

**Measuring the Political Legitimacy  
of  
Biorefineries in Europe**

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## **Abstract**

It is likely that a high degree of political support will be required to realise the biorefinery concept in reality, as capital intensive technology development and stimulation of the most promising technologies for biorefineries requires that government will need to invest heavily before industry has the confidence in biorefinery technologies and bio-based product markets to invest fully. However, among the many problems facing such an innovative business concept as biorefineries, their relative lack of ‘political legitimacy’ is especially critical, as both entrepreneurs and crucial stakeholders may not fully understand the nature of biorefineries, and their conformity to established institutional rules (cultural norms and laws) may still be in question. Following a school of institutional thought that has existed explicitly since the 1990s, Aldrich and Fiol (1994) advocate that lack of political legitimacy translates into a lack of access to “capital, (product) markets and governmental protection”, thereby hindering the progression from the founding of the completely new activity, in an institutional void, through to its development as a legitimate industry.

Whether the massive complexity and lack of clarity surrounding what biorefineries actually are, will hinder the future of biorefineries in Europe is a subject that warrants research. There is a great deal of work required in many areas to understand the mechanisms that will allow the biorefinery to progress beyond its current formative (research) phase. Therefore, one area truly worthy of early attention is to delineate the level of cognitive and political legitimacy of biorefineries (i.e. the level of understanding, acceptance, and support of biorefineries).

Undertaking such a complex task could require a vast amount of resources and the work that will follow on from this thesis (part of a Pan-European research activity) does not have access to such resources. Therefore, a short, succinct, cost effective and “streamlined” approach to understanding whether political legitimacy is a key barrier for the progression of biorefineries needs to be undertaken. In order to do this, it necessary to first understand the key areas of political interest or tension surrounding biorefineries, and the governmental structures that will have an influence on their progression. Thus, the author perceived it necessary to first understand “what” to measure; hence this thesis establishes the political importance and implications of the production and use of biorefinery products, and the cognitive essence of the biorefinery concept (i.e. the technicalities of what a biorefinery is or could be). The author perceived that it was also necessary to determine “who” to measure; hence this thesis identifies the target audience that will have the greatest impact on the progression of biorefineries within the European political sphere. Once these critical factors were identified, a method for determining “how” to go about measuring political legitimacy was required; hence, the focus problem for this thesis lies in understanding how existing knowledge, indicators and literature can be used to determine a logical and streamlined way to measure the “political legitimacy” of biorefineries in Europe.

By gaining a measure of the political acceptance for implementing biorefineries in Europe, we can better understand the manner in which this new area of business and industrial activity can emerge and many of the benefits associated with CO<sub>2</sub> emission reductions, energy security, rural development etc, anticipated by the proponents of biorefineries can be achieved. Thus, a matrix that describes an approach to devising questions around each of the key areas identified to be important to gaining political legitimacy for biorefineries has been developed. It is envisaged that these questions will underpin the development of a set of questionnaires and in-depth interviews within a Pan-European research activity, the answers to which will enable the political legitimacy of biorefineries in Europe to be determined.

**Key words:** Cognitive legitimacy, political legitimacy, integrated industrial biorefinery.





## Executive Summary

While recognising the important role of fossil fuels in the economies of the world, there exists an opportunity for the global economy to be run by means that have less negative impact on the environment because they discharge less CO<sub>2</sub> when utilised. The use of biomass is one pathway towards energy systems and chemical production systems that represents a carbon-neutral renewable resource for the production of primary energy and other bio-based products (e.g. biofuels, solvents, plastics, resins, etc). The biorefinery concept offers the combination of the necessary technologies, biomass raw materials, industrial intermediates, and final products to enable the rearrangement of petroleum based economies to more sustainable ones. However, bio-based product markets also have very broad social and policy related implications associated with them including the potential stimulation of rural and agricultural based economies, energy security issues, environment and land-use issues, and CO<sub>2</sub> emission reduction strategies. However, due to the massive complexity and lack of clarity surrounding what biorefineries actually are, and what implications their encumbering systems can have for the communities that host them, it is unclear whether they can truly offer a course towards atmospheric CO<sub>2</sub> stabilisation and energy security.

Whether the massive complexity and lack of clarity surrounding biorefineries will hinder their progression is a subject that warrants research. There is a great deal of work required in many areas to understand the mechanisms that will allow biorefineries to progress in Europe beyond the formative (research) phase and into the development (pilot) phase. However, among the many problems facing such an innovative business concept as biorefineries, their relative lack of 'political legitimacy' is especially critical, as it is likely that a high degree of political support will be required to realise the biorefinery concept in reality. *The focus problem of this thesis lies in understanding well enough how we can go about determining a logical and streamlined way to measure the level of this 'political legitimacy' of biorefineries in Europe.* This will enable decision makers to focus on the best ways to stimulate the emergence of this new area of business and industrial activity.

Aldrich and Fiol (1994) have established a comprehensive theoretical framework, that links cognitive and socio-political legitimacy to industrial creation that can be adapted to determine a way to measure political legitimacy. Although their framework distinguishes between cognitive and socio-political legitimacy, these two concepts are closely intertwined and often difficult to separate. Therefore, in order to measure the political legitimacy of biorefineries in Europe, the author deemed it necessary to not only understand the *political importance and implications of the production and use of bio-based products*, but also the *cognitive essence of the biorefinery concept* (i.e. the technicalities of what a biorefinery is or could be).

### **Political importance and implications of the production and use of bio-based products**

In order to adapt the identified framework to the context of the biorefinery concept, the political importance and implications of the production and use of biorefinery products needs to be understood. The key areas identified as important to the target audience include: the EU regulatory framework, energy security, CO<sub>2</sub> emission reduction, agriculture and forestry, employment and rural development, environment and land use, economy, genetically modified crops, and sustainability. Each of these key areas was described and analysed in detail in order to determine how they will relate to the progression of biorefineries in Europe. From these key areas, a number of contentious issues were identified as having the potential to dramatically affect the political legitimacy of biorefineries including: the disputes surrounding the CO<sub>2</sub> emission reduction capabilities of biomass feedstocks for the production of bio-based products, the contention between the development of 1<sup>st</sup> and 2<sup>nd</sup> generation biomass conversion technologies and feedstocks, the disputed success of CAP amendments to

encourage energy crop production, and the social issues surrounding genetically modified energy crops.

### **The cognitive understanding of the biorefinery concept**

Even though this thesis concentrates on the measurement of political legitimacy, the author discovered that cognitive legitimacy is so closely intertwined into the potential for political leaders to accept and support a new business concept, that the cognitive essence of biorefineries (i.e. what they are or could be) and the lack of clarity surrounding them also needs to be defined. The key areas identified as important to the target audience include: the biorefinery concept itself, feedstocks and products of biorefineries, technologies required for biorefineries, having a working definition of a biorefinery, the lack of clarity of stakeholders in understanding what a biorefinery is or could be, and defining who the “innovative entrepreneurs” of biorefineries are. Each of these key areas was described and analysed in detail in order to determine how they will related to the progression of biorefineries in Europe. From these key areas, a number of contentious issues were identified as having the potential to dramatically affect the political legitimacy of biorefineries including: cost effective 2<sup>nd</sup> generation conversion technology is complicated and still under development, the general concept of a biorefinery is unclear as there is no convergence around one dominant design, and biorefinery definitions vary significantly between experts. One important aspect of the work undertaken by this author was to define biorefineries as *‘integrated industrial biorefineries’*, in order that political stakeholders are able to differentiate them from the currently existent ‘partial biorefineries’ (that may co-produce biofuels, heat and power, for instance) and devise a description for them that would enable the target audience to understand the concept better:

The *integrated industrial biorefinery* is analogous to the petroleum refinery where an abundant raw material composed of a diverse range of renewable biomass is converted (through an array of processes) into a number of products including transportation fuels (e.g. bioethanol, biodiesel, etc), other bio-based products (e.g. paints, solvents, plastics, resins, agricultural chemicals, industrial surfactants, etc), and energy.

However, throughout this thesis, the terms *‘biorefinery’* and *‘integrated industrial biorefinery’* are synonymous.

### **Findings and implications**

In general, many of the signals that scholars of organisational ecology such as Aldrich and Fiol (1994) propose as indicators of cognitive and socio-political legitimacy are evident for *integrated industrial biorefineries* (albeit indirect in many cases). This is especially apparent in the underlying ground swell of support in the form of policy interventions that favour the cultivation and use of biomass for the creation of energy, transportation fuels, and also some specifically aimed at other bio-based products and biorefineries. Top-level political support for *integrated industrial biorefineries* in Europe is not difficult to find (i.e. the Kyoto Protocol at a global governance level, and the plethora of EU level policy interventions at the European governance level). For example, the EU’s vision for biofuels - Biofuels in the European Union: A Vision of 2030 and Beyond - specifically mentions the importance of developing “integrated refinery concepts”. National level support will also be imperative for the progression of *integrated industrial biorefineries* from their present formative (research) phase to the demonstration (pilot) phase, and beyond. Even though there is evidence of political support (e.g. CHRISGAS and BioFuels Region projects), it is not obvious whether the level of support will be adequate to drive the

progression of biorefineries quickly enough for them to contribute to the outcomes required in a number of policy interventions (such as the Kyoto Protocol, the EU Biofuels Directive, etc). This will be imperative for the measurement of political legitimacy, as large-scale investments will be required for technologies that may take up to 10 years to develop – a time scale that is realistically beyond the period of any political stakeholder to be in power, which makes it highly unlikely that any political benefit will be gained by making decisions to progress biorefineries now.

Once the various components contributing to the legitimacy of *integrated industrial biorefineries* were understood and defined, the author applied them to the theoretical factors influencing the legitimacy of new business concepts. Through this method the author examined these factors and established how they fit within the biorefinery context, thus determining criteria and a number of specific strategies upon which the legitimacy of *integrated industrial biorefineries* can be measured. These strategies have been transcribed into a matrix that describes an approach to devising questions around each of the key areas identified to be important to gaining political legitimacy for biorefineries. It is envisaged that these questions will underpin the development of a set of questionnaires and in-depth interviews within a Pan-European research activity, the answers to which will enable the political legitimacy of *integrated industrial biorefineries* in Europe to be determined.

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# 1 Introduction

While recognising the important role of fossil fuels in the economies of the world, there exists an opportunity for the global economy to be run by means that have less negative impact on the environment because they discharge less CO<sub>2</sub> when utilised and are more equitably distributed across the globe. The biorefinery concept offers the combination of the necessary technologies, biomass raw materials, industrial intermediates, and final products to enable the rearrangement of petroleum based economies to more sustainable ones. The importance of biomass derived energy and other bio-based products is recognised by major policy shifts at the macro level in the European Union (EU), the United States of America (US) and even developing economies. The media is also awakening to certain aspects of the issues surrounding climate change and humanity's excessive use of fossil fuels. However, due to the massive complexity and lack of clarity surrounding what biorefineries actually are, and what implications their encumbering systems can have for the communities that host them, it is unclear whether they can truly offer a course towards atmospheric CO<sub>2</sub> stabilisation and energy security.

