

# Economic and Social Drivers for Optimal Bioenergy Implementation



IEA Bioenergy

IEA Bioenergy: Task 43: 2019:01

# **Economic and Social Drivers for Optimal Bioenergy Implementation**

William A. White, Kingsmere Economics Consulting, Edmonton Canada

Biljana Kulisic, Energy Institute Hrvoje Pozar, Zagreb Croatia

Copyright © 2019 IEA Bioenergy. All rights Reserved

**Published by IEA Bioenergy**

# TABLE OF CONTENTS

<b>TABLE OF CONTENTS .....</b>	<b>1</b>
<b>1. Abstract.....</b>	<b>1</b>
<b>2. Introduction .....</b>	<b>2</b>
1.1. What is economics and who are the players in the economy? .....	3
1.2. How do agents make choices about bioenergy? .....	4
1.1.1. The assumption of “full information” .....	4
1.1.2. Households.....	5
1.1.3. Firms .....	5
1.1.4. Government .....	7
1.1.5. NGOs.....	8
1.3. Conclusion: A social science research agenda for bioenergy .....	8
<b>3. References.....</b>	<b>10</b>

## **1. Abstract**

If bioenergy is to become an important part of the energy mix it must pass the tests of being technically, economically, and socially feasible and then must be chosen ahead of other feasible solutions such as fossil fuels. This paper focuses on the economic and social drivers for optimal bioenergy use. The agents or players in the economy that make the decisions about how much and what kind of energy to include, are households, firms, and governments. Nongovernmental Organizations (NGO) are not an agent in the economy per se but play an important role in the decision-making processes of other agents; their role is also outlined here. The paper outlines how these agents make decisions and proposes potential research for better understanding how these decisions affect the agents' choices with respect to including bioenergy in their energy choices. The primary goal of this paper is to provide those with understanding of the biological, chemical, engineering, or other technical aspects of bioenergy insight into the economic and social aspects that will ultimately determine if projects are undertaken.

## 2. Introduction

Despite recent declines in fossil fuel prices, bioenergy remains a means of providing an alternative source of energy that garners considerable interest and has the potential to supplant traditional energy sources for a portion of the world's energy needs. Bioenergy can be more than a renewable energy source if managed with knowledge: a carbon-sink with a global influence, a domestic source of clean, affordable, storable and secure energy that allows breaking free from fossil energy imports and a tool to create improved living conditions in rural economies, where biomass is largely produced, and even in cities with the availability of municipal solid waste.

A simple list of admirable qualities of bioenergy is not enough to warrant its inclusion in the bioenergy mix. First of all, bioenergy must show itself to be technically feasible; this has been accomplished as it is already in use for tasks as simple as fuel for cooking and as complex as providing heat and power at various scales. Once technical feasibility is achieved, engineers, scientists and others can strive to make these applications more efficient, that is, to provide greater levels of output for each unit of input.

Secondly, projects must pass the test of economic and social feasibility. Practice has shown that, regardless of how marvelous or brilliant a technological application may be, in bioenergy or any other field, it will not achieve widespread use unless society deems it acceptable. Later in this paper, economic and social feasibility will be shown to merge into one concept but let us begin by separating the concepts. Social feasibility carries one extremely important feature: environmental responsibility that is, often, treated as a separate criteria due to its significance in facilitating sustainability. The rest of the social aspects such as rural exodus, ageing of rural population, low education rates etc. are wrapped up as social criteria. We decide to treat environmental concern under the social criteria for simplicity of delivering the message.

If we isolate economic feasibility into a world where there are no social concerns, it could simply be called financial feasibility. If society has no concerns beyond simply producing energy (i.e., pollution, other externalities, regional employment, security of supply, etc. are considered irrelevant), a project need only be considered on its financial merits. Feasibility can be defined as benefits exceeding costs, including the opportunity cost of capital (Zhang and Pearse 2011). The best energy solution, if we are only considering financial merit, will be the one that provides firms with the greatest profit.

When social concerns are considered, economic or financial feasibility is not a sufficient condition to choose one privately funded project over another. A project may have social merits that supersede financial feasibility. A classic example in economics would be significant negative externalities produced by a financially feasible project. In these cases, the market fails to deliver an optimal solution and governments may intervene on behalf of society to ensure that a socially feasible solution is achieved.

