annual Report 2009: The State of Canada's Forests. www.nrcan.gc.ca. Accessed on Nov. 03, 2009.

Natural Resources Canada (NRCan). 2012. Statistical data. Natural Resources Canada. http://www.cfs.nrcan.gc.ca/statsprofile/overview/ca. July 25, 2012.

Neuman, W.L. 1994. Social Research Methods: Qualitative and Quantitative Approaches. Second Edition, Allyn and Bacon, Simon & Schuster, Inc., 160 Gould Street, Needham Heights, Massachusetts.

Norgaard, R.B. 1994. Development Betrayed. Routledge, London, New York. Nov. 16, 2008.

Northwestern Ontario Bio-Economy Corporation (NOBEC). 2011. Grassroots Approach Conference, March 26, 2011, Thunder Bay, Ontario, Canada. http://www.karinahunter.com/?p=24828. September 20, 2013.

Northwestern Ontario Prospectors Association (NWOPA). 2007. Forest Management Activities in Northwestern Ontario. http://www.nwopa.net/landuse/fmulist.htm. April 10, 2010.

Northwest Ontario. 2009. http://www.northwest-ontario.com/. September 15, 2009.

Norusis, M.J. 1992. SPSS/PC+, Advanced Statistics Version 5.0, Chicago.

Odum, H.T. 1971. Environment, Power, and Society. Wiley-Interscience, New York.

Odum, H.T. 1988. Self-organisation, transformity, and information. Science, 242. 1132-1139 pp.

Odum, H.T. 1996. Environmental Accounting: Energy and Environmental Decision Making. Wiley, New York. 294 pp.

Oliver C. and M. Twery. 1999. Decision support systems/models and analyses. N.C. Johnson, Editor, Ecological Stewardship. A Common Reference for Ecological Management 3:661-685.

Olsen, W. 2004. Triangulation in Social Research: Qualitative and Quantitative Methods Can Really Be Mixed. Forthcoming as a chapter in Developments in Sociology. Causeway Press, Holborn, Ormskirk.

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). 2011. Ontario Ministry of Agriculture, Food and Rural Affairs website. http://www.omafra.gov.on.ca/english/crops/bioproducts/bioproducts.html#bioe. July 20, 2013.

Ontario Ministry of Energy (OME). 2007. Ontario Ministry of Energy website http://www.energy.gov.on.ca. Sept. 16, 2007.

Ontario Ministry of Energy (OME). 2009. Ontario's Coal Phase Out Plan. http://news.ontario.ca/mei/en/2009/09/ontarios-coal-phase-out-plan.html. Oct. 20, 2011.

Ontario Ministry of Environment (OMEnv). 2013. Water. http://www.ene.gov.on.ca/environment/en/category/water/index.htm. 26, 2013.

Ontario Ministry of Municipal Affairs and Housing (OMMAH). 2013. List of Ontario Municipalities. Ontario Ministry of Municipal Affairs and Housing. http://www.mah.gov.on.ca/Page1591.aspx. January 10, 2014.

Ontario Ministry of Natural Resources (OMNR). 1997. Silvicultural guide to managing for black spruce, jack pine, and aspen on boreal forest ecosites in Ontario. Book II: Ecological and management interpretations for northwest ecosites. Ontario Ministry of Natural Resources, Queen's Printer for Ontario, Toronto.

Ontario Ministry of Natural Resources (OMNR). 2008a. Annual Report on Forest Management: For the year April 1, 2005 to March 31, 2006. Queen's Printer for Ontario, 2008.

Ontario Ministry of Natural Resources (OMNR). 2008b. Forest Biofibre - Allocation and Use. Forest Management Directives and Procedures, Ontario Ministry of Natural Resources, August 13, 2008. http://www.mnr.gov.on.ca/. Aug. 15, 2009.

Ontario Ministry of Natural Resources (OMNR). 2013. Forest Biofibre -Allocation and Use. Forest Management Directives and Procedures, FOR 03 02 01. Forest Economics Section, Forest Tenure and Economics Branch, Forestry Division, Ontario Ministry of Natural Resources, Sault Ste. Marie, Ontario, Canada.

Ontario Power Generation (OPG). 2004. Annual Report 2004. Ontario Power Generation. http://www.opg.com/pdf/Annual%20Reports/. June 20, 2013.

Ontario Power Generation (OPG). 2010a. Biomass program, Spring 2010. Ontario Power Generation. http://canbio.ca/upload/documents/halifax10todd.pdf. December 15, 2013.

Ontario Power Generation (OPG). 2010b. OPG Calls for Supply of Wood-Based Biomass Fuel for Atikokan Coal-Fired Generating Station. http://dcnonl.com/. March 18, 2010.

Ontario Power Generation (OPG). 2011. Biomass Sustainability Analysis: Summary Report. Ontario Power Generation, April, 2011. www.opg.com/power/thermal/repowering/. June 14, 2013.

Ontario Power Generation (OPG). 2012. Sustainable development report. Ontario Power Generation. http://www.opg.com/pdf/Sustainable%20Development%20Reports/001%20Sustainable%20Development%20Report%202012.pdf. January 13, 2014.

Ontario Power Generation (OPG). 2013. Atikokan Generating Station. Ontario Power Generation. http://www.opg.com/power/thermal/atikokan.asp. July 8, 2013.

Ontario Towns. 2014. The great Canadian experience: Sunset country, Ontario, Canada. http://www.ontariotowns.net/Atikokan/FAQ.cfm. January 15, 2014.

Ornstein, M.D. 1998. Survey Research. Current Sociology 46(4). 136 pp.

Ozone. 2009. Socio-Economic Impact Analysis Dryden Forest Management Plan 2006-2026. https://.ozone.scholarsportal.info/. Oct. 01, 2009.

Paré, D., P. Bernier, B. Lafleur, B.D. Titus, E. Thiffault, D.G. Maynard and X. Guo. 2013. Estimating stand-scale biomass, nutrient contents, and associated uncertainties for tree species of Canadian forests. Canadian Journal of Forest Research 43:599-608.

Pari, L. 2001. Energy production from biomass: the case of Italy. Renewable Energy 22:21-30.

Paris, M. 2011. Should Canada have a cap-and-trade system? CBC News, Apr 13, 2011. http://www.cbc.ca/news/politics/should-canada-have-a-cap-and-trade-system-1.1037192. June 15, 2011.

Parkins, J. 1999. Enhancing social indicators research in a forest-dependent community. The Forestry Chronicle 75(5).

Patrick Reid and Associates. 2006. Economic Development Opportunities for the Township of Atikokan. Patrick Reid & Associates, Business Advisor / Government Liaison for Atikokan, Atikokan, Ontario. 23 pp.

Pennock, D., J.M. Arocena and C.A.S. Smith. 2011. Soils of Canada - Preface. Canadian Journal of Soil Science 91:671-673.

Pennsylvania Department of Conservation and Natural Resources. 2008. Guidance on harvesting woody biomass for energy in Pennsylvania. 50 pp. http://www.dcnr.state.pa.us/PA_Biomass_guidance_final.pdf. August 5, 2013.

Perlack, R., L. Wright, A. Turhollow, R. Graham, B. Stokes and D. Erbach. 2005. Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. U.S. Department of Energy, Oak Ridge National Laboratory/U.S. Department of Agriculture. http://www.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf. August 21, 2013.

Perley, C. 2008. The status and prospects for forestry as a source of bioenergy in Asia and the Pacific. Bangkok, Thailand, FAO Regional Office for Asia and the Pacific.

Pétry, F.1990.Who is afraid of choices? A proposal for multi-criteria analysis as a tool for decision-making support in development planning. Journal of International Development, 2(2):209-231.

Pimentel, D. 2001. The limitations of biomass energy. Encyclopedia on Physical Science and Technology, Academic Press, San Diego. CA. 159-171 pp.