Following an established school of institutional thought, lack of political legitimacy hinders the progression of new activities through to their development as legitimate industries. Therefore, the relative lack of 'political legitimacy' of biorefineries is especially critical, as their political importance incorporates such diverse issues as energy security, CO<sub>2</sub> emission reduction, agricultural and forestry policy, employment and rural development, environment and land use issues, the economy and sustainability. Therefore, one area truly worthy of early attention is to delineate the level of political legitimacy of biorefineries (i.e. the level of understanding, acceptance, and support of biorefineries) amongst the European political sphere. This will enable decision makers to focus on the best ways to stimulate the emergence of this new area of industrial activity.

Within this introductory chapter, issues relating to the use of fossil fuels, the biorefinery concept, and a theoretical framework for measuring political legitimacy have been outlined in Chapter 1.1. The aims and objectives have been defined in Chapter 1.2 and the research undertaken in this thesis has been justified in Chapter 1.3. The methodology used has been clearly defined in Chapter 1.4, as has the scope and limitations in Chapter 1.5. Finally, an overview of the thesis has been provided in Chapter 1.6.

## 1.1 Background

### 1.1.1 Climate change and fossil fuels

Scientific consensus amongst 2500 of the world's recognised climate scientists is clearly expressed in the reports of the Intergovernmental Panel on Climate Change (IPCC). Thus indicating that the issue of climate change is no longer under dispute within the international scientific community. Further, the IPCC (2007) implies that Earth's climate is being affected by human activities, concluding:

“Most of the observed increase in globally averaged temperatures since the mid-20<sup>th</sup> century is *very likely* due to the observed increase in anthropogenic greenhouse gas (GHG) concentrations. Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns.”

The IPCC (2007) also establishes carbon dioxide (CO<sub>2</sub>) as the most important anthropogenic GHG, whose global atmospheric concentration has strikingly increased since the industrial revolution as a result of fossil fuel burning. The majority of this fossil fuel burning has been performed by the electricity generating industry and the petrochemical industry, for production of a plethora of chemical compounds (transport fuels, solvents, detergents, plastics, resins, lubricants, etc). Along with climate change problems associated with the release of CO<sub>2</sub> during fossil fuel burning, comes the problem that crude oil, one of the most commonly utilised fossil fuels, is so unevenly distributed across the globe (75% of the world's oil supplies are in the Middle East) (Dufey, 2006). This fact has caused the volatile and non-competitive price structures surrounding fossil fuels and the dependency of the majority of the world on imported fuels as a primary energy source, which in turn, imposes grave energy security risks to countries that are reliant on their import.

The most commonly utilised fossil fuels are crude oil, coal and natural gas. These were simply biomass<sup>1</sup> that has been converted into hydrocarbons (compounds composed of hydrogen and carbon) by the application of heat and pressure over millions of years under Earth's surface (Fossil fuels, Encarta Encyclopaedia Online, 2007). Within an integrated petroleum refinery, a combination of processes (such as distillation, thermal and catalytic cracking) is used to extract hydrocarbons from fossil fuels (Fossil fuels, Encarta Encyclopaedia Online, 2007). These hydrocarbons range from bulk amounts of product with low value (such as transportation fuels), to small amounts of product with very high value (such as specialised chemical products), and a lot of other products in between.

### 1.1.2 The biorefinery concept

While recognising the important role of fossil fuels in the economies of the world, there exists an opportunity for the global economy to be run by means that have less negative impact on the environment because they discharge less CO<sub>2</sub> when utilised and are more equitably distributed across the globe. With energy demand projected to increase by more than 50% by 2050 (Ragauskas, et al., 2006) an increasing demand for finite petroleum resources cannot be sustained for very much longer. In addition to efforts to reduce end-use energy demand, establishment of a course towards atmospheric CO<sub>2</sub> stabilisation will require rapid development of primary energy sources that do not emit CO<sub>2</sub>.

There are many pathways towards energy systems and chemical production systems that discharge less CO<sub>2</sub>; however, there is no leading given pathway in this regard. For example, possible candidates for alternate primary energy sources can include solar and wind energy, biomass, nuclear (fission, fusion and/or hybrids) and fossil fuels from which carbon has been sequestered (Hoffert, et al., 2002). However, at the present time, all of these possibilities are encumbered with difficult inadequacies that limit their ability to stabilise the global climate.

The use of biomass is one such pathway that represents a carbon-neutral renewable resource for the production of primary energy and also other bio-based products. Mankind can replicate the petrochemical refining processes - both the "creation process" (feedstock creation) and the "conversion and value adding process" (refining) - with freshly grown

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<sup>1</sup> "Biomass is a general term for living material – plants, animals, fungi, bacteria. Taken together, the Earth's biomass represents an enormous store of energy. It has been estimated that just one eighth of the total biomass produced annually would provide all of humanity's current demand for energy. And, since biomass can be regrown, it is a potentially renewable resource" (Australian Academy of Science, 1999).

carbon neutral biomass taking the place of fossil fuels. In essence, the “biorefinery” concept is analogous to the petroleum refinery where an abundant raw material composed principally of renewable biomass is transformed (through an array of processes) into a number of products including transportation fuels, biomaterials (e.g. dyes, paints, polymers, etc), biochemicals (e.g. agricultural chemicals, industrial surfactants, etc), and direct energy (Ragauskas, et al., 2006).

This “biorefinery” concept offers a solution to some (or all) of the demands for the production of bio-based products together with sound environmental practices, sustainable use of renewable resources and for products complying with consumer health, safety and environmental requirements. It also has the potential to better manage and capture value from the production of biomass-derived fuels (e.g. bioethanol and biodiesel) and other bio-based products. However, alternative fuel and energy markets based on biomass also have very broad social and policy related implications associated with them – not all of these being shared by “competing pathways”. These include: energy security issues, CO<sub>2</sub> emission reduction strategies, the stimulation of rural and agricultural based economies, and environment and land-use issues.

There are also competing interests, technologies, technical systems and trade-offs associated with each and every pathway towards energy and chemical production systems that discharge less CO<sub>2</sub>. Political lobbying by vested interest parties, or opponents, can be a critical barrier to legitimacy, sometimes a very deliberate barrier (Aldrich and Fiol, 1994). For instance, political lobbying by the oil and coal industries is still strong enough to continue the global energy supply status quo (Vertes, et al., 2006) in the face of rising concerns regarding climate change and the fast approach of what Deffeyes (2001) refers to as the “peak oil point” or the “point in history where oil production will peak and then start to decline”. In addition, there are also socio-economic and environmental concerns surrounding the production of biomass feedstocks. These potentially adverse effects include deforestation, risks to biodiversity, decreased food security, risks associated with genetic modification, soil degradation and erosion, and water pollution.

Kamm, et al. (2006a) demonstrates that biorefineries offer the combination of the necessary technologies, biomass raw materials, industrial intermediates, and final products to enable the rearrangement of petroleum based economies to more sustainable ones. However, the biorefinery concept is massively complex and difficult to define/ There is also a distinct lack of clarity surrounding them and the impact that their incumbent systems have on the communities that will host them. Therefore, fundamental to progression of the biorefinery concept is that the theory, processes, inputs and production capabilities of the biorefinery are clearly defined, understood and articulated.

### **1.1.3 “Legitimacy” of biorefineries**

The biorefinery is an innovative business concept that is currently in its formative ‘research’ phase and therefore faces the many difficulties of all new businesses. Aldrich and Fiol (1994) claim that these difficulties include creating new markets, raising capital from sceptical sources, and recruiting potentially inexperienced employees. They go on to suggest that one of the major constraints facing innovative business concepts is their lack of cognitive legitimacy. Cognitive legitimacy refers to stakeholders’ knowledge about the new business concept and what will be required for its success (Ranger-Moore, et al., 1991). Confusion at all levels impedes implementation and in the absence of extensive comprehension of their business concept, entrepreneurs may have difficulty gaining support from vital stakeholders. For

example, Aldrich and Fiol (1994) assert that this was obvious within the nascent biotechnology industry, where confusion surrounding the testing procedures for manipulation of DNA was so unclear and misunderstood that it faced tremendous obstacles in gaining government approval. Therefore, where entrepreneurs can establish clarity, comfort, understanding and non-ambiguity of novel technical systems, cognitive legitimacy can be achieved much faster, which becomes vital to their success.

It is likely that a high degree of political support will be required to realise the biorefinery concept in reality. Aldrich and Fiol (1994) suggest that another major constraint facing innovative business concepts is their lack of socio-political legitimacy. Socio-political legitimacy refers to the value placed on a new business concept by "cultural norms and political authorities" (Ranger-Moore, et al., 1991). As we gradually begin to make the shift from a petroleum based economy to one of renewable biomass sources, it is imperative that politicians, policy makers, technologists, manufacturers and the general public maintain a clear understanding of the challenges and opportunities that lie ahead in actively driving fossil fuel change management (Vertes, et al., 2006). Therefore, one area truly worthy of early attention is to delineate the level of understanding, acceptance, and support of biorefineries amongst the European political community.

Although the framework devised by Aldrich and Fiol (1994) distinguishes between cognitive and socio-political legitimacy, these two concepts are closely intertwined and often difficult to separate. Therefore, in order to measure the 'political legitimacy' of biorefineries in Europe, we need to understand the political importance and implications of the production and use of biorefinery products, but also the cognitive essence of biorefineries (i.e. the technicalities of what a biorefinery is or could be).

#### **1.1.4 A model for legitimacy**

Whether the massive complexity and lack of clarity surrounding what biorefineries actually are, will hinder the future of biorefineries is a subject that warrants research. There is a great deal of work required in many areas to understand the mechanisms that will allow biorefineries to progress beyond the formative (research) phase. Once we understand what a biorefinery is or could be, where the lack of clarity around biorefineries originates (determining "cognitive legitimacy") and gain a measure of the level of acceptance for implementing biorefineries within disparate political circles (determining "socio-political legitimacy"), we can better understand the manner in which this new area of business and industrial activity can emerge and process towards all of the benefits associated with CO<sub>2</sub> emission reductions and energy security can be improved. The focus problem for this work lies in understanding well enough how we can go about determining a logical and defensible way to measure the "political legitimacy" of biorefineries in Europe. However, undertaking such a complex task could require a vast amount of resources and since the work that will follow on from this thesis (part of a Pan-European research activity) does not have access to such resources. Therefore, a short, succinct, cost effective and "streamlined" approach to understanding whether political legitimacy is a key barrier for the progression of biorefineries needs to be undertaken.

Aldrich and Fiol (1994) have established a comprehensive theoretical framework, that links cognitive and socio-political legitimacy to industrial creation, that is well recognised within the academic field of organisational theory. They propose a number of determining factors that affect an industry's legitimacy and strategies that can be practised by innovative entrepreneurs to overcome legitimacy obstacles and enhance the chances of the industry to

succeed. This framework has successfully been applied by many other scholars; for example, to determine the liability of newness associated with new biotechnology firms (Katila, 1997), to assess the cognitive legitimacy of new enterprises on potential customers (Shepherd and Zacharakis, 2003), and to determine the influence of a business' legitimacy on the flow of capital into high technology enterprises (Deeds, et al., 2004). This thesis will apply the well-established theoretical framework of Aldrich and Fiol (1994) to determine a logical and streamlined way to measure the “political legitimacy” of biorefineries in Europe.