The goal of this paper is to provide a simplified view of the thought processes of an economist when looking at the role of bioenergy in the world's energy supply. The paper is not intended for economists, who should already have a firm grasp of these concepts, but for *non-economists* wishing to better understand the social and economic drivers and barriers associated with determining the amount of bioenergy used in the world economy and the potential for increased use. Equations, formulas, and jargon will not be used and economic and social terms will be defined where appropriate. Few references are included in the paper as the economic concepts are basic enough to found in an introductory textbook. We do not seek to make groundbreaking new discoveries in this paper but to provide an introduction to non-social scientists and introduction to how economics will ultimately affect the choice to use bioenergy.

The paper begins by providing a definition of economics and explaining the roles of the various agents in the economy. The section that follows discusses how these agents make choices about using bioenergy and outlines the primary drivers and barriers for each agent. The paper concludes with sections outlining research projects to improve the knowledge base of those involved in the bioenergy sector and some concluding remarks. Most of the bioenergy examples are drawn from forest bioenergy but the principles could be applied to other forms of bioenergy. Where heat or electricity is mentioned in an example, we assume it comes from bioenergy. Spatially the concepts apply anywhere where a mixed market economy is in place. That is, economies that are primarily market based but the government plays a role through regulation, taxation, and other policy measures. This includes most of the worlds' economies.

### **1.1. What is economics and who are the players in the economy?**

Economics is the study of choices or in other words the study of human behavior as related to the production, distribution, and consumption of goods and services. Specifically it is about choosing how to use scarce resources to bring about outcomes that are in an entity's best interest. In this case, the entity considered is society. Scarce, in this context, simply means there is not enough for everyone in society to have as much of the resource as they want. We see that in the broadest sense, pursuing economic utility is not about money; it focuses on choices that bring about well-being and those cannot always be measured in monetarily.

This money-free definition of economics also brings about the blending of economic and social goals noted earlier. Choices by households and governments, and sometimes firms are often characterized as social or economic tools. For example, a carbon tax on fossil fuels is viewed as an economic policy tool while encouraging employment in rural and remote communities is normally considered a social policy tool. In reality, any policy aimed at altering agents' behaviour is an economic policy tool. Economics is about entities' (households, firms, and government (acting for society) for example) behaviour in response to the choices placed before them. Whether those choices are altered by economic policy changes or social policy changes, the resulting change in behaviour is an economic phenomenon as entities seek to make themselves as well off as possible, and not only in terms of currency. In sum, all choices that affect agents' behaviour are, by definition, economic even if they are made to effect a social outcome.

Three general groups or entities make the majority of decisions in the economy. These are called agents and include: households, firms, and government. While these three are generally considered the agents in the economy, we will also discuss NGOs (Non-governmental Organizations) as they play an important role in the bioenergy economy. To gain an understanding of how much bioenergy is produced and consumed in an economy, one must appreciate how households, firms and governments make the decision of what to produce and consume and, in the case of government, how and when to intervene in the economy to influence the decisions of households and firms when market-based decisions fall short of what the government believes to be socially optimal. NGOs do not have the power as government to alter the income distribution but have a significant role in providing information. One could argue that the information is only aimed at achieving the NGO's desired end, but it is information and can potentially affect an agent's decision. A household is an individual or a group of people living together who form a decision-making unit. Households make decisions about what goods and services to purchase based on their preferences or likes and dislikes, and supply labour to firms and government. People are assumed to make rational choices constrained by budgets, by laws, by social norms, and other factors to make themselves as well off as possible. To reinforce the point made previously about economics going beyond financial or money measurements, "As well off as possible" does not mean in a financial sense only, but reflects the households' sense of well-being, by whatever measure they choose. The collection of choices that make a household as well off as

possible, forms a utility function. In its simplest form, a social welfare function may be defined as the collection of all individual utility functions and measures how well off society is as a whole.

Firms, ranging in size from the largest multi-national corporation to the smallest at-home business, buy inputs from various markets to produce goods and services and pay wages, interest, and rent in return for services provided. Economic theory portrays firms as profit maximizers. They choose optimal levels of capital, labour and other inputs and a production process to meet this end. Firms may also make choices simply because they believe it is the right or ethical thing to do. The issue here is not why firms are acting ethically and responsibly but to recognize that while the profit maximizing motive may carry the most weight in this function, other elements may also be present (Baumol 1977). Firms are managed by individuals who may have strong elements of ethical behaviour in their utility functions. Consumers might prefer to choose socially responsible goods and services over those that a firm's profit orientation provides at lower price, or consumers might prefer to choose the lower price goods. This paper will only look at firms' choices to produce bioenergy.

