Executive Summary

Concept of this Workbook

This "Pre-Feasibility Workbook for BioEnergy Projects" has been designed as an easy-to-use, flexible tool to assist entrepreneurs, companies or communities to better understand the bio-energy picture in Ontario. The Workbook can be used as a reference in conceiving, planning and developing small biomass-based bioenergy projects. This Workbook considers conversion of biomass through thermal conversion technologies.

The focus of the Workbook material is directed towards combined heat and power projects using forest and agricultural biomass capable of producing electricity up to 10 MW under the Ontario Renewable Energy Standard Offer Program. This program was developed to make it easier for operators of small renewable energy generating facilities to contribute to Ontario's electricity supply. Subject to a number of eligibility requirements, new generators of no more than 10 MW are paid a base rate of 11¢/kWh, and an additional 3.52¢/kWh for on-peak production. In this regard, this Workbook is intended to assist communities and companies in preparing themselves to actively engage in bio-energy projects targeting the Standard Offer Program. However, because the workbook is designed for continual updating and improvement, additions will incorporate new information that adds value to workbook sections addressing biomass supply, technology and processing innovations, economic evaluation, permitting and regulations, project due diligence, and business strategies. The goal is to keep learning and keep advancing toward energy self-sufficiency.

The Workbook provides a literature review for learning and a set of tools to support taking action. The major sections provide:

- A review of biomass supply in Eastern Ontario from both Crown and private land and including forested and abandoned farm lands.

- A review of the thermal conversion technologies, combustion, gasification and pyrolysis, and the primary power systems available for production of heat and power.

- A base-line financial analysis to assess the financial feasibility of projects within each of the three conversion technology categories based on representative systems.

- A review of key elements required in considering a bioenergy business initiative in Ontario.

- Workbook tools designed to:

    - Help communities and developers better understand the critical attributes of forest biomass that can make or break a project (Tool 1).

- Enable communities or companies to organize and map biomass data to determine what and how much is accessible, where it is, and what is available in the future (Tool 2).
- Assist communities and companies to “get started” looking for vendors and developers who may have technology relevant to their project initiative (Tool 3).
- Ensure communities and companies have the appropriate information to conduct a preliminary due diligence on a developer/vendor, their technology and their business model (Tool 4).
- Provide communities and developers with a list of government incentives and subsidies relevant to their project initiative (Tool 5).
- Provide developers and communities with references for a financial analysis tool to evaluate project feasibility and risk (Tool 6).
- Enable communities to prepare and position themselves to capitalize on opportunities or create their own by developing information required by developers or investors to more forward, faster (Tool 7).
- Enable bio-energy project developers to better assess the real energy cost of purchased biomass, and optimize the biomass energy output of their CHP system (Tool 8).
- Provide the person in a community or company who is assigned the task of leading a bio-energy project with a checklist that helps convey the magnitude and complexity of the project and ensure the appropriate experts are engaged (Tool 9).

The Framework for bioenergy projects in Ontario

The development of bioenergy projects that produce heat and electricity through the conversion of biomass are just at their beginning in Ontario. The Ontario Standard Offer Program has been the key driver in stimulating interest. As a result, this Workbook focuses on opportunities that can be implemented now but also within a longer time-frame (5-10 years). The key areas for exploration in the Workbook are: biomass availability; technology readiness; financial analysis; and the business of bioenergy.

Biomass Availability

The categories of forest and agricultural biomass that can be used include:

- Mill residue including heritage piles
- Harvest waste
- Mortality from natural disaster

- Stand management and plantations (agro-forestry)
- Standing timber

Currently, mill residue (primarily bark or "hog" fuel), heritage piles (old mill waste) and harvest residues provide the most cost-effective source of biomass. Standing timber, whether from standing residual, by-passed stands, allocated but not harvested, or mortality from natural disaster (fire, insects, disease, blowdown, etc.) will gradually become more important sources of biomass as ways are found of driving down the collection, processing and delivery costs. In the longer term energy plantations of willow, poplar and other crops on marginal forest or farm lands will come on stream. However, at present, the Ministry of Natural Resources' bio-fiber policy is still under review which creates uncertainty regarding access to and costs of different types of biomass on Crown Land. This is not an issue on private lands.