## 1.2 Purpose

**This thesis aims to understand how existing knowledge, indicators and literature can be used to determine a logical and streamlined way to measure the “political legitimacy” of biorefineries in Europe.**

In order to achieve this, the following objectives will be undertaken:

1. A framework for understanding the factors that influence and enhance the political legitimacy of new business concepts will be described.
2. The political importance and implications of the production and use of bio-based products will be explored and the various impediments or drivers for the progression of biorefineries will be analysed.
3. A clear definition of what a biorefinery is, or could be, will be established.
4. An understanding of where the lack of clarity surrounding biorefineries originates will be established.
5. A strategy for understanding and measuring the political legitimacy of biorefineries in Europe will be developed.

## 1.3 Justification of research

There are a number of consortiums, national groups, researchers and private investors, within Europe and the US for example, that are working to facilitate the progression of the biorefinery from its current formative (research) phase towards the demonstration (pilot) phase. These actors will be further investigated in Chapter 4.7. One Pan-European research network, BIOPOL, was established through the EU's 6<sup>th</sup> Framework Program for Research and Technological Development in order to better achieve “sustainable management of Europe's natural resources and their integration with human activities, specifically in the materials and chemical industry, bioenergy and fuels” (BIOPOL, 2006). In recognition of the need to comprehend the potential implications of the biorefinery concept, this network has committed to improve understanding of “the status (technical, social, environmental, political, and implementation) of the biorefinery concept and it's implications for agricultural and forestry policy” (BIOPOL, 2006). In order to fulfil its commitments, BIOPOL has established a project that seeks to measure the political legitimacy of biorefineries in Europe. It is envisaged that the outcomes of this thesis will feed directly into this project.

This thesis is one small project within all of the current activity surrounding biorefineries that is intended to generate valuable knowledge required by the BIOPOL agenda:

1. To enable the political legitimacy of biorefineries in Europe to be determined;
2. To enable decision makers to focus on the best ways to stimulate the emergence of this new area of industrial activity; and
3. To contribute to the partial fulfilment of the research agenda of the Biomass Action Plan of the European Commission (Commission Proposal COM(2005)628 final).

## 1.4 Methodology and its justification

This thesis undertakes to integrate research, knowledge development and problem solving, to capture information that cannot otherwise be predetermined. This thesis adapts a framework linking cognitive and socio-political legitimacy to industrial creation, to enable the legitimacy of innovative new business concepts to be measured. The framework is then applied to the various components contributing to the legitimacy of biorefineries, in order to determine criteria and a number of specific strategies upon which the legitimacy biorefineries can be measured in Europe. The units of analysis are the key factors affecting the cognitive and political legitimacy of biorefineries. The variables that characterise the legitimacy of biorefinery systems, have been identified as the EU regulatory framework, energy security, CO<sub>2</sub> emission reduction, agriculture and forestry, employment and rural development, Environment and land use issues, economy, genetically modified crops, sustainability, and the biorefinery concept itself. In order to conduct this research, both quantitative (the existence of policy interventions, and statistics from reports and databases) and qualitative (descriptions and opinions) data has been gathered as analysis of the variables.

Review of literature, other documents and media published by key actors and stakeholders has been conducted. These documents included technical studies, research articles, legal documents (e.g. EU policy directives and communications), conference presentations, textbooks, and media articles. The key topics and search words that have been used in order to completely capture the areas of study, are shown in Table 1-1.

Review of interview transcripts conducted by Associate Professor Philip Peck, Lund University, of key personnel within chemical industries undertaking R&D into bio-based products has also conducted.

Table 1-1 Key topics and search methods for undertaking literature review

Key topic	Search method	Search word
Legitimacy	ELIN, Lovisa, Libris, Europa, EurActiv, Google scholar, ENDS.	“cognitive legitimacy”, “political legitimacy”, “socio-political legitimacy”, “defining legitimacy”, “measuring legitimacy”, “enhancing legitimacy”.
Biorefineries	ELIN, Lovisa, Libris, Europa, EurActiv, Google scholar, ENDS.	“biorefinery”, “biorefineries”, “industrial biorefineries”, “integrated industrial biorefineries”.
Biofuels	ELIN, Lovisa, Libris, Europa, EurActiv, Google scholar, ENDS.	“biofuels”, “political implications of biofuels”, “Europe biofuels”.
Bio-based products	ELIN, Lovisa, Libris, Europa, EurActiv, Google scholar, ENDS.	“bio-based products”, “biofuels”, “biomaterials”, “biochemicals”, “bioplastics”, “green chemistry”.

## 1.5 Scope and limitations

This thesis is limited to determining a logical and streamlined strategy for measuring the political legitimacy of biorefineries in Europe. It is not intended that this thesis will carry out the actual measurement of political legitimacy for biorefineries in Europe. This will be an area for future research.

Achieving the complex task established by the aim of this thesis could require a vast amount of resources. Since the work that will follow on from this thesis (part of a Pan-European research activity) does not have access to such resources, this thesis seeks out to devise a short, succinct, cost effective and “streamlined” approach to understanding political legitimacy.

Although it is envisaged that the strategy devised as an outcome of this thesis will be applicable to any political sphere, this thesis concentrates on Europe, namely the EU. Due to the commitments of the BIOPOL network, the strategy developed in this work will in the future, first focus on an assessment of political legitimacy in Sweden. It is envisaged that the work will then be replicated throughout the other BIOPOL network countries (i.e. the Netherlands, Germany, the UK, Poland and Greece) as part of a Pan-European research activity.

## 1.6 Overview

The literature regarding organisational theory provides a framework around which the political legitimacy of new business concepts can be analysed and enhanced. This framework links cognitive and socio-political legitimacy to industrial creation, and can be adapted to enable the legitimacy of innovative new business concepts to be measured, a task that has

been undertaken in Chapter 2. In order to apply this framework to the context of the biorefinery concept, the political importance and implications of the production and use of biorefinery products needs to be understood, a task that has been undertaken in Chapter 3. However, because socio-political and cognitive legitimacy are so closely intertwined, the cognitive essence of biorefineries (i.e. what biorefinery is or could be) and the lack of clarity surrounding them also needs to be defined, a task that has been undertaken in Chapter 4.

Once the various components contributing to the legitimacy of biorefineries are understood and defined, the next step will be to apply them to the theoretical factors influencing the legitimacy of new business concepts. Therefore, within Chapter 5, the author examines these factors and establishes how they fit within the biorefinery context, thus determining criteria and a number of specific strategies upon which the legitimacy biorefineries can be measured. These strategies are summarised and transcribed into a matrix that describes an approach to devising questions around each of the key areas identified to be important to gaining political legitimacy for biorefineries, a task that has been undertaken in Chapter 6. It is envisaged that these questions will underpin the development of a set of questionnaires and in-depth interviews within the BIOPOL Pan-European research activity, the answers to which will enable the political legitimacy of biorefineries in Europe to be determined.

## **1.7 Conclusion**

This Chapter laid down the foundations of the thesis. The research problem, aims and objectives have been introduced. The research was then justified, the methodology was described, and the scope and delimitations were defined. Upon these foundations, the thesis can now proceed with a detailed description of the research.



## **2 Theoretical background and analytical framework**

### **2.1 Introduction**

There is a great deal of work required in many areas to understand the mechanisms that will allow a move from a fossil fuel towards a biomass-based economy. However, among the many problems facing such an innovative business concept as ‘biorefining’, its relative lack of ‘political legitimacy’ is especially critical. This is because both entrepreneurs and crucial stakeholders may not fully understand the nature of biorefineries, and the extent to which they conform to recognised principles or accepted laws and standards (i.e. established institutional rules) may still be in question<sup>2</sup>. The focus problem lies in understanding well enough how we can go about determining a logical and streamlined way to measure the level of this ‘political legitimacy’ of biorefineries in Europe. This will enable decision makers to focus on the best ways to stimulate the emergence of this new area of industrial activity.

There is no specific established literature providing a framework to actually measure political legitimacy. However, the literature regarding organisational theory provides a framework around which the political legitimacy of new business concepts can be analysed and enhanced. Frameworks such as those established by Aldrich and Fiol (1994), Ranger-Moore et al. (1991), Mezner and Nigh (1993), and Jacobsson and Bergek (2004), that link cognitive and socio-political legitimacy to industrial creation, can be adapted to also enable the legitimacy of innovative new business concepts to be measured. As already discussed briefly in Chapter 1, the framework established by Aldrich and Fiol (1994) is very well established amongst organisational and managerial theorists. It proposes a number of determining factors that affect an industry’s legitimacy and strategies that can be practised by innovative entrepreneurs to overcome legitimacy obstacles and enhance the chances of the industry to succeed. Therefore, this thesis is intending to utilise these factors to determine a logical and streamlined way to measure the political legitimacy of biorefineries in Europe. This will enable decision makers to focus on the best ways to stimulate the emergence of this new area of industrial activity.

According to Aldrich and Fiol (1994), an entirely new business concept begins with low ‘legitimacy’. They specify the components of legitimacy as being two-fold: cognitive and socio-political. Although their framework distinguishes between cognitive and socio-political legitimacy, these two concepts are closely intertwined and often difficult to separate. Therefore, in order to adapt this framework to the context of the biorefinery concept, the political importance and implications of the production and use of biorefinery products needs to be understood, a task that has been undertaken in Chapter 3. However, because socio-political and cognitive legitimacy are so closely intertwined and because the biorefinery concept is massively complex and difficult to define, the cognitive essence of biorefineries (i.e. what a biorefinery is or could be) and the lack of clarity surrounding them also needs to be defined, a task that has been undertaken in Chapter 4.

Once the various components contributing to the legitimacy of biorefineries have been understood and defined, the next step will be to apply them to the theoretical factors influencing the legitimacy of innovative business concepts. Establishing how these factors fit

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<sup>2</sup> As discussed further within this chapter, ‘socio-political legitimacy’ refers to “the process by which key stakeholders, the general public, key opinion leaders, or government officials accept a venture as appropriate and right, given existing norms and laws” (Aldrich and Fiol, 1994).

within the biorefinery context will allow the author to determine criteria upon which the cognitive and socio-political legitimacy of biorefineries can be measured, a task that has been undertaken in Chapter 5. These strategies can then be transcribed into a matrix that describes an approach to devising questions around each of the key areas identified to be important to gaining political legitimacy for biorefineries, a task that has been undertaken in Chapter 6. It is envisaged that these questions will underpin the development of a set of questionnaires and in-depth interviews within a Pan-European research activity, the answers to which will enable the political legitimacy of biorefineries in Europe to be determined.

## 2.2 Legitimacy

'Legitimacy' is a theoretical concept that has been constructed within an array of organisational and managerial schools of thought, such as neo-institutional theory (Powell and DiMaggio, 1991), organisational ecology (Haveman, 1983; Aldrich and Fiol, 1994). The potential relevance of legitimacy for entrepreneurship theory and research has also been well established by authors such as Aldrich and Fiol (1994). A highly quoted concept of legitimacy has been established by Suchman (1995):

**Legitimacy** refers to a “generalised perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs and definitions”.

Aldrich and Fiol (1994) suggest that one of the major constraints facing innovative business concepts is their lack of cognitive legitimacy.