Governments also consume goods and services to increase social welfare through redistribution of income and wealth through laws, taxes and subsidies, as well as pay households and firms for services. The goal of all these interventions is to increase social welfare by collectively making the people better off even if it is at the expense (loss of utility or profit) of some individual agents. In the area of environmental regulation, the social welfare function may include future generations as well as our own.

NGOs are organisations that can have a significant influence on society by advocating a position or set of actions on a topic of concern or interest. NGOs are diverse in form, actions and topics they address. According to the UN, any kind of private organization that is independent from government control can be termed an "NGO", provided it is not-for-profit, non-prevention, and not simply an opposition political party (Davies, 2014). A special and more organised form of influence held by international NGOs is demonstrated by their role in developing global Agenda 21. (UN, 2011)<sup>1</sup>.

## **1.2. How do agents make choices about bioenergy?**

This section assesses what drivers exist that may encourage agents to use bioenergy rather than other available energy choices and the barriers or constraints that discourage agents from choosing bioenergy. The discussion begins with a barrier common to all agents: the lack of full, accurate information.

### **1.2.1. The assumption of "full information"**

In developing a model of a perfectly competitive economy, economists assume that agents have full information with respect to their choices. That is, households are assumed to have perfect knowledge of the goods and services available to them, their prices and the satisfaction they will gain from their choices. In the case of bioenergy, they would even have knowledge of the reliability of their energy choice and even the subtle differences between the heat provided by natural gas versus district heating versus fuelwood or pellet stove. They would know also if that bioenergy comes from sustainably sourced feedstock, if purchasing that particular energy form improves the well-being of the feedstock producer, and if their choice and willingness to

---

<sup>1</sup> United Nations Conference on Environment and Development. ["Agenda 21 – Chapter 27: Strengthening the Role of Non-governmental Organizations: Partners for Sustainable Development, Earth Summit, 1992"](#). [Habitat.igc.org](#). Retrieved 2011-12-20.

potentially pay more for bioenergy actually contributes to the well-being of the future generations. Firms have a perfect understating of labour and capital markets and production technology. In a perfect market economy<sup>2</sup>, governments would not need to intervene so the information dilemma is not important for them. In reality this level of information does not exist and the allocation of resources will not be optimal.

Agents to whom the choice of energy source is important may make an effort to close this information gap. Others may not believe it is an optimal use of their time to research the information necessary to switch to any energy system that uses bioenergy. The question of the information gap will be revisited in the discussion of the role of government in determining the amount of bioenergy used in the energy mix.

### **1.2.2. Households**

A consumer may choose a furnace, stove or boiler that uses pellets, chips, or other woody material for space heating or/and hot water in their home. A district heating plant powered by bioenergy may provide service in their area or a new bioenergy plant is to be erected. In some cases electricity may be available from a bioenergy source. What drivers can potentially lead households to act to increase bioenergy's share of the energy market and what may limit the desire of households to use bioenergy? For many households, cost in terms of capital investment and energy will be a primary concern. A secondary consideration will be the perception of the security and comfort related to supply of bioenergy. A third consideration may be the perceived affect on the community and/or the environment. If the bioenergy supply is of local origin, it may provide employment opportunities or improved welfare due to a larger local tax base. Locally supplied bioenergy may also be perceived by some as harmful to the environment if they believe forests are being cut beyond renewable limits or that air quality is reduced. In some areas, there may be concern that fuel is replacing food production on the land from which it is sourced.

Households may expect that the bioenergy utility company will behave in a socially responsible manner or implement sustainability in its code of business conduct. since its work, in some cases is supported by taxpayers' money. If faced with a tight budget constraint, the desire to be "a good environmental citizen" may be less important in households' utility functions than having funds to purchase other necessary goods and services. Other non-monetary factors may also enter the household's utility function such as "doing the right thing" for the future generations (Sims and Richards, 2004). The lack of full and accurate information has already been noted above as a potential barrier to households choosing bioenergy, although perceived trust or goodwill of a firm might override the information gap. Many bioenergy suppliers will be relatively new entrants in a community's economy and there may be real or perceived concerns about levels of support and service. Poor service could lead to a shorter lifespan or inefficient operation for new equipment. This would be particularly important in cold climates where households must have confidence that service can be obtained on short notice.