Limitations exist in Eastern Ontario on the availability of mill residue, both bark and sawdust and shavings due to utilization by existing markets (wood panels, energy, landscaping, horticulture, etc.). However, the economics can change based on the price that can be paid for residues and the technology and processing efficiencies developed**.** For example, in New England and New Brunswick, where integrated processing systems have been employed for utilization of biomass, substantive cost savings have been realized. The Workbook provides general estimates of biomass availability by economic sub-region and reference to mapping tools.

Technology Readiness

Three broad areas of thermal conversion technology and associated power production systems exist to convert biomass to heat and electricity:

- Combustion
- Pyrolysis
- Gasification
- Power Production Systems

For combined heat and power (CHP) units up to 10 MW, only combustion technology can be termed "fully commercial" where vendors exist that can supply turnkey technology with proven long-term performance. Commercial gasification systems for heat production exist and can be found operating in Europe predominantly to support institutional, residential and/or recreational/resort facilities or broader district heating systems. Most of these systems operate within a range of 50 to 250 KW and may not justify the additional cost of power integration. The gasification and power production technology to produce both electricity and heat is evolving and some developers can supply well-tested systems in a prototype configuration which accommodate the 1 to 10 MW range. The current effort in development of gasification technology is in gas cleaning and conditioning to capture increased efficiency for use in CHP systems, and to enable the use of the gas in production of alcohols without risk to the catalysts. A number of government supported projects involving gasification of biomass for energy and/or liquid fuels production were initiated in the US and Canada in 2006/2007. Those studies are still under review.

Although a number of developers in Canada are actively engaged in advancing fast pyrolysis technology, the lack of existing markets for the pyrolysis liquid or standards to ensure consistent quality has hampered progress. Some developers have pyrolysis systems capable of producing bio-liquids that can be burned or co-fired in existing combustion systems to produce heat only, and vendors exist that can supply turbines for the use of bio-liquids to produce heat and electricity. However, burning pyrolytic liquid under continuous operation for sustained periods of time using more sophisticated, higher efficiency systems for power production remains a challenge.

The primary problem affecting most pyrolytic systems if that the liquid produced is very poor quality for energy relative to #2 fuel oil and although it may have some high value chemicals as part of the total chemical mix most are in such small proportions by weight that it could take millions of gallons of through-put to generate enough to satisfy market demand. That being said, a few companies have developed market niches for specialty products like liquid smoke in food flavoring and bio-resins for composite wood products.

More recently a small number of pyrolysis, or pyrolysis-like, systems have surfaced that appear capable of producing a pyrolytic liquid that is far superior to the traditional fast pyrolytic liquid as an alternative source of energy or transportation fuel. At this time, only one of those systems is targeting plant biomass as the primary feedstock. This appears to be because the profit margin is greater and the technological issues easier for the waste material of choice.

Guiding Principles for Bioenergy Business Development

The following guiding principles are synthesized from this Workbook, from literature reviewed, and personal experiences of contributors and advisors. The principles cover the harvest-to-market value chain. They reflect issues, precautions or reality checks, and opportunities. These practices are an attempt to represent the situation as it exists and to help prepare bioenergy project developers to be well-positioned for the future.

Business development is more than just demonstration of technological proof of principle. It embodies multiple components, each an integral part of the business system. The Workbook is designed to encourage the reader, whether a developer or a partner on a project, to consider all elements relevant to the success of a bio-energy business system. Each element is critical and has the potential to “trip you up” if neglected. More often than not, it is the lack of attention to the details of the business system that sinks the ship.

A key point – avoid repeating old mistakes. Reading the literature, talking to the experts, convening a local team that includes knowledgeable individuals from different disciplines (e.g. engineering, forestry, agriculture, finance, etc.), and asking questions and requiring answers, are fundamental to a successful, non-painful venture. The literature between 1970 and 2007 provides a wealth of information on what not to do, what to do, and what’s uncertain. Much is already proven and re-inventing old problems translates into loss of time and money. But, it does not hurt to repeat old tests if there is uncertainty in the results. The following are words to the wise.