**Cognitive legitimacy** refers to the spread of “knowledge about a new activity and what is needed to succeed in an industry” (Ranger-Moore, et al., 1991). Cognitive legitimacy can be assessed by “measuring the level of public knowledge about a new activity”, of which the highest level is achieved when “a new product, process, or service is taken for granted” (Aldrich and Fiol, 1994).

Confusion at all levels impedes implementation and in the absence of extensive comprehension of their business concept, entrepreneurs may have difficulty gaining support from vital stakeholders. For example, Aldrich and Fiol (1994) assert that this was obvious within the nascent biotechnology industry, where confusion surrounding the testing procedures for manipulation of DNA was so unclear and misunderstood that it faced tremendous obstacles in gaining government approval. Therefore, where entrepreneurs can establish clarity, comfort, understanding and non-ambiguity of novel technical systems, cognitive legitimacy can be achieved much faster, which becomes vital to their success.

As was discussed briefly in Chapter 1.1.2, there is also significant confusion regarding the properties, roles, and environmental implications (among other factors) for the emerging biofuels and bio-based product sectors. The legitimacy of biorefineries in the eyes of many other social stakeholders (e.g. the general public, NGOs, governments at many jurisdictional levels) is also required on a social, economic, environmental and developmental plane. Moreover, significant political support is required for the progression of biorefineries from their current formative (research) stage to the demonstration (pilot) phase in the short time

frames called for in a number of policy interventions, such as the Kyoto Protocol, the EU Biofuels Directive (Council Directive 2003/30/EC), etc<sup>3</sup>. Thus, it appears that support and acceptance from many stakeholders is important. However, since the process of progressing biorefineries in such a short period of time is a process that could cost hundreds of millions of euros (VIT, 2006), political support at all governance levels will be imperative.

**Socio-political legitimacy** refers to “the process by which key stakeholders, the general public, key opinion leaders, or government officials accept a venture as appropriate and right, given existing norms and laws” (Aldrich and Fiol, 1994). Socio-political legitimacy can be assessed by “measuring (the) public acceptance of an industry, government subsidies to the industry, or the public prestige of its leaders” (Aldrich and Fiol, 1994).

Cognitive legitimacy is paramount to the survival of new business concepts because without widespread knowledge of their activities and long-term consequences, entrepreneurs may face difficulties obtaining the approval of cautious government agencies (i.e. obtaining socio-political legitimacy) (DiMaggio and Powell, 1983; Aldrich and Fiol, 1994). The importance of socio-political legitimacy to the survival of new business concepts has also been highlighted by a number of other authors. For instance, Hargreaves (2003) shows that although legitimacy is grounded in a notion of societal approval, analysing its practical application usually examines stakeholders who “act as the providers or withholders of legitimacy”, and Mezner and Nigh (1993) show that the legitimisation and survival of the innovative business concept may hinge on effectively managing social and political stakeholders.

## 2.3 The liability of newness

Literature on industry lifecycles usually identifies two main phases of evolution - a formative period and one of market expansion – that differ in terms of the character of technical change, the patterns of entry/exit and the role of market growth (Van de Ven and Garud, 1989; Aldrich and Fiol, 1994; Jacobsson and Bergek, 2004). Although there is an enormous range of variation in the time span involved in the formative period, it can often be very long. For instance, Carlsson and Jacobsson (1997) report that the formative period of the US technological system for computers and semiconductors lasted for several decades, and Geels (2002) reports that the first major commercial market for steam ships took almost 50 years to be realised. Both authors report that this time frame is not unusual and often times the investment required during this formative period is substantial with little or no return. Aldrich and Fiol (1994) propose that some fraction of this formative period reflects the new business venture’s struggle to develop cognitive and socio-political legitimacy.

Authors examining the ecological theory of organisational evolution (Hannan and Carrol, 1992; Baum and Singh, 1994; Reuf and Aldrich, 2006), surmise that during the formative period, new business concepts lack legitimacy or ‘social taken-for-grantedness’. Low or absent legitimacy means that organising the new business venture will be difficult: capital sources are suspicious, suppliers and customers need to be educated, and hostile government regulations must be transformed (Jacobsson and Bergek, 2004). Therefore, enhancing

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<sup>3</sup> Policy interventions important to the progression of biorefineries will be discussed in much greater detail within Chapters 3 and 5.

legitimacy early in the evolution of an innovative business concept reduces this formative phase and all of the difficulties associated with it.

Moreover, new business concepts have a higher propensity to fail because this ‘liability of newness’ – the greater risk of mortality experienced by innovative entrepreneurs – is related to legitimacy in the formative period (Singh, et al., 1986; Aldrich and Fiol, 1994). Both authors claim that one of the major reasons for this is their relative lack of cognitive and socio-political legitimacy. Other supporters of this theory (Carroll and Delacroix, 1982; Rao, 1994; Dobrev, 2001) have used it to describe the evolution of the Irish and Argentinean newspaper industries, the US automobile industry and the post-war Bulgarian newspaper industry. In terms of the biorefinery concept, the liability of newness does not necessarily relate to “mortality”, as it contains many of the basic building blocks required to gain political support (as detailed in Chapter 3.4) and succeed to become a new industry over time. However, its “failure” to progress from the formative (research) phase to the demonstration (pilot) phase and beyond, quickly enough to contribute to the outcomes required in a number of policy interventions (such as the Kyoto Protocol, the EU Biofuels Directive, etc) could certainly be attributed to this liability of its newness.

In comparison with established businesses, innovative business concepts often have a cost disadvantage, because even though they may be offering reduced societal costs, for example in terms of CO<sub>2</sub> emission reduction, they do not offer any direct benefits to the buyer/investor (Jacobsson and Bergek, 2004). This highlights the classic example for competition between biorefineries and the petrochemical industry, with approximately 100 years of experience, growing from an industry that began by distilling a few barrels of petrol a day to tens of millions of tonnes from each refinery and a full range of petrochemicals. Adding to this, is the fact that established businesses are often subsidised. For example, the UNDP (2000) estimates that conventional energy received subsidies in the order of 250-300 billion US\$ annually during the 1990s. Some established businesses, such as the conventional energy sector, are also subsidised indirectly due to the negative external effects associated with their technologies (e.g. CO<sub>2</sub> emissions and their implications for climate change, energy security, etc) and the European Commission estimates that “the cost of producing electricity from coal or oil would double... if the external costs such as damage to the environment and to health were taken into account” (Jacobsson and Bergek, 2004).

## 2.4 Why legitimacy is important to entrepreneurs

The absence of legitimacy has been identified as a factor in the “liability of newness” faced by innovative business concepts and should be of prime importance to researchers and practitioners in the field of entrepreneurship (Singh, et al., 1986; Aldrich and Fiol, 1994; Suchman, 1995; Hargreaves, 2003).

Proponents of established businesses often attempt to block cognitive dissemination of innovative business concepts by influencing the institutional framework so that it continues to work to their advantage (Jacobsson and Bergek, 2004). They also establish that lack of legitimacy is a prime blocking mechanism for the success of a new technology and has not only directed research away from innovative fields of research, but has also blocked the supply of resources and the formation of markets. A prominent example of this was seen in the Swedish ‘nuclear power trauma’ (see Box 2-1). Undeniably, political lobbying by the oil and coal industries is also still strong enough to continue the global energy supply status quo (Vertes, et al., 2006) in the face of rising concerns regarding climate change, hence blocking the political will to move away from a fossil fuel to a biomass based economy.

Box 2-1 Case study: The Swedish nuclear power trauma

### The Swedish nuclear power trauma

The nuclear power issue has been debated in Sweden since the 1970s and led to a referendum in 1980 after the ‘Three Mile Island incident’<sup>4</sup>. The outcome of the referendum was that nuclear power would be phased out by 2010, but the issue has still not been settled. Over time, the ‘nuclear power trauma’ emerged which reduced all energy issues into a decision over whether or not to dismantle Sweden’s nuclear power plants. This had the undesirable consequence of simply reducing renewable energy technology to a substitute for nuclear power, and all efforts to disseminate renewable energy technologies were justified within that context.

The trauma had two major implications for renewable energy technology:

1. Each renewable energy technology was only valued by its ability to replace the power generated by a nuclear reactor, which was usually only a small fraction. This weakened the legitimacy of renewable energy technologies and contributed greatly to an inability to reach its growth potential.
2. Renewable energy technology was perceived as a threat to the availability of the vast amount of energy that was supplied by nuclear power, and therefore a betrayal of Swedish industry that relied so heavily upon it. Thus, it was not surprising that renewable energy did not gain legitimacy in the eyes of the capital goods industry, users, and large parts of the media.

As a consequence of the lack of socio-political legitimacy, the supply of resources was constrained, the market did not grow, and only a small amount of firms entered the industry supplying renewable energy technology.

Source: *Jacobsson and Bergeke, 2004*

An example of a potential competitor to biorefineries, in terms of competition for biomass resources, is the pulp and paper industry. A recent study presented by the Confederation of European Paper Industries claims that “it is four times more economically viable to use wood as a paper resource first, than to use it for energy” (EurActiv, 2007a). This is a clear, but carefully constructed, example of a competing industry attempting to block the legitimacy of biorefineries.

Aldrich and Fiol’s (1994) examination of the formative period of a new business concept also demonstrates that many promising new activities never realise their full potential because their entrepreneurs “fail to develop trusting relations with stakeholders, are unable to cope with opposing industries, and never win institutional support”. In Germany for example, the 1986 Chernobyl accident had a dramatic and permanent effect on the community’s trust in nuclear power, indirectly giving the renewable energy sector broad legitimacy which led to a

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<sup>4</sup> “The accident at Three Mile Island on March 28, 1979 was the most serious in US commercial nuclear power plant operating history, even though it led to no deaths or injuries to plant workers or members of the nearby community. But it brought about sweeping changes involving emergency response planning, reactor operator training, human factors engineering, radiation protection, and many other areas of nuclear power plant operations” (US Nuclear Regulatory Commission, 2007).

Parliamentary Resolution calling for more R&D in the area of renewable energy technologies (Jacobsson and Bergek, 2004). In contrast, the Swedish ‘nuclear power trauma’ highlights the failure of the renewable energy sector to achieve trust and hence socio-political legitimacy, which led to a poorly developed market in the 1980s. However, the bioenergy industry has now been broadly established within Sweden (Erik, 2006). In 2005, the share of renewable energy in primary energy consumption in Sweden was approximately 30%, second only to Latvia at approximately 40% (European Commission, 2007a). The Swedish Prime Minister, Göran Persson, even opened the World Bioenergy Conference in 2006 with a speech that shared his vision for the future “... in which we have freed ourselves from the dependence of oil” (World Bioenergy, 2006).

## 2.5 Enhancing legitimacy

Aldrich and Fiol (1994) believe that innovative entrepreneurs need strategies to promote the shared expectations, reasonable efforts, and competence of the new business concept to stakeholders. They go on to say that without reliable information and evidence of their competence, innovative entrepreneurs need other methods on which to base trust-building strategies. Therefore, an innovative entrepreneur must “engineer consent, using powers of persuasion and influence to overcome the scepticism and resistance of guardians of the status quo” (Dees and Starr, 1992).