### **1.2.3. Firms**

The firm can become an agent in the bioenergy market either in response to pure market forces or in response to government regulations and/or subsidies and taxes. If government gets involved in the market, it must foster long term market development to provide an environment for long term profitability, since profitability is the underlying driver that encourages firms to get involved with

---

<sup>2</sup> A perfect market economy is a theoretical construct that acts a base from which events in the economy can be compared. See Zhang and Pearse (2012) or any introductory economics textbook for a discussion of the characteristics of the perfect market economy.



bioenergy. A firm cannot realistically enter a market without the expectation of sustainable profits. Since initial profitability may only stem from government assistance (e.g. tax treatments, subsidies), a firm may be unlikely to enter a market if it does not see a clear path to profitability in the absence of such assistance. Once in the market and operating profitably, firms may make the choice not to maximize profits (e.g. reducing profits to act socially responsibly), but these choices cannot go so far as to eliminate profits. A firm link is difficult to establish between corporate social responsibility and increasing profits since almost all firms try to act in a socially responsible manner. Governmental interventions such as taxes or sudden policy changes may reduce profits or even drive firms from their core businesses.

A firm can be involved in bioenergy in a number of ways such as: producing bioenergy for its own use; producing bioenergy as its core business; and/or becoming a bioenergy consumer. A firm might gradually involve itself in bioenergy depending on how backward and forward linkages and market systems are being developed. The lack of existing supply chains and services may also discourage firms from entering this market (Silveira et al. 2006). In addition, the lack of support from the financial sector in terms of loans or high investment costs is also an important obstacle. Each of these roles is described briefly below in the context of drivers and barriers. Yet, as highlighted in the section dealing with households, a firm involved in bioenergy would look beyond short term profit to long term horizons.

Production of bioenergy for the firm's own energy needs may result in energy cost savings and thereby improve profits. Technological development might find solutions where the investment in bioenergy production from the firm's core business residues pays for itself through energy savings. Waste treatment policy or/and the desire to be a good corporate citizen may also be the drivers that encourage recycling of, for example, forest industry mill residues that would no longer be left to accumulate or simply burned off. These residues could be used for bioenergy and may represent a lower-cost disposal alternative or positive image in public. This level of engagement in bioenergy is usually the first step in bioenergy utilisation because it is the least complicated since exogenous obstacles (such as legal framework, backward and forward linkages etc.) are minimised and the agent has total control over the full life cycle of the energy source. The lack of capital represents the most important obstacle for a firm at this level. Bioenergy utilisation necessitates a certain level of investment that might require support from financial institutions. Other drivers that may discourage the uptake of bioenergy in firms are similar to those facing households. Lack of information and know-how, concerns about long term supply of inputs, perceived risk associated with change, and concerns about service could all impede a firm's increased use of bioenergy.

Considering bioenergy production as a core business presumes the existence of a bioenergy market. A company must know the answers to the fundamental economic questions of how, what, and for whom to produce, within a clear legal framework as well as the procedures related to administrative permits. Profit as a driver is at its peak, meaning, bioenergy must have a positive investment appraisal when compared to the next best alternative. The same applies when creating a backward linkage such as producing or/and supplying biomass although this business activity could manifest itself as product differentiation or expanding the core business. A company could decide that it is better to sell its biomass (e.g., waste) in the market rather than utilise it for its own energy purposes. This could be either because of excess supply of biomass or shortage of biomass (its availability is not sufficient to reach the economies of scale for its own bioenergy production) or simply, the firm might be risk averse towards a new business concept such as bioenergy.

The firm may purchase heat or electricity produced by firms using bioenergy. Improved profits are the key driver here too. If the supplying firm is local, supporting the local community may also be

an important reason to use bioenergy. However, the reliability of supply and trust in bioenergy as an energy source might be the turning point for consuming bioenergy from a third party. In this position, a firm as an agent in the bioenergy market has similar behavioural characteristics as an individual consumer.

#### **1.2.4. Government**

This section considers all levels of government from civic to county or region to state or province to national governments. Where private firms were seen as responding primarily to the driver of profits, actions by governments may be driven by a desire to improve social welfare regardless of the role they are playing in the bioenergy sector. The primary energy-related drivers for a government seeking to improve social welfare are: energy security, energy supply, energy affordability and adapting to and mitigating climate change. However, different drivers do not necessarily assume different policies. Corporate profitability balanced with improvements in overall standard of living will also be a component of social welfare.