Understand the markets

- The main driver for small heat and power plants should be the production of heat for a well-defined user. Electricity will be sold directly into the grid under the conditions of the SOP. While the revenue from electricity sales can make the project financially viable it should not be the project driver. Be clear – right from the start - about the ability and costs to hook up to the grid.
- If you are already in the industrial sector considering a CHP project for your heat production, be aware that the “energy business” is a new segment likely to be outside of your core business and for which new skills may be required.
- Generally, for every 2 Megawatts of heat 1 MW of electricity can be produced.
- Line up a customer or customers that can use the heat (industrial, greenhouses, community infrastructure and district heating). As much as possible contract with customers for year-round use and for an extended period of time. Understand that the price of the heat will have to be lower (or more secure) than current alternate sources (natural gas, heating fuel, electricity) in order to provide an incentive for customers to switch.
- Don’t scrap the project if the CHP scenario appears to be unprofitable. Investigate a heat only option. Remember, in northern latitudes heat can be the major component of the total energy consumption package.
- Identify by-product opportunities. Depending on the technology employed there can be ash, which is used in cement production or as a soil amendment, or char (or carbon black), which can have a variety of uses depending on the quality.
- Regardless of the technology, the availability of biomass supply, or government incentives, make sure you have a solid, sustainable market for your product before flipping the go switch.

Understand Biomass Supply

- A developer from outside your region is not likely to have a good appreciation for the biomass supply data – make sure they listen to you and understand all the implications of what you and your experts convey to them about biomass supply.
- Identify and map all the available types of biomass in your catchment area. Even for small projects establish a capture radius of at least 100 km.
- To help ensure a longer-term sustainable supply consider ownership models, lease options and/or local cooperatives, don’t just rely on short-term contracts.
- Conduct a burn test by a reputable laboratory to determine the actual combustion characteristics of the biomass mix – the amount of energy derived from a given amount of biomass (Figure 1, Business of Bioenergy section). You may need both a

proximate and an ultimate analysis. A reputable engineering firm can assist, where required.

- Determine delivered costs of the biomass to the plant site and account for biomass preparation costs, e.g. cleaning, sizing, drying, etc.

- Establish a standard biomass mix that will be consistent in physical characteristics and cost over time. This is critical for larger projects that use multiple sources of biomass.

- To maximize efficiency and minimize costs you should know the BTU/pound value of biomass from each of your suppliers and pay according to the energy value, not the delivered weight. For example, biomass at 50% moisture has an energy value of about 4,200 BTUs/pound, while at 20% moisture it is close to 7,000 BTUs/pound. Don't pay for water, pay for energy.

- Know the limits of the technology regarding key biomass attributes (moisture content, ash production, piece size, etc.). The developer should be explicit in articulating this type of information.

- Don't allow the developer to underestimate the challenges and costs of handling, transporting and processing biomass. Use local experts to ensure the supply side of the equation is accurate.

- Recognize that the moisture content of biomass can increase during storage. This may or may not be a serious problem depending on the technology. If dry material is required (pyrolysis, downdraft gasifiers, etc.) then consider this when selecting different biomass types in your area and provide for drying and covered storage.

- Drying of biomass should be considered from a number of different perspectives: a) reducing transportation costs, b) increasing the energy value of a given amount of biomass, and c) the importance of creating a consistent, higher energy value mix for burning.

- Biomass supply chains need to be developed and optimized. This can be done by both technology and process innovations. Where possible, conventional equipment should be used and modified, as appropriate, to capture efficiencies.

- Different technologies have different biomass attribute requirements. Regardless, the key point is that any conversion reactor needs biomass inputs that are consistent and standardized on a day to day basis. This can be a significant challenge and demands a well conceived biomass strategy.

Assess the technology

- The only real thermal conversion technology that is commercial as of 2008 is combustion technology. Anything else is a "demonstration" project.

- For whatever combustion technology you finally select, you will need to go through a conceptual engineering phase to understand heat requirements and processes, especially if the technology will replace a current industrial boiler. You will need to develop a profile of your requirements to which potential technology vendors can respond and provide what you need rather than just what they sell.