Pimentel, D., and M. Pimentel. 1996. Food, Energy and Society. Colorado Univ. Press, Boulder, CO. 363 p.

Pimentel, D., R. Doughty, C. Carothers, S. Lamberson, N. Bora, and K. Lee. 2002. Energy inputs in crop production: comparison of developed and developing countries *in* Lal, R.; D. Hansen; N. Uphoff and S. Slack (eds.) 2002. Food Security & Environmental Quality in the Developing World. CRC Press, Boca Raton, FL. 129-151 pp.

Pimentel, D., S. Cooperstein, H. Randell, D. Filiberto, S. Sorrentino, B. Kaye, C. Nicklin, J. Yagi, J. Brian, J. O'Hern, A. Habas and C. Weinstein. 2007. Ecology of Increasing Diseases: Population Growth and Environmental Degradation. Human Ecology 5:653-668.

Ponder, F., Jr., R.L. Fleming, S. Berch, M.D. Busse, J.D. Elioff, P. Hazlett, R.D. Kabzems, J.M. Kranabetter, D.M. Morris, D. Page-Dumroese, B.J. Palik, R.F. Powers, F.G. Sanchez, D.A. Scott, R.H. Stagg, D.M. Stone, D.H. Young, J. Zhang, K.H. Ludovici, D.W. McKenney, D.S. Mossa, P.T. Sanborn and R.A. Voldseth. 2012. Effects of organic matter removal, soil compaction and vegetation control on 10th year biomass and foliar nutrition: LTSP continent-wide comparisons. Forest Ecology and Management. 278: 35-54.

Puddister, D., S.W.J. Dominy, J.A. Baker, D.M. Morris, J. Maure, J.A. Rice, T.A. Jones, I. Majumdar, P. Hazlett, B.D. Titus, R.L. Fleming and S. Wetzel. 2011. Opportunities and challenges for Ontario's forest bioeconomy. The Forestry Chronicle 87(4):468-477.

Rafferty, J. 2012. The state of the forestry industry in Canada. From the House - week of July 6 to July 13, 2012. http://johnrafferty.ndp.ca/post/from-the-house-week-of-july-6-to-july-13-2012-the-state-of-the-forestry-industry-in-canada. July 25, 2012.

Raison, R.J. 2006. Opportunities and impediments to the expansion of forest bioenergy in Australia. Biomass and Bioenergy 30:1021-1024.

Ralevic, P., M. Ryans and D. Cormier. 2010. Assessing forest biomass for bioenergy: Operational challenges and cost considerations. Forestry Chronicle 86:43-50.

Reijnders, L. 2006. Conditions for the sustainability of biomass-based fuel use. Energy Policy 34(7):863-876.

Remedio, E. 2003. Socio-economic aspects of bioenergy: a focus on employment. FAO Report. Rome, Italy: FAO.

Resource Systems Group and Energetics Inc. 1994. The Economic Impact of Wood Energy in the Northeastern States. Washington DC, Northeast Regional Biomass Program. http://www.nrbp.org/pdfs/abstr01.pdf. October 13, 2013.

Reynolds, R., D. Cormier and M. Ryans. 2008. Feasibility of Forest Feedstock for Bioenergy in Northwestern Ontario. Contract Report CR-0366-3, FPInnovations FERIC, Pointe-Claire, QC.

Rhodes, J.J. and W.L. Baker. 2008. Fire probability, fuel treatment effectiveness, and ecological tradeoffs in Western U.S. Public Forests. The Open Forest Science Journal 1:1-7.

Rhodes, J.S. and D.W. Keith. 2007. Biomass with capture: negative emissions within social and environmental constraints: an editorial comment. Climatic Change DOI 10.1007/s10584-007-9387-4. http://people.ucalgary.ca/~keith/papers/95.BiomassWithCaptureEd.e.pdf. Oct. 01, 2009.

Richardson, J. 2006. Sustainable production systems for bioenergy: Forest energy in practice. Biomass and Bioenergy 30:999-1000.

Ride, R. 2008. Current and Short-Term Status of Forest Biofibre Supply and Utilization in Ontario. Draft V5.1. Ontario Ministry of Natural Resources.

Rokeach, M. 1973. The Nature of Human Values. New York: The Free Press.

Rosch, C. and M. Kaltschmitt. 1999. Energy from biomass - Do non-technical barriers prevent an increased use? Biomass and Bioenergy 16: 347–356.

Ross, I. 2013. Rentech drops woody jet fuel for wood pellets. Northwestern Ontario Business, June 10, 2013. http://www.northernontariobusiness.com/Regional-News November 1, 2013.

Saldana, J. 2013. The Coding Manual for Qualitative Researchers. SAGA Pulications Inc., Thousand Oaks, Callifornia, USA. pp.175-259.

Samson, R., S.B. Stamler, J. Dooper, S. Mulder, T. Ingram, K. Clark and C.H. Lem. 2008. Analysing Ontario Biofuel Options: Greenhouse Gas Mitigation. Efficiency and Costs. Final Report. BIOCAP Canada Foundation. p. iii. http://www.biocap.ca/reports/BIOCAP-REAP_bioenergy_policy_incentives.pdf. November 16, 2013.

Schindler, B. 2007. Public acceptance of wildland fire conditions and fuel reduction practices: challenges for federal forest managers. In: Daniel, T.C., M.S. Carroll, C. Moseley and C. Raish editors. People, fire and forests: a synthesis of wildfire social science. Oregon State University Press, Corvallis. 37-54 pp.

Schoenhuth, M., and U. Kievelitz. 1994. Participatory learning approaches - rapid rural appraisal: an introductory guide. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Postfach 5180, D-65726 Eschborn.

Searchinger, T.D., S.P. Hamburg, J. Melillo, W. Chameides, P. Havlik, D.M. Kammen, G.E. Likens, , R. Lubowski, M. Obersteiner, M. Oppenheimer, G.P. Robertson, W.H. Schlesinger and G.D. Tilman. 2009. Fixing a critical climate accounting error. Science 326(23): 527–528.

Seine River Watershed. 2013. Valerie Falls Dam. http://www.seineriverwmp.com/valeriefalls.html. June 20, 2013.

Selfa, T. 2009. The Biofuels Revolution: Understanding the Social, Cultural, and Economic Impacts of Biofuels Development on Rural Communities, Socio-economic Impacts of the Biofuels Revolution Project, Kansas State University Department of Sociology, Anthropology & Social Work, 255A Waters Hall. http://www.ksu.edu/sasw/kpc/biofuels/index.html. Oct. 11, 2009.

Sen, A. 2013. The Ends and Means of Sustainability. Journal of Human Development and Capabilities: A Multi-Disciplinary Journal for People-Centered Development 14(1):6-20.

Shaughnessy, J.J., E.B. Zechmeister and J.S. Zechmeister. 2006. Research Methods in Psychology. Seventh Edition, New York: Higher Education, New York. 143-192 pp.

Sims, R.E.H. 2003. Climate change solutions from biomass, bioenergy and biomaterials. Agricultural Engineering International: The CIGR E-Journal 5:28.

Smeets, E., A. Faaij and I. Lewandowski. 2005. The Impact of Sustainability Criteria on the Costs and Potentials of Bioenergy Production, Copernicus Institute, Utrecht University, Utrecht.

Smith, C.T. and J. Gan. 2005. Analysis of the Forest Biomass Value Chain in the U.S. IEA Bioenergy Task 31. Conference on Status, Trends, and Future of the South's Forest and Agricultural Biomass, University of Georgia, Athens, 30 August 2005.

Smith, D.L. and A. Web. 2013. Forests as a Sustainable Biofuel Feedstock. Second Workshop on Forest Biomass; FPInnovations, Pointe-Claire, Quebec, Canada, April 9-10, 2013. http://www.reseauvco.ca/en/activities-networking/workshops/second-biomass-workshop-april-2013/. June 14, 2013.