In the mixed economy (primarily free market with government intervention to mitigate market failure) that varies in degree of intervention depending on the current ruling party, the extent and the role of government in bioenergy market will be defined by the general governing style/system. While governments may participate directly in the bioenergy economy as an owner of a production facility, policy development that affects the behaviour of households and firms is a more common role for governments in the bioenergy economy. Governments -- through taxes, subsidies, statutes and regulations can have a direct impact on household utility and firms' profits. The usual tools for assisting the start-up of bioenergy firms or the continuing operations of these firms are either influencing the price (i.e. feed-in tariffs) or quantity (i.e. quotas). These policies must be tailored to the dominant drivers of the agents (noted above) in the bioenergy market. For example, government subsidization of district heating may help firms overcome barriers to enter the market and may allow them to profitably sell energy at lower prices than they could otherwise. Profitability is the primary driver for a firm (or lack of profitability the primary barrier). But helping the firm with this driver is not sufficient to ensure a successful market is created and more bioenergy is used in the economy. Even if, in this example, households were provided with a lower cost option, there are other barriers such as confidence in the new technology/energy source that must be overcome if a market is to be developed. Households and firms must have confidence that policies remain stable and non-conflicting regarding the bioenergy market. (White et al 2013) This does not mean policies cannot be changed, but that policy changes must reflect rational, non-conflicting actions toward desired outcomes. While not related to bioenergy, an example can be drawn from solar energy where governments have been reducing subsidies as the price of materials comes down. Firms are expecting this and can respond appropriately.

Governments at all levels face barriers in their efforts to encourage growth in the bioenergy sector. The lack of information has already been introduced as an overarching barrier to the growth of the bioenergy sector. From the economist's view, governments can supply information in a cost-effective manner but will only do so if the cost involved would be justified by the resulting increase in social welfare. This can be done through demonstration projects, funding and dissemination of research results, various forms of media, pamphlets, web sites, or social media that inform potential customers and producers about bioenergy.

The primary driver for governments to get involved in bioenergy is to improve the overall welfare of their citizens. Governments at all levels may invoke policies aimed at improving global economic welfare. Policies to mitigate climate change would be an example of this.

Governments face barriers in increasing bioenergy use. Gaps exist in information needed to make optimal/effective choices. Limited budgets constrain available resources and bioenergy is just one

of many topics to which limited research budgets can be directed. Governments also answer to all sectors and geographies in the economy. Potentially conflicting actions across the same as well as across different levels of government may make achieving consistent policies in this area challenging. For example, a local government interested in local control of energy supply and more local jobs may opt for a bioenergy project. Hypothetically this could take jobs away from another region of the country where let's say, poverty was an extreme problem and these job losses only exacerbate the problem. The national government, interested in social welfare on the national scale sees this action as decreasing overall social welfare. A similar challenge faces governments negotiating international agreements. Would a government trying to contribute to global welfare actually harm what is perceived as its own country's welfare?

### **1.2.5. NGOs**

NGO is an organisation where people are involved voluntarily and they can be present in the bioenergy market either as promoters or opponents to specific or overall bioenergy projects and politics. NGOs are advocacy groups but tend to present their message as "independent and objective information". Due to its informal structure, and narrow focus, NGOs are flexible and can, at times, spot a controversial issue before government. Many local, national and international NGOs participate in bioenergy market worldwide, and in some cases, their efforts facilitate discussion across all levels of agents in bioenergy markets. In other cases, NGOs advocate for specific positions and actions in line with their beliefs. For example, in the EU, NGOs involved in bioenergy have had a strong influence in shaping future bioenergy policy.

### **1.3. Conclusion: A social science research agenda for bioenergy**

How can research assist in informing the effective integration of bioenergy into the global economy? Bioenergy is a dynamic system with emerging issues and a constant complex learning path. Research on the technical, economic, and social aspects of bioenergy are all essential to understanding how bioenergy can be used effectively in the economy. The focus in this paper is on social and economic issues, but research must integrate economic, social and technical issues to effectively and objectively inform policy. For example, if a new method to remove biomass from the forest is being researched, could economic and social considerations be included in the same study?