Bateson (1988) describes trust, reliability and reputation as methods of achieving collaboration based on increasing familiarity and evidence. Hence, more trust is required when there is a lack in reliable information and evidence; an important determinant of the success of innovative entrepreneurs where there is an inherent absence of information and evidence regarding the new business concept. As information and evidence accumulate and patterns of reliability and reputation increase, the need for trust diminishes (Aldrich and Fiol, 1994). They go on to say that legitimacy of new business concepts is therefore realised through the processes of achieving stakeholder trust.

Within their comprehensive framework, Aldrich and Fiol (1994) identified several propositions that innovative entrepreneurs can adopt in their pursuit of legitimacy, so that innovative business concepts can collectively reshape industry and institutional environments in order to evolve more quickly and certainly. These eight propositions for overcoming legitimacy obstacles are presented in Table 2-1. If adopted, they will enable trust, reliability, and reputation of the new business concept to be enhanced, so that it can finally gain institutional (i.e. political) legitimacy within four levels of progressively broadening social context (organisational, intra-industry, inter-industry and institutional).

Table 2-1 Factors that influence and enhance the legitimacy of innovative business concepts

Level of Analysis	Type of Legitimacy	
	Cognitive	Socio-political
<b>Organisational</b>	1. Develop knowledge base via symbolic language and behaviours.	2. Develop <b>trust</b> in the new business concept by maintaining internally consistent stories.
<b>Intra-industry</b>	3. Develop knowledge base by encouraging convergence around a dominant design.	4. Develop perceptions of <b>reliability</b> by mobilising to take collective action.
<b>Inter-industry</b>	5. Develop knowledge base by promoting activity through third-party actors.	6. Develop the <b>reputation</b> of a new business concept as a reality by negotiating and compromising with other industries.
<b>Institutional</b>	7. Develop knowledge base by creating linkages with established educational curricula.	8. Develop <b>legitimacy</b> by organising collective marketing and lobbying efforts.

Source: Aldrich and Fiol, 1994

Since the progression of biorefineries from their current formative (research) stage to the demonstration (pilot) phase in the short time frames called for in a number of European policy interventions could cost hundreds of millions of euros, political support at all governance levels will be imperative. In recognition of the need to comprehend the potential implications of the biorefinery concept, the BIOPOL network has established a project that seeks to measure the political legitimacy of biorefineries in Europe. Therefore, this thesis will concentrate on the political factors affecting biorefineries, as opposed to understanding how to measure ‘social’ or ‘socio-political’ legitimacy. It is envisaged that the outcomes of this thesis will feed directly into this project and generate valuable knowledge required by the BIOPOL agenda.

## 2.6 Measuring legitimacy

The focus problem lies in understanding well enough how we can go about determining a logical and streamlined way to measure the level of the ‘political legitimacy’ of biorefineries in Europe. Aldrich and Fiol (1994) propose that socio-political legitimacy can be assessed by “measuring (the) public acceptance of an industry, government subsidies<sup>5</sup> to the industry, or the public prestige of its leaders”. Determining the level of government interventions to enable biorefineries is tangible at least; however, measuring public acceptance or the public prestige of the leaders of biorefineries is much more ambiguous. Nevertheless, by examining the extent to which Aldrich and Fiol’s eight propositions for enhancing legitimacy are being carried out by the entrepreneurs of *integrated industrial biorefineries*, a measure of their legitimacy can be undertaken.

<sup>5</sup> For the purpose of this work, the author has interpreted “government subsidies” to mean any kind of policy intervention that may enhance or hinder the progression of biorefineries.

**Hence, we can determine the political legitimacy of an innovative business concept by examining whether Aldrich and Fiol's propositions for enhancing legitimacy are currently hindering or supporting the progression from the founding of the completely new activity, in an institutional void, through to its development as a legitimate industry.**

## 2.7 Conclusion

The literature regarding organisational theory provides a framework around which the political legitimacy of new business concepts can be analysed and enhanced. The framework established by Aldrich and Fiol (1994) is very well established amongst organisational and managerial theorists. It proposes a number of determining factors that affect an industry's legitimacy and strategies that can be practised by innovative entrepreneurs to overcome legitimacy obstacles and enhance the chances of the industry to succeed. Therefore, this thesis is intending to utilise these factors to determine a logical and streamlined way to measure the political legitimacy of biorefineries in Europe. This will enable decision makers to focus on the best ways to stimulate the emergence of this new area of industrial activity, from its current formative (research) phase to the demonstration (pilot) phase and beyond, quickly enough to contribute to the outcomes required in a number of policy interventions (such as the Kyoto Protocol, the EU Biofuels Directive, etc).

According to Aldrich and Fiol (1994), an entirely new business concept begins with low 'legitimacy'. They specify the components of legitimacy as being two-fold: cognitive and socio-political. Although their framework distinguishes between cognitive and socio-political legitimacy, these two concepts are closely intertwined and often difficult to separate. Therefore, in order to adapt this framework to the context of the biorefinery concept, the political importance and implications of the production and use of biorefinery products needs to be understood, a task that has been undertaken in Chapter 3. However, because socio-political and cognitive legitimacy are so closely intertwined and because the biorefinery concept is massively complex and difficult to define, the cognitive essence of biorefineries (i.e. what a biorefinery is or could be) and the lack of clarity surrounding them also needs to be defined, a task that has been undertaken in Chapter 4.

Once the various components contributing to the legitimacy of biorefineries have been understood and defined, the next step will be to apply them to the theoretical factors influencing the legitimacy of innovative business concepts. Establishing how these factors fit within the biorefinery context will allow the author to determine criteria upon which the cognitive and socio-political legitimacy of biorefineries can be measured, a task that has been undertaken in Chapter 5. These strategies can then be transcribed into a matrix that describes an approach to devising questions around each of the key areas identified to be important to gaining political legitimacy for biorefineries, a task that has been undertaken in Chapter 6. It is envisaged that these questions will underpin the development of a set of questionnaires and in-depth interviews within a Pan-European research activity, the answers to which will enable the political legitimacy of biorefineries in Europe to be determined.

As stated by Hargreaves (2003), "if this research can, in turn, assist new (business) ventures in overcoming the 'liability of newness', then it will be a very worthwhile exercise".



### **3 Political importance and implications of the production and use of bio-based products**

#### **3.1 Introduction**

In order to adapt the identified framework to the context of the biorefinery concept, the political importance and implications of the production and use of biorefinery products needs to be understood. This chapter explores the key areas that the author has identified as important to the political legitimacy of biorefineries in Europe. The key areas include: the EU regulatory framework, energy security, CO<sub>2</sub> emission reduction, agriculture and forestry, employment and rural development, environment and land use, economy, genetically modified crops, and sustainability. Each of these key areas has been described and analysed in detail in order to determine how they will relate to the progression of biorefineries. From these key areas, a number of contentious issues were identified as having the potential to dramatically affect the political legitimacy of biorefineries including: the disputes surrounding the CO<sub>2</sub> emission reduction capabilities of biomass feedstocks for the production of bio-based products, the contention between the development of 1<sup>st</sup> and 2<sup>nd</sup> generation biomass conversion technologies and feedstocks, the disputed success of CAP amendments to encourage energy crop production, and the social issues surrounding genetically modified energy crops. However, before the political implication of the production and use of bio-based products is explored, an overview of bio-based products has been undertaken.

#### **3.2 Background**

It is fast being recognised that an extraordinary change in the way that we produce and use chemical products derived from fossil fuels is required, in order to counter the dramatic global issue of climate change and increasing energy security issues. As already stated, one path towards this goal is to enhance the production and use of bio-based products, that as well as having many desirable chemical properties, also offer many benefits with respect to global climate change and energy security (Lynd, 1991).

Bio-based products are simply biologically based materials that have been created from biomass, usually through extensive processing (Biomaterial, Encarta Encyclopaedia Online, 2007). Biomass is defined by the European Parliament and Council as “the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste” (Council Directive 2001/77/EC). Plant biomass consists of the basic mix of carbohydrates, lignin, proteins and fats, as well as various other substances in individual plants that have very different chemical structures (Kamm and Kamm, 2004).

At the beginning of the 20<sup>th</sup> century, many industrial materials were bio-based products (such as dyes, solvents, paints, detergents) made from trees, plants and agricultural crops. However, due to the relative ease and economics of producing identical products from petrochemicals, the majority of these bio-based products were replaced by those derived from petrochemicals by the beginning of the 1970s (van Wyk, 2001). Nevertheless, increasing oil prices, the negative implications associated with fossil fuel depletion, and the release of CO<sub>2</sub> during the petroleum refining process are driving a shift back towards the production and use of bio-based products (Sanders et al., 2007). As shown in Figure 3-1, bio-based products include a plethora of important industrial substances including biomass derived transport fuels (such

as bioethanol and biodiesel – “biofuels”), chemical products (such as solvents, detergents, plastics, resins, etc – “biomaterials”) and other biological products (such as agricultural chemicals, industrial surfactants, oxy fuel additives etc – “biochemicals”) (Kamm and Kamm, 2004).

The market for bio-based products is fast growing and gaining increasing attention from large chemical manufacturers, the petroleum industry, governments and consumers. The EU produced almost 4 million tonnes of biofuel in 2005, which marks a 65.7% growth in production. Biomaterial production is also increasing with demand for products such as bio-based resins rising above 25% (Blanchfield, 2006) and the market for bio-based plastics seems to be as large as the plastic market itself. The limiting factors for production of these bio-based products seems to come from supply of the bio-based building blocks, due to either a lack of supply of biomass feedstock or efficient techniques to convert them into useable bio-based products, and the current cost of these conversion techniques.