Statistics Canada. 2007a. Canada 2001 Census Canada. http://www12.statcan.ca/english/profil01/CP01/Index.cfm? June 20, 2013.

Statistics Canada. 2007b. 2006 Community Profiles. http://www12.statcan.ca/census-recensement/2006/. March 10, 2010.

Statistics Canada. 2009. Canada 2006 Census: Canada 2006 community profile. http://www12.statcan.ca/census-recensement/2006/dp-pd/prof/92-591/index.cfm? June 20, 2013.

Statistics Canada. 2012. Canada 2011 Census: Census profile. http://www12.statcan.ca/census-recensement/2011/dp-pd/prof/details/page.cfm? June 20, 2013.

StatSoft Inc. 2009. Electronic Statistics Textbook. StatSoft, Tulsa, Oklahoma, USA. http://www.statsoft.com/textbook/. Nov. 8, 2009.

Stevens, V. 1996. The ecological role of coarse woody debris: An overview of the importance of CWD in B.C. forests. Research Branch, B.C. Ministry of Forests, Victoria, B.C. Working paper 30/1997.

Stewart. W., R.F. Powers, K. McGown, L. Chiono and T. Chuang. 2011. Potential positive and negative environmental impacts of increased woody biomass use for California. California Energy Commission. Publication Number: CEC-500-2011-036. 217 p.

Stone, J., J. Parminter, A. Arsenault, T. Manning, N. Densmore, G. Davis and A. MacKinnon. 2002. Dead tree management in British Columbia. USDA Forest Service General Technical Report, PSW-GTR-181.

Stupak, I., A. Asikainen , M. Jonsell, E. Karltun, A. Lunnan, D. Mizaraitė, K. Pasanen, H. Pärn, K. Raulund-Rasmussen, D. Röser, M. Schroeder, I. Varnagirytė, L. Vilkriste, I. Callesen, N. Clarke, T. Gaitnieks, M. Ingerslev, M. Mandre, R. Ozolincius, A. Saarsalmi, K. Armolaitis, H.-S. Helmisaari, A. Indriksons, L. Kairiukstis, K. Katzensteiner, M. Kukkola, H.P. Ravn and P. Tamminen. 2007. Sustainable utilisation of forest biomass for energy -Possibilities and problems: Policy, legislation, certification, and recommendations and guidelines in the Nordic, Baltic, and other European countries. Biomass and Bioenergy 31:666-684.

Stupak, I., B. Titus, N. Clarke, T. Smith, A. Lazdins, I. Varnagiryte-Kabasinskiene, K. Armolaitis, M. Peric and C. Guidi. 2013. Approaches to soil sustainability in guidelines for forest biomass harvesting and production in forests and plantations. In Helmisaari, H-S. & Vanguelova, E. (eds.). Proceedings of the Workshop W6.1 Forest bioenergy and soil sustainability at EUROSOIL Congress, Bari, Italy, July 2-6, 2012.

Suits, D. 1984. Dummy Variables: Mechanics VS Interpretation. Review of Economics 66:132-139. Cited from Baltagi, B.H. 1998 *in* Econometrics, Springer Verlag, Berlin. 396 pp.

Sundstrom, S., M. Nielsen-Pincus, C. Moseley and S. McCaffery. 2012.Woody Biomass Use Trends, Barriers, and Strategies: Perspectives of US Forest Service Managers By Shiloh Sundstrom, Max Nielsen-Pincus, Cassandra Moseley, and Sarah McCaffery. Journal of Forestry 110:16-24.

Sustainable Bioenergy Wiki. 2006. Sustainable Bioenergy Wiki, 2006. http://www.sciencedirect.com. Dec. 10, 2011.

Sygration. 2011. Ontario Electricity Reports and Tool. http://www.sygration.com/. December 25, 2011.

Tamborra, M. 2002. Socio-Economic Tools for Sustainability Impact Assessment: the Contribution of EU Research to Sustainable Development. European Communities. 59 pp.

Taylor, C.N., C.H. Bryan and C.G. Goodrich. 2004. Social Assessment: Theory, process and techniques. Social Ecology Press, Christchurch.

The Chronicle Journal. 2013. Resolute to build sawmill in Atikokan. The Chronicle-Journal, Friday, February 1, 2013. http://www.chroniclejournal.com/content/news/local/2013/02/01/resolute-build-sawmill-atikokan. June 20, 2013.

The Programme for the Endorsement of Forest Certification (PEFC). 2013. Facts & Figures. The Programme for the Endorsement of Forest Certification. http://www.pefc.org/about-pefc/who-we-are/facts-a-figures. October 30, 2013.

Thiffault, E., D. Paré, S. Brais and B.D. Titus. 2010. Intensive biomass removals and site productivity in Canada: A review of relevant issues. Forestry Chronicle 86:36-42.

Thiffault, E., D. Paré, S. Dagnault and J. Morissette. 2011a. Guidelines - Establishing permanent plots for monitoring the environmental effects of forest biomass harvesting. Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, Québec, QC. 80 p.

Thiffault, E., K.D. Hannam, D. Paré, B.D. Titus, P.W. Hazlett, D.G. Maynard, S. Brais. 2011b. Effects of forest biomass harvesting on soil productivity in boreal and temperate forests – A review. Environmental Reviews 19:278-309.

Titus, B.D., E. Thiffault, D. Paré, S.M. Berch and D. Morris. 2013. Harvesting residue removal guidelines to protect soils in Canada and the science behind them *in* Helmisaari, H.S. and E. Vanguelova (eds.) 2013. Proceedings of the Workshop W6.1 Forest bioenergy and soil sustainability at EUROSOIL Congress; Bari, Italy, July 2-6, 2012. 72 p. www.helsinki.fi/forestsciences/eurosoil/index.html. June 5, 2013.

Township of Atikokan. 2008. Atikokan Strategic Community and Economic Development Plan: Final Report. The Township of Atikokan, Atikokan, Ontario.

Town of Atikokan. 2012. Official website of Town of Atikokan. http://www.atikokan.ca. June 20, 2013.

Tracy, S.J., Lutgen-Sandvik, P., and J.K. Alberts. 2006. Nightmares, demons and slaves: Exploring the painful metaphors of workplace bullying. Management Communication Quarterly 20:148-185.

Tripathi, R.S. and V.K. Sah. 2000. A biophysical analysis of material, labour and energy flows in different hill farming systems of Garhwal Himalaya. Agriculture, Ecosystems and Environment.

U.S. Environmental Protection Agency (EPA). 2013. Clean Energy. http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html. November 10, 2013.

U.S. Government Accountability Office (GAO). 2006. Natural Resources: Woody Biomass Users' Experiences Provide Insights for Ongoing Government Efforts to Promote Its Use. GAO-06-694T. 12 p.

UN-Energy. 2007. Sustainable bioenergy: A framework for decision makers. www.fao.org/docrep/010/a1094e/a1094e00.htm. July 12, 2011.

United States Institute of Peace (USIP). 2013. Social Well-Being. http://www.usip.org/guiding-principles-stabilization-and-reconstruction-the-web-version/10-social-well-being. August 15, 2013.

Upreti B.R. and D. van der Horst. 2004. National renewable energy policy and local opposition in the UK: the failed development of a biomass electricity plant. Biomass and Bioenergy 26:61-69.

Upreti, B.R. 2004. Conflict over biomass energy development in the United Kingdom: some observations and lessons from England and Wales. Energy Policy 32:785-800.

Urban, F. and T. Mitchell. 2011. Climate change, disasters and electricity generation. Strengthening Climate Resilience Discussion Paper 8. Institute of Development Studies. Brighton, UK.

US Forest Service. 2008. Benefits of Woody Biomass Utilization. Woody Biomass Utilization. http://www.fs.fed.us/woodybiomass/benefits.shtml. Nov. 1, 2009.

Ushiyma, I. 1999. Renewable energy in Japan. Renewable Energy 16(1-4):1174-9.