Research focused on households could improve our understanding of the attitudes and values that drive consumer energy decisions, including bioenergy, within households. Studies by Haider et al (2012), Kraxner et al (2009), and Wegner and Kelly (2008) are some examples of attitudinal studies directed at bioenergy but new studies could be directed specifically at households and their attitudes. Attitudes and values as well as investment and cost concerns likely vary from country to country and within countries from region to region. An initial multinational study with a large enough sample to cover multiple regions in the countries surveyed could begin to help illuminate and quantify any such differences. Clearly, such studies would be large, complex and potentially expensive undertakings needing international collaborative research efforts to succeed.

Firms can act as either producers of bioenergy, consumers, or both. In their role as consumers, cost studies such as those described above for households would be valuable. Production cost studies across different technologies and commercial scales would be valuable. Market studies complementary to attitudinal studies for households would also be valuable as they would provide information on both the supply and demand sides of the market. Technologies, various feedstock supply chains, taxes, and other factors are simply too different to create one study that will serve everyone. Such a complex situation would require multiple studies with efforts to integrate the research questions and results.

Ideally governments, along with universities and other research partners, would be the source of

much of the independent research noted above. Government will need information on the impact that policies will have both on the bioenergy sector and other sectors of the economy and how the changes may affect economic opportunity and public welfare including income distribution and regional equity. Studies using computable general equilibrium models could be used to achieve this. Policy consistency can be better achieved if governments have access to sound research on the expected impacts of the policy **before** the policy is implemented (White et al 2013). A wide variety of research methods can be applied to provide needed policy analysis.

NGOs could also play an important role in any future research agenda but including them as a full partner has proved challenging. Their presence on the ground, connections with local groups, and communication skills bodes well for key contributions to research but their projects are often goal-oriented and short term in nature. This conflicts with academic research which is often long term and interested in creating new knowledge as opposed to quickly solving problems. These conflicts may be overcome by talking early on in a project and developing projects together (Green 2016). The research studies needed to address these issues would quickly overwhelm the most generous of research budgets. It may be most effective to undertake a study to prioritize the research to be done. It may be that the most valuable study initially may be a comprehensive study of attitudes and values as that could inform both researchers and policy-makers about critical gaps in bioenergy understanding of most interest or importance.

### 3. References

- Baumol, W. J. (1977), *Economic Theory and Operations Analysis*. 4<sup>th</sup> Ed. Prentice-Hall Englewood, NJ
- Davies, T. (2014) *NGOs: A New History of Transnational Civil Society*. Oxford University Press. New York, NY.
- Green, D. (2016) Academics and NGOs can work together in partnership but must do so earlier and with genuine knowledge exchange.  
<http://blogs.lse.ac.uk/impactofsocialsciences/2016/10/19/why-is-it-still-so-hard-for-academics-and-ngos-to-work-together/> Accessed 2018/12/9
- Halder, P., P. Prokop, C. Chang, M Usak, J. Pietarinen, S. Havu-Nuutinen, P. Pelkonen, and M. Cakir (2011) International Survey on Bioenergy Knowledge, Perceptions, and Attitudes Among Young Citizens. *Bioeng.Res* 5(1) 247-261.
- Kraxner, F., Yang, J., Yamagata, Y. (2009): Attitudes towards forest, biomass and certification – A case study approach to integrate public opinion in Japan.
- Bioreso. *Techno*, 100 (2009): 4058-4061
- Silveira, S., L. Anderson, A. Lebedys (2006), Opportunities to boost bioenergy in Lithuania. *Biomass and Bioenergy* 30(12) 999-1082
- Sims R. E. H. and K. Richards (2004), Bioenergy for the global community, *Renewable Energy World* 7 (1), 128-133
- Wegener, D. and J. Kelly (2008) [Social psychological dimensions of bioenergy development and public acceptance](#). *Bioeng.Res* 1:107-117
- White, W., A. Lunnan, B. Kulisic. (2013) The role of governments in renewable energy: The importance of policy consistency. *Biomass and Bioenergy*. 57:97-105.
- Zhang, D. and P. Pearse (2012) *Forest Economics*. UBC Press, Vancouver, British Columbia



#### **Further Information**

IEA Bioenergy Website  
[www.ieabioenergy.com](http://www.ieabioenergy.com)

Contact us:  
[www.ieabioenergy.com/contact-us/](http://www.ieabioenergy.com/contact-us/)