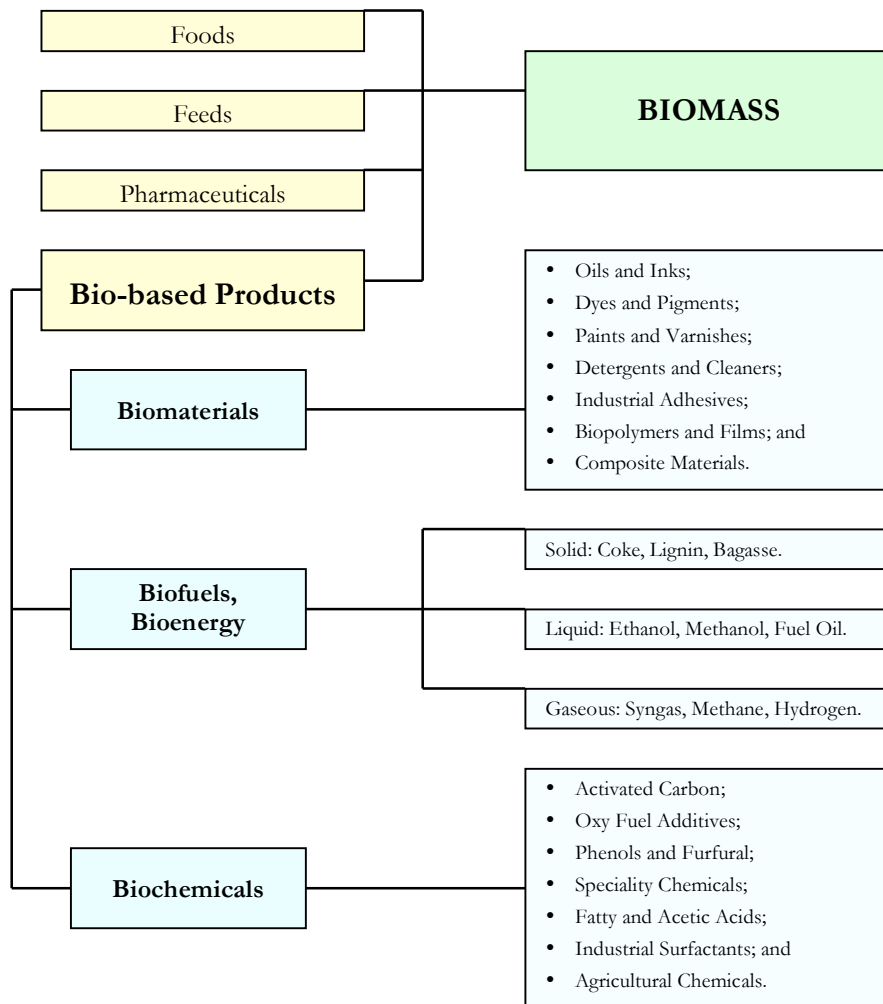


Figure 3-1 Bio-based products and product classes

Source: Morris and Ahmed, 1992

### 3.3 Overview of transportation biofuels

Biofuels are simply transportation fuels derived from biomass and can be either in liquid form (such as fuel bioethanol or biodiesel), or gaseous form (such as biogas or hydrogen). They can be produced from agricultural and forest products, and the biodegradable portion of industrial and municipal waste.

Bioethanol and biodiesel are the two major transport biofuels that account for more than 90% of global biofuel usage. Global biofuel production has increased dramatically in the last decade, with an estimated 35 billion litres now being produced. However, this figure is very small when compared with the 1200 billion litres of petroleum produced annually worldwide (Dufey, 2006). However, according to the IEA (2004), world biofuel production is expected to quadruple to over 120 000 million litres by 2020, accounting for about 6% of global motor fuel and 3% of total road transport energy use.

There exists a wide variety of “first generation” technologies and feedstocks for producing bioethanol and biodiesel; however, these are much more limited for biodiesel. An emerging “second generation” of conversion technologies are currently being developed to gasify practically any type of biomass, and then convert it into almost any type of liquid fuel.

#### 3.3.1 Bioethanol

Bioethanol is undoubtedly the most widely used biofuel for transportation worldwide, principally because of the large production volumes in Brazil and the US (IEA, 2004). It is produced from the fermentation of sugars from sugar plants (sugar beet and cane) or starch from cereal crops (corn, wheat, sorghum). The production process of bioethanol is presented in Figure 3-2. It can be used in pure form in specially adapted vehicles, or blended with conventional petrol (up to 10% without any required engine modification). Ethyl-tertio-butyl-ether (ETBE) is produced from bioethanol by reaction with isobutylene, which is then blended with conventional petrol (up to 15% without any required engine modification). ETBE is less volatile than bioethanol, but requires an additional production step (European Commission, 2004).

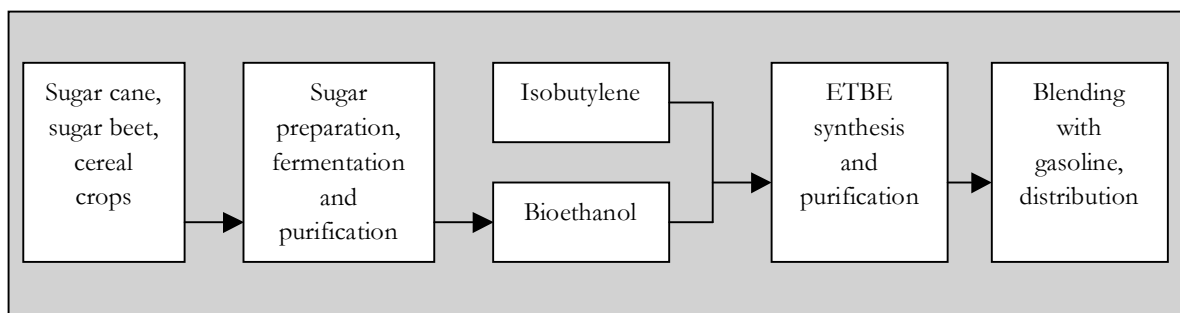


Figure 3-2 ETBE and Bioethanol manufacturing process

Source: Adapted from Dufey, 2006

As described above, bioethanol is currently produced from energy crops that are rich in sugars and starches. However, plants are mainly composed of lignin and cellulose, which are

difficult to convert into bioethanol. Current research is aiming to solve this problem. One option, which is currently under development, is an efficient lignocellulosic<sup>6</sup> enzymatic fermentation conversion process. However, fermentation pathways are not the only possibilities. Another example, out of the many under development, is to convert the biomass into 'synthesis gas', which can then be catalysed into synthetic diesel or alcohol type biofuels. Extensive test operations on biomass gasification equipment are already being undertaken by Finnish company VTT, who claim that the technology will enable a reduction of the additional costs incurred for the national economy from the use of biofuels by half and increase the share of bioenergy to as much as 20% by 2020 (VTT, 2006). These processes would have important advantages, including allowing a wider range of raw materials for biofuel production (such as grasses, trees and other forms of agricultural residues), and considerably improve the life-cycle energy efficiency and further reduce GHG emissions (European Commission, 2004).

*Box 3-1 Second generation technologies: Lignocellulosic bioethanol*

**Second generation technologies: Lignocellulosic bioethanol**

Most plant matter is not comprised of sugar or starch - but cellulose, hemicellulose and lignin - the green part of which is composed almost entirely of these three substances. Cellulose and hemicellulose can be converted into alcohol by first converting them into sugar (lignin cannot). However, this process is more complicated than that of converting starch into sugars and then into alcohol (as in first generation biofuel technologies), as it requires hydrolysis or special enzymes to convert the lignocellulosic matter into bioethanol. At present these enzymes are expensive and inefficient and are therefore a key obstacle to the widespread adoption of lignocellulosic alternatives. The creation of novel enzymes that will make this process more feasible is imminent, with experts envisaging commercial development of the technology to be available by 2015. Since lignocellulosic bioethanol can be produced from a range of forestry products, including short rotation coppices and energy grasses that can be grown on marginal land, they require minimal fertiliser or water and have higher energy contents than conventional first generation energy crops. According to the US Department of Energy, for every unit of energy available at the fuel pump, only 0.2 units of fossil energy are used to produce lignocellulosic bioethanol. In comparison, 0.74 units of fossil energy are used to produce corn-based bioethanol, and 1.23 units of fossil energy is used to produce conventional petrol.

*Source: Dufey, 2006 and IEA, 2004*

### **3.3.2 Biodiesel**

Biodiesel production is highest in Europe and as discussed further in Chapter 2.4, there have been many recent efforts to expand its production and use of biofuels. Biodiesel, or vegetable oil methyl ester (VOME), is produced from the reaction of vegetable oil, mainly rapeseed, sunflower, soybean, palm, coconut and jatropha. Waste (cooking) oils and animal fats can also be used as feedstock. The extracted oils are converted by transesterification to produce biodiesel. The production process of biodiesel is presented in Figure 3-3. Biodiesel

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<sup>6</sup> Lignocellulose is a strengthening substance composed of lignan and cellulose found in the woody tissues of plants (Lignocellulose, Encarta Encyclopedia Online, 2007).

is used in compression-ignition diesel engines, usually as a 5% blend in cars, up to a 30% blend in ‘captured fleets’ as such as city buses and in its pure form in appropriately modified engines (European Commission, 2004).

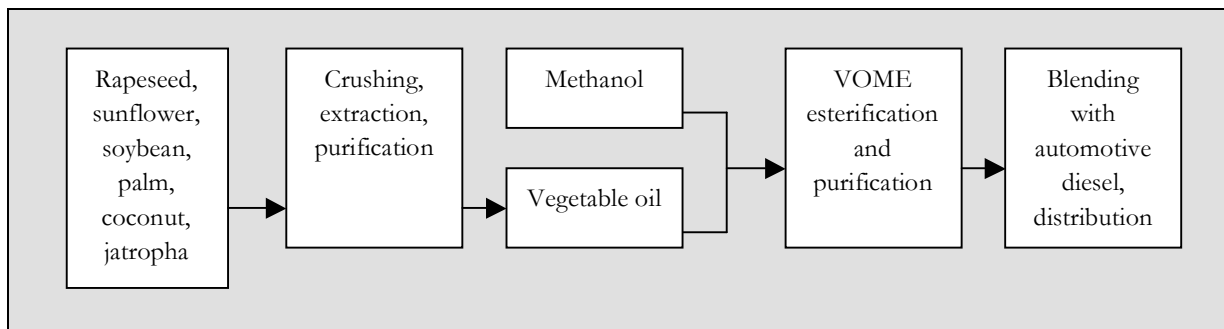


Figure 3-3 Biodiesel manufacturing process

Source: Adapted from Dufey, 2006

### 3.3.3 Gasification

Another approach for converting biomass into liquid or gaseous fuels is through gasification, followed by conversion of the gas to a useable fuel (IEA, 2004). The most simple gasification process converts biomass into a mixture of methane (up to 60%) and CO<sub>2</sub> by anaerobic fermentation. Organic wastes such as livestock manure, food processing residues, as well as municipal sewage sludge, are used as raw material to produce biogas in dedicated reactors. Biogas can also be recovered as landfill gas from urban waste landfill sites. Its use in transport is currently limited, however biogas can be used in vehicles adapted to run on natural gas (European Commission, 2004). This is relatively common in some places. Sweden, for example, has approximately 4500 natural gas vehicles, most of which are transit buses in major cities of which approximately half of the fuel comes from biogas (CALSTART, 2004).

New, second generation, biofuel conversion technologies are also utilising the gasification process to specially design new systems to produce a variety of gases and liquid fuels. Such fuels include methanol, synthetic diesel and gasoline (or which the latter two can be converted using Fischer-Tropsch (F-T) synthesis), dimethyl ether (DME) and gaseous fuels such as methane and hydrogen (see Box 3-2 for more detail). Regardless of the final fuel type, or the process, second generation conversion technologies are still under development and generally held to be very expensive. IEA (2004) consider that the costs of second generation conversion technologies will need to decrease by at least half in order to be able to compete with petroleum fuels. VTT Technical Research Centre of Finland launched an extensive test operation for the development of second generation transport biofuels (see Box 3-2) last year (VTT, 2006). According to VTT, the new technologies will enable the costs of biofuels in Finland to be reduced by half and could enable bioenergy to amount to as much as 20% of the national energy consumption.