Valavanis, S. 1959. Econometrics: An Introduction to Maximum Likelihood Methods. Mc Graw-Hill Book Company, Inc., New York & London.

van den Broek, R. 2000. Sustainability of biomass electricity systems. Ph.D. Thesis, Utrecht University, Department of Science Technology and Society, Utrecht, the Netherlands. 216 pp.

van den Broek, R., T. van den Burg, A. van Wijk and W. Turkenburg, 2000. Electricity generation from eucalyptus and bagasse by sugar mills in Nicaragua. A comparison with fuel oil electricity generation on the basis of costs, macro-economic impacts and environmental emissions. Biomass and Bioenergy 19(5):311-335.

van den Broek, R., A. van Wijk and W. Turkenburg, 2002. Electricity from energy crops in different settings - a country comparison between Nicaragua, Ireland and the Netherlands. Biomass and Bioenergy 22(2):79-98.

van der Horst, D. and S. Vermeylen. 2011. Social scale and social impacts of biofuel production. Biomass and Bioenergy 35:2435-2443.

Vanclay, F. 2003a. Conceptual and methodological advances in Social Impact Assessment. In Vanclay, F. and Becker, H.A. 2003. The International Handbook for Social Impact Assessment. Edward Elgar Publishing Limited, Cheltenham.

Vanclay, F. 2003b. Social Impact Assessment: International Principles. International Association for Impact Assessment, IAIA Special Publications Series No. 2.

Vertès, A. A. 2010. Axes of Development in Chemical and Process Engineering for Converting Biomass to Energy *in* Vertès, A. A.; N. Qureshi; H.P. Blaschek and H. Yukawa (eds.) 2010. Biomass to Biofuels: Strategies for Global Industries. Blackwell Publishing Ltd., Oxford, UK.

Virginia, H.D., R.A. Efroymson, , K.L. Kline, M.H. Langholtz, P.N. Leiby G.A Oladosu, M.R. Davis, M.E. Downing and M.R. Hilliard. 2013. Indicators for assessing socio-economic sustainability of bioenergy systems: A short list of practical measures. Ecological Indicators 26:87-102.

Vita, A. 1974. A History of Atikokan. 75th Anniversary Booklet Committee.

Volk, T.A., T. Verwijst, P.J. Tharakan, L.P. Abrahamson and E.H. White. 2004. Growing fuel: a sustainability assessment of willow biomass crops. Frontiers in Ecology and the Environment 2(8):411-418.

von Bertalanffy, T. 1968.General System Theory, Foundations, Development, Applications. George Braziller, New York.

Waito, B. And L. Johnson. 2010. A national scan of regulations and practices relevant to biomass harvesting. Report prepared for World Wildlife Fund - Canada and The Forest Products Association of Canada. 45 p.

Wallace, T.D. and J.L. Silver. 1988. Econometrics: An Introduction. Reading, Mass., UK.

Wartburg, W.P.V. and J. Liew. 1999. Gene Technology and Social Acceptance. University Press of America. 338 pp.

Wasserman, L. 2006. All of Nonparametric Statistics. Springer. 1-23 pp.

Weetman, G.F. and B. Webber. 1972. The influence of wood harvesting on the nutrient status of two spruce stands. Can. J. For. Res. 2:351-369.

Wegener, D.T. and J.R. Kelly. 2008. Social Psychological Dimensions of Bioenergy Development and Public Acceptance. Bioenergy Research 1:107-117.

Wisconsin Council on Forestry. 2008. Wisconsin's forestland woody biomass harvesting guidelines. December 16, 2008. http://council.wisconsinforestry.org/biomass/pdf/BHG-FinalizedGuidelines12-16-08.pdf. October 10, 2013.

World Coal Association. 2011. World Coal Association website. http://www.worldcoal.org/coal-the-environment/coal-mining-the-environment/improving-efficiencies/. Oct. 20, 2011.

World Energy Council. 1999. The Challenge of Rural Energy Poverty in Developing Countries. World Energy Council.

World Health Organization (WHO). 2006. The world health report 2002. World Health Organization.

Zerbe, J. 1988. Biofuels: production and potential. Forum for applied research and public policy (winter). http://www.rmmn.org/documnts/pdf1988/zerbe88a.pdf. Nov. 15, 2010.

Zerbe, J.I. 2006. Thermal energy, electricity, and transportation fuels from wood. Forest Products Journal 56(1): 6-14.

Total number of references = 378.

APPENDIX I

QUESTIONNAIRE FOR INDIVIDUAL SURVEY

Name of respondent ______________________________

Name of Community ______________________________

A. Socio-economic profile:

1. Age ---------, Gender------------, Ethnicity---------------.

2. Educational level:

Below Primary	[ ]	Primary	[ ]
12 Grade	[ ]	College Graduate	[ ]
University Graduate	[ ]	Post Graduate	[ ]

3. What is your main occupation?

4. What was your main occupation prior to the present occupation /source of income?

5. How long have you been living at this locality?

6. How many times did you move for job purpose during the last 15 years?

7. On average how much do you spend per month on the following items for household fuel purpose?

Energy Items	Monthly Average Cost ($)	Use for what purpose
a. Oil b. Electricity c. Propane d. Natural gas e. Bioenergy f. Fuel wood g. Diesel h. Coal i. Pellet j. Others		

8. On average what percent of your income do you spend per month on energy purposes?

9. Are you a member of any community organization? Yes [ ] No [ ]

10. What benefits do you receive from the organization?

B. Financial Credit for Business Development

11. Do you own or operate a business? Yes [ ] No [ ]
(If 'No' proceed to question 16. If 'Yes,' please answer the following questions)

12. Have you received any financial credit for your business?
Yes [ ] No [ ]

13. If you answered 'Yes' to Q.12, from whom did you receive the credit? Please state. (e.g., Bank, Fed Nor, Local Development Corporation, Northern Ontario Heritage Fund, Industry Canada, Aboriginal Business Canada, etc.)

14. How has this credit helped you?

15. Have you received any advice or support for business development? If 'yes', from which source? What kind of advice and support did you receive? Please explain.

C. Attitude toward and opinion about community development

16. What do you feel is important or special about your community development? Please rank the following statements by indicating if you: Strongly Agree (1); Agree (2); Neutral (3); Disagree (4); Strongly Disagree (5); or Don't Know/ Not Applicable (9). Please circle the appropriate number.

Item	Strongly Agree				Strongly Disagree	Don't Know or N/A
	←				→	
1. Culture	1	2	3	4	5	9
2. Diverse population	1	2	3	4	5	9
3. Rural values	1	2	3	4	5	9
4. Employment	1	2	3	4	5	9
5. Natural environment	1	2	3	4	5	9
6. Access to amenities	1	2	3	4	5	9
7. Services (banking, transportation etc.)	1	2	3	4	5	9

17. What do you consider important to the quality of life in this community? Please rank the following statements by indicating if you think it is: Very Important (1), Important (2); Neutral (3); Somewhat Unimportant (4); Very Unimportant (5); or Don't Know/ Not Applicable (9). Please circle the appropriate number.

Item	Very Important				Very Unimportant	Don't Know or N/A
	←				→	
1. Clean air and water	1	2	3	4	5	9
2. Good jobs	1	2	3	4	5	9
3. Arts and culture	1	2	3	4	5	9
4. Security and safety	1	2	3	4	5	9
5. Good relations with neighbours	1	2	3	4	5	9
6. Good place to raise kids	1	2	3	4	5	9

18. What do you think is important to consider to enhance the quality of life in this community?
19. Do you feel the quality of life has improved or worsened over the last 2, 5, 10, 20 or 30 years? Why?

Item	Quality of Life		Reason
	Improved	Worsened	
2 Year			
5 Year			
10 Year			
20 Year			
30 Year			

20. What do you envision as an ideal future for this community?
21. Do you see any opportunities for this community?
22. What barriers do you see as limiting sustainable economic development for this community?