- There are new technology and/or process innovations entering the mix all the time. Try and select a technology/process solution that easily accommodates future adjustment and advancement so you are well positioned to keep pace, keep efficiencies high, and drive costs down.

- Don't get talked into a project or technology just to get in the game – there is plenty of time to do it right.

- The building and ancillary facilities for the power plant should be sized to accommodate the equipment required. Allowance for expansion is recommended. Where possible, existing infrastructure should be considered, but beware of trying to force a round peg into a square hole just to save bucks.

- The permitting and regulatory pathway needs to be well understood, particularly as it relates to hidden fees (hiring experts to be able to provide what is required), actual policy-based hurdles of note, and situations where it is not so much the policy as it is the interpreter that can impede the process. Be prepared to be patient as you work through the many complications of permitting and regulation.

- Demonstration projects are risky. Ensure that the business is strong and that the project financing is sufficient to fully capitalize the project, including the unforeseen events likely to occur during the demonstration and pre-commercial phase

- Where possible, establish a cooperative relationship between the developer, local industry and a 3rd party research organization to work together on the demonstration project. The objective is to create efficiencies, minimize costs, resolve problems, and stay focused.

- Determine whether a scale up involves infrastructure enlargement or replication of a modular unit that is already operational. The risks of the former are much greater than the latter.

- Maintain focus on the objective – continual side-tracking to "innovate" reduces attention to process detail – detail that is essential to a successful demonstration. Beware of developers that lack focus, are easily distracted and do not consider your needs and interests.

- Third party validation should always be considered in evaluating a project proposal by a developer or vendor – it is strongly recommended. The evaluation should include the technology, the business and the financing.

- Gas cleaning and conditioning remain the largest problem in gasification. If someone tells you their technology can provide a gas clean enough for use in alcohol production, check it out.

- There are a number of issues unique to gasification, pyrolysis and combustion technologies. Establish an expert team in your community/business responsible for asking the right questions (or learning what questions to ask) and getting the right answers.

- Just because you get burnt in a project that was not immediately viable don't give up. Identify your mistakes and correct them. Many of the principles and points in this document arise from communities and companies that were not as diligent as they needed to be given the risk and uncertainty involved.

Ensure good business planning

- Get in Sync! All the components of the "business" need to be in place and in sync, or detailed plans to that end confirmed.

- A detailed, comprehensive business plan is essential to provide investors or banks with what they need to conduct a due diligence evaluation of the project. If you have never developed a business plan for a bio-energy project, then don't hesitate to engage those who can provide advice.

- For projects over 2 MW, the project is an "energy business", not a modification of a lumber, paper or composite wood production business. It is a different business requiring its own set of corporate priorities and business objectives to fully capture its potential.

- Fully understand capital and operating cost structures for the particular project. Currently the capital/engineering cost per MW for units under 10 MW is in the range of $2.5 million to $4 million per MW. *That cost can drop considerably for a heat only strategy, particularly in smaller systems.*

- A good resource for financial planning is "RETScreen", a model available through Natural Resources Canada (See www.retscreen.net). This is a unique tool developed with the contribution of experts from government, industry and academia. Its purpose is to reduce the cost of pre-feasibility studies by sharing knowledge. The product has a particular application for small-scale heat and power plants. It does not replace the need for engaging experts, but it does help those responsible for a project better understand what is required to assess viability.

- Ensure that the Business Plan correctly assesses the risks and how such risks can be minimized, i.e. uncertainty associated with long-term biomass supply, long-term commitments for use of heat, reliability of the technology, etc.

- Make the bio-energy investment decision based on a solid, realistic analysis of the risks and rewards as it relates to the entire value chain, harvest to grid, for at least a 10-year project life.

- Apart from the Government of Ontario Standard Offer Program, other incentives may be available from the provincial and federal governments, depending on the region of the province. Incentives may also depend on the status of the project proponent, such as whether the proponent is private sector, a not-for-profit corporation, or a municipality.
- Fully understand the regulations with which the project must comply, particularly those of the Ministry of the Environment and the Ministry of Natural Resources. Under the Standard Offer Program, an environmental assessment is not required for projects under 5 MW.