*Box 3-2 Second generation technologies: Gasification*

### **Second generation technologies: Gasification**

Second generation gasification processes typically use heat and chemicals to break down the biomass into gas, without the use of microbial action. The process is dominated by the fact that lignin cannot easily be converted to gas via anaerobic fermentation (as used to produce biogas), just as it cannot be easily converted into an alcohol as previously mentioned. However, lignin can be gasified through a heat process, then the resulting gases can be used in a variety of ways to produce the following BtL (biomass to liquid) fuels:

- Fischer-Tropsch (F-T) fuels: The F-T process converts “syngas” (mainly carbon monoxide (CO) and hydrogen) into diesel fuel and naphtha (basic gasoline) by building polymer chains out of these basic building blocks. Typically, a variety of co-products are also produced and finding markets for these co-products is essential to the economics of F-T synthesis, which is quite expensive if only the gasoline and diesel products are considered.
- Methanol: Syngas can also be converted into methanol through dehydration and other techniques. However, methanol is not very popular as a transport fuel as it has a relatively low energy content and high toxicity. It is however, an excellent hydrogen carrier and research is underway to enable its use in the development of fuel cell vehicles.
- Dimethyl ether (DME): Syngas can also be converted into DME in a manner similar to methanol. It is a promising fuel for diesel engines, due to its good combustion and emission properties. However, its use is still in an experimental phase as it requires specific fuel handling and storage equipment and some modification to conventional diesel engines.

There are several large-scale projects for the development of these second generation conversion technologies underway, with experts envisaging commercial development to be available circa 2008.

*Source: Hemmes, et al., 2003 and IEA, 2004.*

### **3.4 Overview of biomaterials and biochemicals**

Akin to the petroleum refining process, the process of producing biomaterials and biochemicals takes advantage of the many functionalities of the feedstock (in this case, biomass instead of crude oil) and utilises these as precursors for the production of specific chemicals. Biomaterials and biochemicals may or may not be biodegradable and are most often used for packaging, solvents, plastics, lubricants and fragrances. Auras (2004) exemplifies some modern biomaterials and biochemicals:

- Polyacetic acid, which is fermented from corn starch or sugar cane and used as the building block for products in a wide range of industries including the food packaging and apparel industries;
- Bio-based resins, which are fermented from corn starch and used for grocery bags and food service (e.g. plates, cups, lids etc); and

- Bio-based plastics, which are fermented from hemp oil, soy bean oil and corn starch and used in many applications in place of conventional plastics (e.g. bottled water containers).

Wood (2004) reports that significant developments in the biochemical industry are continuing to allow for the production of new materials with enhanced properties and a smaller environmental footprint. However, the production of these biomaterials and biochemicals requires purified biomass feedstock and the main barrier to their development is the improvement of processes that can separate, purify, and convert them into useable bio-based products (Ragauskas, et al., 2006). These issues have been further elaborated in Chapter 4.

### **3.5 Political importance and implications of the production and use of bio-based products**

The next section of this chapter explores the key areas that the author has identified as important to the political legitimacy of biorefineries in Europe. Each of these key areas has been established as vitally important to understanding the biorefinery concept. They also highlight areas where a lack of understanding could be causing a level of discomfort amongst political stakeholders that biorefineries and their incumbent systems will conform to recognised principles or accepted laws and standards (i.e. established institutional rules). This will be a crucial factor in measuring the level of political legitimacy of biorefineries.

#### **3.5.1 EU regulatory framework**

The Kyoto Protocol to the United Nations Framework Convention of Climate Change (UNFCCC) calls for “stabilisation of GHG concentrations at a level that would prevent dangerous anthropogenic interference with the climate system”. Through the Kyoto Protocol the EU Member States have committed to collectively reduce their GHG emissions by 8% compared with 1990 levels, by 2012. A way towards this goal is to enhance the production and use of biomass derived products (bio-based products including transportation biofuels such as bioethanol and biodiesel).

In line with the Kyoto Protocol and the UNFCCC, the EU Biofuels Directive (Council Directive 2003/30/EC) adopted in 2003 as part of the EU Strategy for Biofuels established the target that 2% of all petrol and diesel transport fuels were to be biomass-derived by December 2005, increasing to 5.75% by the end of 2010 (see Table 3-1). There are currently no targets for biomass-derived chemicals; however, the Biofuels Directive already includes ethanol, methanol, dimethyl ether, hydrogen, and biomass pyrolysis which Kamm, et al. (2006b) claim to be fundamental product lines of the future bio-based chemical industry. The action of passing such directives is evidence that setting targets for bio-based chemicals is on the European political agenda, which will hopefully be realised in the near future to encourage the growth of bio-based product industries within Europe.

Table 3-1 EU targets for the use of renewable resources

Year	2001	2005	2010	2020-2050
Energy	7.5 %	-	12.5 %	26% (2030)
Transportation Fuels	1.4 %	2.8 %	5.75%	20% (2020)
Chemicals	8-10%	no target	no target	no target

Source: The EU Biofuels Directive (2003)

The EU Strategy for Biofuels is “supporting biofuels with the aim of reducing greenhouse gas emissions, boosting the decarbonisation of transport fuels, diversifying fuel supply sources, offering new income opportunities in rural areas and developing long-term replacements for fossil fuel”. The EU Biomass Action Plan (Council Directive 2003/30/EC) sets out the measures to achieve these targets, by creating market-based incentives and removing barriers to development of the market. These measures focus on the promotion of biomass use for heating, electricity and transport, while also concentrating on issues affecting biomass supply, financing and research.

In 2005, around 6.38% of the EU’s total primary energy consumption was met from renewable sources (European Commission, 2007). Figure 3-4 illustrates the share of each resource in renewable primary energy production. Approximately two thirds of the total energy produced from renewables comes from biomass, making it by far the largest renewable energy source providing approximately 4% of the EU’s total primary energy consumption. Greater quantities of biomass derived fuels are expected to be used as transportation fuel in the future as a direct result of the EU Biofuels Directive (Council Directive 2003/30/EC) which implicitly requires that biofuels should make up 5.75% of transport energy consumption by 2010, thus requiring a substantial rise in EU production (EEA, 2006).

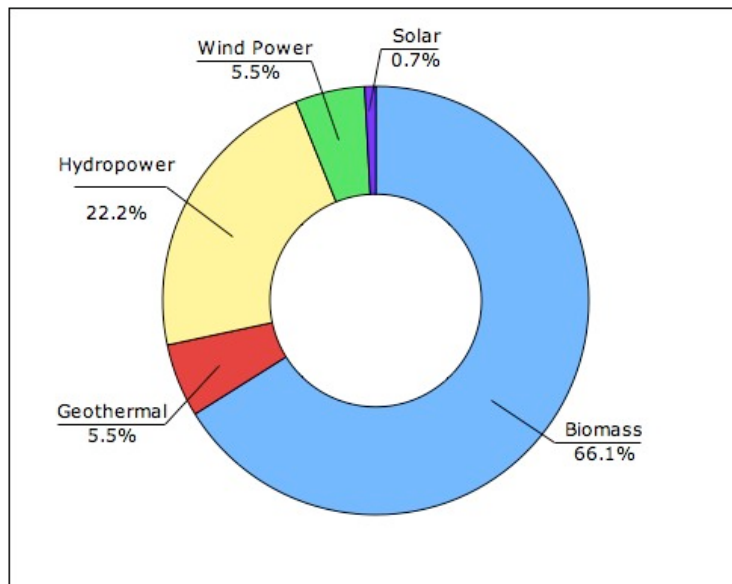


Figure 3-4 Share of each resource in the renewable primary energy production (in %) in the EU in 2005

Source: Adapted from European Commission (2007)



Figure 3-5 demonstrates that Europe’s desire to replace a share of its fossil fuel derived energy consumption with biomass is being fulfilled by the major agricultural countries, such as France (9669 Mtoe), Sweden (7937 Mtoe), Germany (7861 Mtoe) and Finland (6608 Mtoe) (European Commission, 2007). The European Commission (2007) also considers that implementation of the Biomass Action Plan (Commission Proposal COM(2005)628 final) will lead to further increases in the use of biomass (predominantly from solid biomass, biogas, biofuels and renewable municipal waste) to approximately 150 Mtoe in 2010 (an intended 55 Mtoe for electricity production, 75 Mtoe for heat production and 20 Mtoe for transport).

Despite the many initiatives and directives supporting sustainable energy solutions and reduced GHG emissions, several key socioeconomic, technological and financial mechanisms continue to hinder the implementation of more global and productive actions in energy policy to prevent climate change (Vertes, et al., 2006). Many important environmental effects of biofuel production are poorly understood (Farrell, et al., 2006) and even though it is clear that in theory, biomass energy sources could solve the problems we now face of shrinking fossil fuel reserves and rising atmospheric CO<sub>2</sub> concentrations, there are significant areas of resistance to change that are not only limited to the fossil fuel industry, but also to the agricultural and forestry industries (discussed in further detail in Chapter 3.4.4).

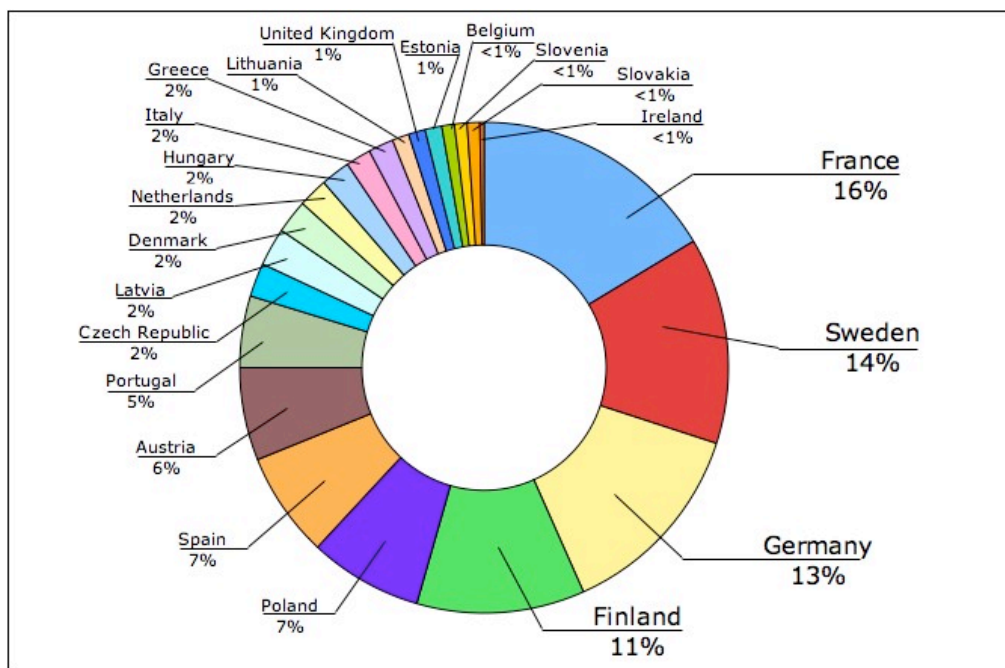


Figure 3-5 Primary energy production from solid biomass (in %) in the EU in 2005

Source: Adapted from European Commission (2007c)

### 3.5.2 Energy security

As has been indicated, global energy, including for electricity and transportation, is primarily derived from fossil and nuclear fuels. The stability of this ‘energy economy’ is currently dependent on the constant availability of petroleum reserves in adequate quantities to balance supply and demand, despite the consequences of any associated geopolitical stresses (Vertes, et al., 2006). The uneven global distribution of oil supplies (75% in the Middle East)

has led to volatile and non-competitive price structures and the dependency of the majority of the world on imported fuels (Dufey, 2006). Moreover, all of these issues are imposing grave energy security risks to countries that are reliant on the import of primary energy sources.