D. Individual's attitude toward and opinion about Woody Biomass-based Bioenergy

23. What in your opinion is the purpose of developing wood-based bioenergy projects?

(For the following statements please indicate if you Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), Strongly Disagree (5) or Don't Know/ Not Applicable (9). Please circle the appropriate number.)

Item	Strongly Agree				Strongly Disagree	Don't Know or N/A
	←				→	
1. It is renewable	1	2	3	4	5	9
2. It is affordable	1	2	3	4	5	9
3. It creates job opportunities	1	2	3	4	5	9
4. It creates business opportunities	1	2	3	4	5	9
5. It reduces global warming	1	2	3	4	5	9
6. It generates profit from waste	1	2	3	4	5	9
7. It provides energy self-sufficiency for rural communities	1	2	3	4	5	9
8. It provides energy self-sufficiency for industry	1	2	3	4	5	9
9. To develop alternative energy to fossil fuels	1	2	3	4	5	9
10. Others: please specify	1	2	3	4	5	9

24. Are you concerned about harvesting forest residues for bioenergy? [Yes] [No]

25. If 'yes' to Q.24, what are your main concerns?

26. Are you concerned about harvesting unmerchantable trees for bioenergy? [Yes] [No]

27. If 'yes' to Q.26, what are your main concerns?

28. Are you willing to take advantage of business opportunities arising from bioenergy production programs in future? Yes [ ] No [ ]

29. If 'Yes' to Q.28, what type of business? Please mention.
(supply of residuals/ harvesting of biomass/ transportation of biomass/ collection of forest residues/ grinding of forest residues/ wood chip/ wood pellet etc. for bioenergy production/ other…………………)

30. If yes to Q.28, can you please give some reason why you are willing to involve in the bioenergy based business?

31. If no to Q.28, can you please give some reasons why you are not willing to involve in the bioenergy based business?

32. What are your top 5 environmental concerns? Please mention.

33. How have your concerns about the environment changed over time? (i.e. 20 years ago, 10 years ago, childhood, present concerns)

34. Comments-

(Write your thoughts/concerns about wood-based bioenergy production.)

APPENDIX II

FORMAT FOR FOCUS GROUP DISCUSSION

PART ONE - INTRODUCTION (20 minutes)

FACILITATOR: Cassia Sanzida Baten
ASSISTANCE (flip chart notes; tape recording)

1) Thanks and appreciation for taking time to attend
   a) Introduce myself.
   b) Participants introduce themselves, stating what their interests are in wood-based biomass development.

2) Objective of the focus group discussion: To seek your opinion about the use of wood-based biomass for energy production for the Atikokan area. Explain the focus of the study and who is involved. Provide context (review handout)—why is Atikokan considering wood-based biomass development? We will do a SWOT analysis, exploring what you think are the strengths, weaknesses, opportunities and threats to wood-based biomass development. The discussion will last no more than two hours (promise to end on time).

3) Consent forms. I ask permission to tape record this session. Impossible to ensure confidentiality in group setting. However, there should be no discussion during the session which might cause harm to any participant, and participants are free to discuss the issue among themselves after the session and with others. You are free to leave at any time. You may choose to not participate in any part of the discussion. There are no "wrong" answers; everyone's comments on the topic are welcome and will be incorporated in the study.

4) Any questions or comments before we begin?

PART TWO: PARTICIPATORY DISCUSSION (90 minutes)

INTRODUCTION: Tell me about your community. What are the economic conditions? What is special about the community? What is important to the quality of life for this community? Are services in the community adequate?

First, we will look at the strengths and weaknesses within your community that might contribute to or hinder development of wood-based bioenergy.

TOPIC 1: What are the potential strengths within the Atikokan area that would help to develop wood-based bioenergy?

TOPIC 2: What are the potential weaknesses within the Atikokan area that might hinder the development of wood-based bioenergy?

Next, we will look at the external environment to consider what are the opportunities and threats to the development of wood-based bioenergy in the Atikokan area.

TOPIC 3: What are the opportunities that might be available because of wood-based bioenergy development?

TOPIC 4: What do you think might threaten the development of wood-based bioenergy businesses?

PART THREE - CONCLUSION (10 minutes)
Ask participants if they have any concluding remarks.

Thanks, facilitator's contact information, if anything, comes up later for participants, gifts for participants.

APPENDIX III

QUESTIONNAIRE FOR INTERVIEW

People's Perspectives on Wood Biomass-Based Development

1. Get background information about Interviewee. What is his/her role in the town of Atikokan? How long has he/she lived in the area?
2. Tell me about your community. What are the economic conditions? What is special about the community? What is important to the quality of life for this community? Are services in the community adequate?
3. How have conditions changed since you've lived here?
   What do think the future will bring to the community?
4. Have you been directly involved in projects to use wood biomass for energy development? Please explain in as much detail as possible your expertise in this area.
5. What do you think about using wood biomass for energy production?
6. Why do you think using wood biomass for energy is or is not a good idea?
   (PROMPTS: Good idea: Jobs (how many?), income, green energy, clean air, less carbon, reduce fire hazard
   Bad idea: environmental degradation from overharvesting, loss of biodiversity, costs, unwilling workforce)
7. What are the conditions which might lead to successful wood-based biomass business development?
8. What are the barriers to such development?
9. If there are barriers to develop wood-based biomass energy businesses, do you think these barriers can be overcome? How?
10. Is there broad public acceptance for using wood biomass for energy production? If yes, why is there such support? If no, what are people concerned about?

APPENDIX IV

Table1. Survey participants' opinions (rank) on important factors of community development by percentage of respondents in different categories.

Rank	Culture	Diverse population	Rural values	Employment	Natural environment	Access to amenities	Services
1	32%	9%	20%	62%	37%	17%	22%
2	17%	20%	23%	18%	20%	27%	28%
3	17%	24%	15%	6%	16%	20%	17%
4	12%	12%	9%	5%	8%	9%	6%
5	9%	12%	9%	2%	6%	8%	10%
6	3%	8%	8%	1%	7%	7%	5%
7	7%	9%	9%	6%	6%	8%	9%
9	3%	6%	8%	0%	1%	4%	3%
Total	100%	100%	100%	100%	100%	100%	100%

Note: Rank 1: Most important, Rank 7 = Least important, 9 = No comment/do not know.

Table 2. Survey participants' opinions (rank) on important factors of community development by percentage of responses in different categories.

Rank	Culture	Diverse population	Rural values	Employment	Natural environment	Access to amenities	Services	Total
1	16%	5%	10%	31%	18%	9%	11%	100%
2	11%	13%	15%	12%	13%	18%	19%	100%
3	15%	21%	13%	5%	14%	18%	15%	100%
4	20%	20%	15%	8%	13%	15%	9%	100%
5	16%	21%	16%	4%	10%	14%	19%	100%
6	8%	20%	20%	2%	18%	18%	12%	100%
7	13%	17%	16%	11%	11%	14%	17%	100%
9	13%	25%	31%	0%	3%	16%	13%	100%

Note: Rank 1: Most important, Rank 7 = Least important, 9 = No comment/do not know.

APPENDIX V

Table 1. Survey participants' opinions (rank) on important factors of quality of life by percentage of respondents in different categories.

Rank	Clean air and water	Good jobs	Arts and culture	Security and safety	Good relation with neighbours	Good place to raise kids
1	63%	63%	31%	40%	40%	54%
2	15%	18%	19%	24%	19%	21%
3	10%	10%	14%	15%	11%	12%
4	5%	1%	11%	12%	6%	3%
5	4%	5%	11%	5%	11%	5%
6	1%	2%	11%	3%	11%	4%
7	0%	1%	0%	1%	1%	2%
9	2%	2%	2%	1%	2%	0%
Total	100%	100%	100%	100%	100%	100%

Note: Rank 1: Most important, Rank 7 = Least important, 9 = No comment/do not know.

Table 2. Survey participants' opinions (rank) on important factors of quality of life by percentage of responses in different categories.

Rank	Clean air and water	Good jobs	Arts and culture	Security and safety	Good relations with neighbours	Good place to raise kids	Total
1	22%	21%	11%	14%	14%	19%	100%
2	13%	15%	17%	21%	17%	18%	100%
3	14%	14%	19%	20%	16%	17%	100%
4	14%	2%	29%	31%	16%	8%	100%
5	10%	12%	27%	12%	27%	12%	100%
6	2%	7%	36%	10%	33%	12%	100%
7	0%	20%	0%	20%	20%	40%	100%
9	27%	18%	27%	9%	18%	0%	100%

Note: Rank 1: Most important, Rank 7 = Least important, 9 = No comment/do not know.

APPENDIX VI

Table 1. Survey participants' opinions on the purpose of developing wood-based bioenergy projects by percentage of respondents.

Rank	Renewable	Affordable	Job opportunities	Business opportunities	Reduce global warming	Profit from waste	Energy self-sufficiency	Energy for industry	Alternative to fossil fuel
1	69%	32%	66%	55%	39%	56%	39%	47%	51%
2	10%	15%	19%	19%	11%	15%	12%	21%	16%
3	8%	19%	6%	6%	14%	11%	17%	9%	10%
4	5%	6%	1%	3%	4%	2%	2%	2%	3%
5	1%	2%	2%	2%	6%	0%	4%	1%	1%
6	0%	1%	0%	1%	0%	0%	0%	0%	0%
9	6%	26%	6%	14%	27%	15%	26%	20%	19%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 2. Survey participants' opinions on the purpose of developing wood-based bioenergy projects by percentage of responses.

Rank	Renewable	Affordable	Job opportunities	Business opportunities	Reduce global warming	Profit from waste	Energy self-sufficiency	Energy for industry	Alternative to fossil fuel	Total
1	15%	7%	15%	12%	9%	12%	9%	10%	11%	100%
2	8%	10%	14%	14%	8%	11%	9%	15%	12%	100%
3	8%	19%	6%	6%	14%	11%	17%	9%	10%	100%
4	17%	20%	3%	11%	14%	6%	9%	9%	11%	100%
5	5%	14%	9%	9%	32%	0%	23%	5%	5%	100%
6	0%	50%	0%	50%	0%	0%	0%	0%	0%	100%
9	4%	16%	4%	9%	17%	10%	16%	13%	12%	100%

APPENDIX VII

Barrier: Social Service Sector

	Barriers	Frequency
Government	Government	1
Environment	More pollution due to biomass collection	5
	Pollution due to wood smoke	
	More waste will be produced by wood pellet than coal	
	Possibility to have plastic in pellet	
	Disposal of ash could be a problem	
Cost	Bioenergy procurement cost is high	6
	High transportation cost	
	High start up cost	
	Biomass energy is very expensive than coal energy	
	As cheap source people like to use coal for energy production. Other provinces use coal for energy why not Ontario	
	More production cost is involved	
Supply	Long term supply of raw material (wood) is uncertain	2
	Uncertainty of wood allocation for bioenergy	
Sustainability	Chance of over harvesting forest	4
	Supply availability (long term supply is uncertain)	
	More water needed for switch grass and biomass plantation	
	More land is required for bioenergy production	
Policy	Lack of policy support	3
	Lack of financial support to start biomass plant.	
Market	No market for biomass (pellet)	1
Social	Trade unions are not supportive of bioenergy production because it is modern, mechanized and less manpower oriented	1
No barrier	No barrier	2
No comment	No comment	3

Barrier: Education Sector

	Barriers	Frequency
Government	Lack of communication and initiatives from the government with different stakeholders of bioenergy development.	2
	Lack of long term commitment from government for biomass industry.	
Cost	Bioenergy is more expensive than coal energy. Huge funding is needed to start-up biomass business.	5
	Expensive	
	Transportation cost for bioenergy is more expensive than coal.	
Policy	Not enough incentives, political legislation, wood/land	10

	allocation and licenses	
	Difficult to get license for biofuel production.	
	Lack of political legislation	
	Lack of incentives for biofuel production	
	Bureaucracy, decision for bioenergy development not yet supported by all levels of government. NWO understanding of implications of wood burning acceptance or deterrence	
	Wood supply and allocations are a bureaucratic process.	
	Industry managed forest policies are bureaucratic. Industry manages forest – government oversees and assures adherence to policies.	
	Lack of compensation for transporting biofuel.	
	Permits and access to resource are complicated.	
Social	Wood allocation license for bioenergy is complicated	9
	Needs more consumers – not just residential, large industrial consumers are essential	
	More support for clean coal technology. Willingness to pursue more research on clean coal technology.	
	Live tree harvest is bad. Do we have enough?	
	Toronto views northwestern Ontario as "one wilderness park." Any compensation for community power/energy? Transportation of energy, why so expensive?	
	Lack of communication by OPG with community stakeholders in bioenergy field.	
	Toronto views northwestern Ontario as "one wilderness park." Any compensation for community power/energy? Transportation of energy, why so expensive?	
	Concern about the impact of bioenergy. It could be double-edged sword for the community.	
	Concern about cutting trees for bioenergy	
Supply	Difficult to get wood/land allocation for biofuel production.	1
Sustainability	Fear about resource depletion for utilizing unscientific harvesting for bioenergy. No jobs in the community; so no resource should be destroyed to create quick job.	5
	Low prediction for the hardwood market. Now market for hardwood is low, but it will fight back (supply for biomass).	
	Fear of sustainability of supply of forest resources for new biomass industry when the environmental impact is unknown.	
	Fear about the misuse of timber for biofuel purpose.	
	Concern about sustainable supply for bioenergy.	
Environment	Concern about more pollution for its transportation, production.	3
	Fear about potential site degradation	
	Fear of the nutrient loss in the soil	
Market		0
No barrier		0

No comment	No comment	3

Barrier: MNR Personnel

	Barriers	Frequency
Government	Lack of proper planning. Requires intensive planning.	3
	Lack of decision power for the local forest management personnel involved. Local MNR people are not involved with the OPG plant. It is done by Thunder Bay, Ontario high level officials.	
	Top-down process.	
Environment	Environmental concern for bioenergy development. Government land, more emphasis on environmental concerns.	10
	Concern on burning wood for bioenergy. Burning wood is not economically sound and no environmental benefits.	
	Concern on environmental degradation.	
	Concern on destruction of sound ecological system.	
	Alters land base. Fear for destroying ecosystem.	
	Concern on biodiversity loss.	
	Lack of scientific information about the long term impact of bioenergy development on environment.	
	Concern on possible habitat loss for wildlife.	
	Concern on forest depletion for bioenergy.	
	Lack of scientific information about the long term impact of bioenergy development on environment.	
Policy	Biofuel feedstock is mostly supplied from crown land. There are lot of rules and regulations to use crown land for using private business. Lot of environmental issues and acts need to be considered before starting any different type of utilization, new utilization must follow the sustainable forest certification process.	2
	No regulation about the type of wood used for biofuel.	
Supply	Anxiety for the requirement of large amount of wood.	6
	Concern on long term supply availability of biomass.	
	Concern on large scale supply requirement for bioenergy. Big scale biomass utilization is not acceptable.	
	Concern on land requirement for biofuel development.	
	Concern on land availability for biofuel plantation. How much land is required for this is needs to be considered.	
	Concern on long term biomass availability for bioenergy production. How much trees to be cut for this purpose is need to be considered.	
Cost	Costly. It is far too expensive.	2
	Costly. Wood is far more expensive to handle, far more expensive to use for electricity production.	
Social	Requirement of SFL holders. SFL (Sustainable Forest License)	2

	holders' negotiation is essential.	
	Deals with many players (institutions and organizations) in the production system.	
Market		0
Sustainability	Concern on the supply for the future timber industry. When forest industry is back, then there is no supply for energy production.	1
Other	Lack of communal land and community managed forest. Local forest lands under community management would lead to more control on forest resources which facilitate small industries in the community and increase the local economy strength.	1
No barrier		0
No comment		0

Barrier: APGS Personnel

	Barriers	Frequency
Government	Bureaucratic allocations of resources	2
	Lack of trust on future political support. Political movement must be maintained though other governing platform must be preserved.	
Cost	High cost for energy production	5
	More expensive than traditional coal	
	Price of bio-power should be more costly than coal based power. In Ontario lot of industries closed only for the high price of electricity. If the cost is going up and up and not going down, it is hard to attract the consumers to buy it.	
Sustainability	Uncertainty for the success of new industry. Setting up a new industry is not an easy task.	1
Social	Lack of communication with different levels of stakeholders, such as Ministry of Energy, Ministry of Natural Resources, Ministry of Northern Development, Mines and Forestry and local government.	2
	Down turn of communities' economic condition for mill closures. Communities' sole focus is primarily economic sustainability, enthusiasm of job creation.	
Policy	Lack of incentives. Becomes less attractive to business due to no incentives.	2
Environment	More polluted process (combination of biomass transportation, biofuel production and bio-power development). Impact on environment is of concern, but air quality is exceptional regardless of industry.	1
Supply		0
Market		0
No barrier		0
No comment		0

Barrier: Elected Leaders

	Barriers	Frequency
Government	It is a new idea –"The Jury is still out, with no prospect of immediate agreement."	1
Sustainability	Fear for over-harvesting though it cleans up environment. Biofuel development would utilize unmerchantable and unutilized trees.	1
Environment	Fear of chemical presence in biofuel (pellet) which is bio-power feedstock. The US allows 10% plastic in pellets to be stored outside.	1
Cost	Costly. It is more expensive than coal.	1
Social	More support for clean coal technology. Cleaning up coal is better way to go.	2
	The possible impact on overcoming the recession of Atikokan by bio-power is still unknown. Unknown information in bioenergy is cure for Atikokan recession and energy issue.	
Supply	There is no prospect of immediate agreement for bio-fuel (pellet) development and bioenergy production.	1
Policy	Lack of legislation and landuse policy to support bioenergy. Land tenure comes into question.	1
Market		0
No barrier		0
No comment		0

Barrier: First Nation Organizations

	Barriers	Frequency
Government	Absence of outside funding; INAC funding, government subsidies, etc. for biofuel and bioenergy development.	3
	Options for providing fuel and energy to the First Nations communities by government. First Nations have paid for fuel and energy in the past and till today, it may not be a large change with biomass power for them.	
	Lack of government assistance and legislation	
Supply	Bureaucratic wood allocations and fear about long term supply of biomass	1
Social	Down turn effect of forest industries i.e. mill closure impacts harvesting, which would have negative impact on consumer of chips for biomass etc.	9
	Protests of First Nation communities to build new power line on their traditional land. First Nations have rights to deny power line construction on their traditional land.	
	Lack of communications, incentives and involvement of First Nation in bioenergy development projects. First Nations require benefits of such projects.	

	Fear of uproar for single First Nation community involvement in bioenergy project. May cause turmoil amongst other First Nations communities.	
	Fear for laid off workers. Concern of modern technologies uses for biofuel and bio-power development which would require less workers and which may lead to layoffs.	
	Believes wood pellets are a mistake/trap. Biomass unnecessary. Hydro dams more than enough electricity for northwestern Ontario	
	Lack of proper and cheap transportation facility for biofuel development.	
	Presence of traditional use of wood as fuel in the First Nations communities	
Environment	Anxiety for overuse of water, depletion of forest resource and pollution of air by bioenergy development. Land/water/air preservation; proof of mitigation and protection of those 3 key elements; biggest hurdle.	9
	Concerns on by-product impacts, e.g. Hydro acid	
	Possible destruction of ecosystem for biofuel harvesting.	
	Fear for over-harvesting.	
	Fear for biodiversity loss.	
	Concerns of nutrients loss	
	Fear for plastic in pellet (for wood pellet: 8% plastic, 80% wood and 12% binding materials (glue etc.)).	
	Fear for chemical presence in biofuel (pellets)	
	Fear for toxin release from burning wood	
	Concerns of smoke for surrounding communities from plant	
Cost	Economic barrier – in remote northern nations everything is more expensive and difficult.	6
	Lack of support and communication. Ongoing support and maintenance of facilities are essential.	
	First Nations lack finances to support such industries	
	Presence of cheap hydro power facilities in the communities.	
Sustainability	Absence of long term life cycle (20-25 years) for biofuel and bioenergy development. Short term life span of facility is a large concern within the First Nations communities.	2
	Fear of long term sustainable supply biomass feedstock.	
Market	Biomass market requires less jobs. 800 jobs for mill of equal fibre consumed as pellets plants 40 jobs.	6
	Concern for down turn fibre market. Timber markets will rise again and fibre supply is needed.	
	Concern for wood allocation. Allotted for bioenergy inaccessible to wood market.	
	Lack of market for biofuel. NAFTA agreement limits ability to stop American export.	

	Presence of bureaucracy in marketing of forest products. Wood pellet supply to US must be maintained.	
Other	Lack of proper infrastructure for bioenergy development. Must restructure infrastructure of forest industry so impact is least "contagious"	4
	Absence of power grid connection in the remote communities. Power grid connections to remote communities very difficult.	
	Bioenergy: wood stove, no biomass initiatives.	
	Absence of proper definition of wood biomass for energy. Biomass must be better defined.	
No barrier		0
No comment		0

Barrier: First Nation Individuals

	Barriers	Frequency
Government	Bureaucratic process by INAC and government for bioenergy development. Complicated guidelines by INAC and government for energy production.	4
	Bureaucratic process. First Nation is managed by federal government and APGS personnel in managed by provincial government – lot of regulations and lot of bureaucracy for biomass-based energy generation.	
	Lack of trust in government.	
	Lack of government support for biomass.	
	Government needs better relationship with First Nations. Initiative of community ownership for purchasing plant leads to failure.	
Policy	Lack of proper guidelines and policy for bioenergy development.	3
	Lack of guidelines and policy for the selling price of biofuel and bio-power.	
	Absence of definite land use policy for biomass production.	
Cost	Cost of operation is too much.	8
	Costly. Biomass production and power generation are expensive.	
	Biomass feedstock (wood chip) cost is much higher than coal.	
Social	First Nation community view on bio-power is negative. Most people in the community think using biomass for electricity is a bad idea.	5
	Lack of faith for bioenergy development. Lack of trust for bioenergy development. They do not believe that it can happen.	
	Lack of trust by the financial institution to allocate money to bioenergy developer. Bank is reluctant to give money; stuck as consumer for slow return in biomass development.	
	Negative attitude about biomass-based power development	

	Unwilling to pay bills. First Nations community members are not willing to pay the bill for water, heat etc.	
Environment	Anxiety for overharvesting of biomass.	1
Sustainability	Worried about sustainability of supply.	1
Supply	Worried about supply of wood.	1
Market		0
Other	Presence of welfare facility in the community. To involve in biomass development activity welfare mentality think it may jeopardize the welfare.	14
	Lack of availability information; distance from source to plant is unknown	
	Lack of intra-community relationship for supporting any new small business.	
	Knowledge and interest of credit return is absent in the First Nations community.	
	Lack of knowledge about budgeting skill in the society.	
	Lack of trained operator.	
	For lack of communication and improper motivation the attitude changed from supportive to negative.	
	Lack of education and research in this area.	
	Lack of knowledge and education.	
	Youth displacement from non-industrialized communities.	
	Lack of knowledge/science results to communicate people for bioenergy	
	Lack of communication between buyer (OPG) and retailer (pellet producer).	
	Lack of emphasis to develop value added (wood pellet) products.	
	Lack of education and assistance from OPG side.	
No barrier		0
No comment.		4

Barrier: Local Community Organizations

	Barriers	Frequency
Government	Lack of communication. Government decides.	3
	Lack of First Nation recognition. Needs for First Nation recognition	
	Lack of consultation with First Nation. More consultation is needed with First Nations.	
Cost	Costly. May not produce cheaper power.	3
	Presence of cheaper natural gas and hydro power facilities.	
	Economics is the main barrier.	
Environment	Absence of information on its long term impact in forest. Long term impact of biomass harvesting is a concerning issue.	2
	Fear for overharvesting which leads to depletion of forest	

	resources.	
Policy	Lack of proper policy and legislation. Governments, both federal and provincial, need to change policy and other regulations in favor of biofuel and bioenergy development.	2
	Limiting access to fibre, grass	
Supply	Lack of information about long term availability and supply of biomass for biofuel.	3
	Lack of proper information on species use for biofuel. Underutilized species should be used.	
	Absence of long term purchasing contract with biofuel developer and bio-power producer. The pellet company needs guarantee by OPG to buy a certain percent of pellet before they started to produce pellet.	
Sustainability	Fear about sustainable and long term availability of biomass for biofuel and bioenergy.	1
Social	Lack of First Nation involvement in the project. First Nation involvement in the whole process is necessary; not only for trucking, but also in main activity they should be involved.	1
Other	Long term contract for biofuel (at least 5 year).	4
	Problem for rising Canadian dollar. It is being more competitive due to strong dollar.	
	Lack of scientific information on issues like growing biomass trees, burning nutrients, nutrient loss in soil, biodiversity loss.	
Market		0
No barrier		0
No comment		0

Barrier: Forest Industry Sector

	Barriers	Frequency
Government	Local land under government management (Crown forest) and less policy and regulation to use for small business development which lead to less control on local industry and hamper to increase the local economy. Local lands under community management would lean more to industry and economy strength.	17
	Lack of government cooperation. Government uncooperative – OMNR, MTO (Ministry of Transportation) etc.	
	Lack of quick decision making process. Decisions should be made more imminently – too long to verify, too much bureaucracy and discrepancy with government.	
	Lack of local decision making facility. Ore power issue to local government officials to make decision.	
	Presence of bureaucratic and top down management system. Local government officials who make soil decisions should not be reprimanded severely for a possible wrong decision – fear of	

	making mistake which could cost their jobs.	
	Time consuming and unsupportive MNR process for bioenergy development. Operations stop up to a year before a decision to reroute around obstruction.	
	Not enough support for large bio-power (electricity) plant but have support for local biofuel (pellet) production.	
	Lack of funding is available for bioenergy development. Successful business loan is needed.	
	Lack of financial support for bioenergy development.	
	Lack of trust on governments for future support of bioenergy development.	
	Lack of government incentives for biofuel and bioenergy development.	
	Bureaucracy of government.	
	Lack of incentives for small forest business.	
	Lack of government support for small and medium woody biomass-based industries or business. Government mainly supports large forest industries.	
	“Government red tape”	
	no apparent interest in small business	
	Government must work with small –medium businesses not just large	
Supply	Lack of long term biomass availability and supply. No raw trees for biomass.	7
	Concern for long term supply of raw material.	
	Concern for wood allocation for biofuel production.	
	Long gestation period for biomass development.	
	Uncertainty of bio-power development.	
	Uncertainty of wood supply and crown forest land allocation for biofuel development.	
	Wood supply –competition for supply, market needs to be available and demanding, government incentives/investments.	
Environment	Concern about harvesting whole tree for biofuel and bioenergy.	12
	Concern about plastic in pellets. Plastics in pellets – no use for potash (Ash)?	
	Slow growing forest and poor land.	
	Poor rocky soil condition, not enough nitrogen.	
	Concern on possible environmental degradation.	
	Environmental concern for biofuel development.	
	Negative impact on forest nutrient levels.	
	Concern on overharvest and excess collection of residues.	
Sustainability	Concern on managing continuous supply of biomass for future. Maintain supply for demand.	4
	Concern on sustainable biomass availability.	
	Concern on long term availability.	

	Concern on long term supply availability for biofuel.	
Policy	Lack of government regulations to support bioenergy.	10
	Ontario Power Authority, it is difficult to purchase Ontario Power Agreement.	
	Permanent status of our Sustainable Forest License (SFL), tenure change is needed.	
	Government policy is a barrier. Policy and land a political stumbling block.	
	Absence of International Organization for Standardization (ISO) Certification for biofuel in Ontario. European countries have ISO certified biofuel.	
	Lack of policy and legislation for use of forest land for biofuel and bioenergy purpose.	
	Lack of support, law, regulation etc. for new biofuel development.	
	Bureaucratic and lengthy (time consuming) process of wood allocation system.	
	Hard to get the license for biofuel development.	
	Lack of law and regulation for land tenure and allocation of wood for supporting biofuel development.	
	Lack of law and regulation for licenses, tax, fees, wood supply	
Cost	Cost is the main issue.	14
	Coal is cheaper than the biomass use.	
	Concern about high price of new bio-power.	
	The price of the bio-power would be higher than coal power.	
	High transportation cost for hauling and delivery.	
	Costly. Higher cost is involved for bio-power production.	
	Concern about price of unused tree species increase due to high demand for bioenergy.	
	The start up of biofuel and bio-power is expensive.	
	The beginning stage of bioenergy production is not profitable. The financial support for this stage is necessary. Lack of proper institutions to support this type of business.	
	Availability of cheap hydro power production in northwestern Ontario.	
	More pollution from transportation, hauling and delivery.	
	Competition with other uses than biofuel will lead the price increase of raw material.	
	Utilization of merchantable timber for biomass, increased stumpage rates/reforestation.	
	High tax, fee etc. for biofuel business.	
Social	Concern about using wood for another purpose aside from lumber. General public feel good about waste wood as biofuel.	13
	Concerns about using regular trees for bioenergy.	
	Lack of financial support to buy modern technology based	

	equipment for biofuel transportation (such as Fuel hose tanks).	
	Lack of communication between government, industry, community and First Nation.	
	Lack of communication between government and different stakeholders	
	Concern of First Nation about tree cutting.	
	Unwillingness of people for paying expensive green energy.	
	People won't want to pay increased cost of "green energy."	
	Lack of communication between different parties (government, industry, local government and community).	
Market	Concern for returning market of lumber in future.	4
	Lack of local market for biofuel and bio-power.	
	Lack of market for biofuel.	
	Lack of consumer for bio-power.	
Other	Lack of support, supervision and communication by the local resource controller (manager). "Hiccups" occur even in the best FMPs and operations are shut down until "hiccup" can be re-evaluated – i.e. building a road where an area poses an obstruction and planned road construction cannot proceed.	14
	Lack of safety Infrastructure.	
	Lack of education on biofuel and bioenergy.	
	Concern there will be fewer jobs in bioenergy feedstock production than in traditional managed forest (timber)	
	Concern about availability of proper infrastructure and safety measure. Infrastructure – housing, locals would return for work.	
	Poor information in public – false impressions.	
	Concern about supply from cheaper feedstock by countries like China, Brazil etc. than the locally produced feedstock. Compete Brazil.	
	Overall forestry business is worse now. It would not rise soon.	
	Absence of efficient experts for biofuel and bioenergy development.	
	At present most of the big pulp and paper industries are operating at 30-40% of their normal production capacity. So the supply of forest harvest residues is low.	
	Demand for products, supply of raw material, allowable cut newer (user) issue, few years ago demand for pulp higher.	
	Concern for other uses (fuel wood, sports sticks etc.) of small diameter trees due to bioenergy use.	
	Lack of scientific research and information.	
	New, long time development, going up, show First Nation connected	
No barrier		0
No comment		0