Pressures on the current energy model are escalating every day due to ever increasing energy demands from flourishing economies, such as India and China, petroleum shortages and a decline in the discovery of new oil reserves. Wuebbles and Jain (2001) see these issues, coupled with the environmental concerns of rising atmospheric concentrations of GHGs, as a “near term threat to continued quality of life and economic growth across the globe”.

The Commission of the European Communities (European Commission) Green Paper on Energy (Commission Proposal COM(2006)105 final) predicted that the deterioration of EU fossil fuel resources would increase its dependency on oil, natural gas, and coal imports from the then level of 50% up to 70% within the next 20-30 years, unless suitable mitigation measures are taken. Greater energy security can be achieved by increasing and diversifying domestic primary energy sources, diversifying the sources of energy imports and increasing the proportion of energy obtained from politically stable regions, for instance, by enhancing the production and use of biofuels (Farrell, et al., 2006; Herrera, 2006; Vertes, et al., 2006; Lynd, et al., 1991).

### **3.5.3 CO<sub>2</sub> emission reduction**

Since the dawn of the industrial revolution around the 1850s and accelerating ever since, human consumption of fossil fuels has dramatically elevated CO<sub>2</sub> concentrations in the atmosphere contributing drastically to climate change. The potential for utilising biomass for the production of biofuels would save non-renewable energy sources and reduce GHG emissions to the atmosphere, as biofuels are said to be what is known as ‘carbon neutral’ (Ragauskas, et al., 2006). That is, crops used for the production of biofuels sequester carbon as they grow, and when they are used, no more CO<sub>2</sub> is released than was absorbed during growth of the plants.

Different studies reveal substantial variation in estimates of GHG savings from the production of biofuels ranging from negative to more than 100% depending on the type of feedstock, cultivation method, conversion technology and disparities regarding reductions associated with co-products (Dufey, 2006). Delucchi (2003) even claims that biofuels could actually increase GHG emissions as land, such as tropical forests in developing countries like Brazil, is cleared to make way for the cultivation of energy crops.

For biofuels to be a viable alternative to fossil fuels, they should provide “a net energy gain, environmental benefits, be economically competitive and be producible in large quantities” (Hill, et al., 2006). Pimentel and Patzek (2005) show that bioethanol and biodiesel production from corn and soybeans, for example, can require more energy than they provide. Whereas opposing studies (Shapouri, et al., 2003; Shapouri, et al., 1995; Wang, 2001) suggest that overall bioethanol production has a positive energy yield. One thing that all parties seem to agree on however is that more energy efficiency can be gained from producing biofuels other than corn or grain derived bioethanol (Herrera, 2006).

The IEA (2004) suggests that the cost of biofuel production and distribution must be fairly low in comparison to their GHG reduction, which must be fairly high. Figure 2-3 shows a range of cost-per-tonne estimates for an example of different biofuels, based on numbers

from 2002 and projections for 2010, based on estimates of production/distribution costs and CO<sub>2</sub> reduction developed by IEA (2004). It is clear that cost-per-tonne estimates vary considerably between fuels and that over time ongoing technology and production improvements should eventually bring the costs down dramatically by 2010.

Second generation biofuels derived from lignocellulosic or woody sources such as straw, timber and woodchips, or via new technologies to convert biomass to liquid (BtL) offer greater energy efficiency with much lower GHG emissions (Hill et al. 2006), but according to authors in *Can Biofuels Cure Our Oil Dependency?* (EurActive, 2007b), they cannot yet be produced economically on a large scale. However, as Figure 3-6 shows, these new technologies, such as gasification with Fischer-Tropsch (F-T) synthesis, could provide GHG reductions at under US\$100 (€ 76) per tonne within the next few years. This will mean that F-T synthesis will soon become competitive with the EU's projected cost-per-tonne estimates for the production of bioethanol from grain and biodiesel from rapeseed.

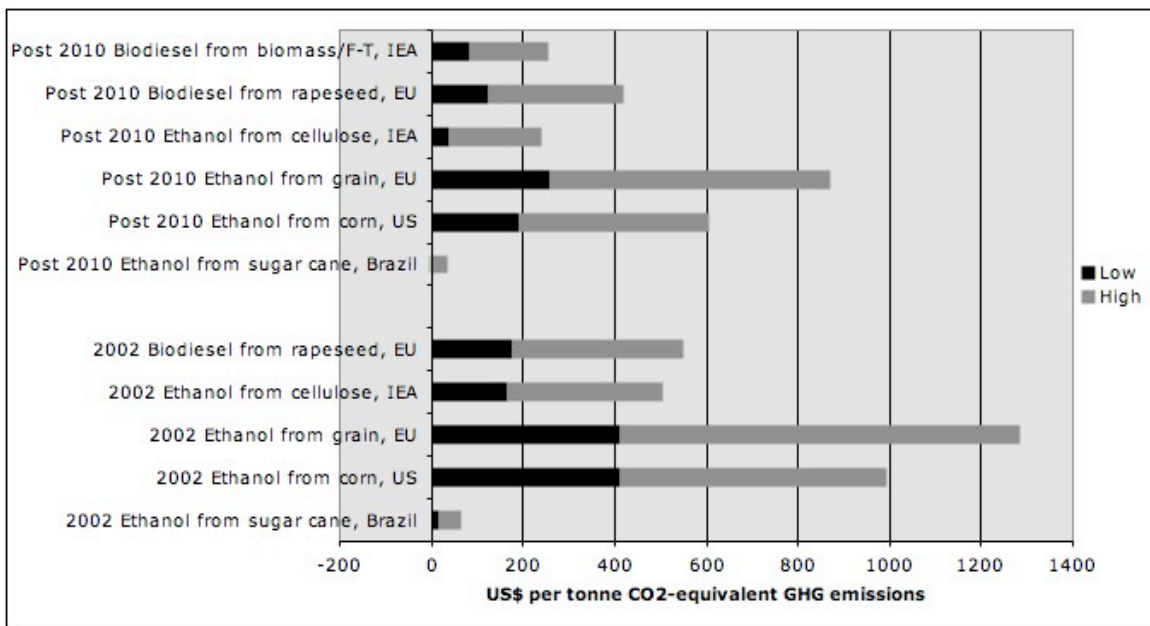


Figure 3-6 Biofuels cost per tonne GHG reduction

Source: Adapted from IEA (2004)<sup>7</sup>

Lowering production costs, increasing crop yields and energy outputs can enhance the benefits of biofuels. Increasing crop yields per hectare and decreasing energy input (for instance, from fertilisers) will reduce costs, increase potential energy outputs, and significantly improve the environmental benefits including the GHG reduction capabilities of the crop (IEA, 2004). Figure 3-7 demonstrates the considerable variations in energy yields from different feedstocks for the production of bioethanol and biodiesel, with sugar cane and palm oil currently producing the highest yields, respectively, per hectare. Other crops with much lower energy yields require so much land that they are not economically competitive (Moreira, 2005).

<sup>7</sup> “Ranges were developed using highest cost/lowest GHG reduction estimate, and lowest cost/highest GHG reduction estimate for each option, then taking the 25% and 75% percentile of this range to represent the low and high estimates in this figure. In some cases, ranges were developed around point estimates to reflect uncertainty” (IEA, 2004).

As Dufey (2006) points out, estimating these energy balances can be very complex and need to consider the entire lifecycle of the fuel, which varies dramatically depending on the cultivation methods and type of technology used to convert the crop into a fuel. For instance, bioethanol production from sugarcane in Brazil is deemed to be one of the most energy efficient forms of bioethanol production. A study by Langevin (2005) shows that this is due to natural soil and weather conditions which allow crop production with almost no additional inputs of fertilisers or irrigation and also because the surplus bagasse (remains of the sugar cane once the sugar has been extracted) is used for electricity co-generation, making the conversion process almost completely free of energy needs from fossil fuels.

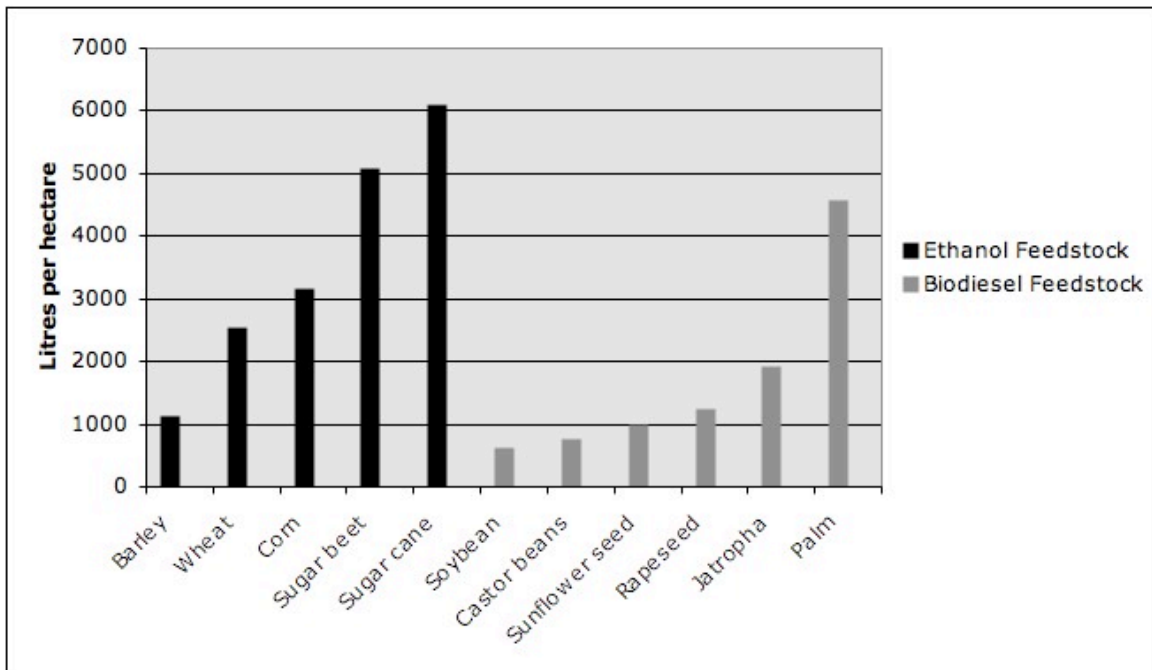


Figure 3-7 Biofuel yields of selected bioethanol and biodiesel feedstock

Source: Adapted from Worldwatch Institute (2006)

### 3.5.4 Agriculture and forestry

The EEA (2006) indicates that in order to reach the 2010 5.75% target set by the EU Biofuels Directive (Council Directive 2003/30/EC) with European biomass from crops, energy crops would need to occupy between 4-13% of total agricultural area of the EU-15 countries. However, using agricultural land to grow energy crops has the potential to compete with the use of land for food and/or animal feed production and to cause additional pressures on agricultural and forestry biodiversity and on soil and water resources. This trade-off is complicated by extensive farm subsidies in many countries, which may in some cases, be shifted towards biofuels production and away from other purposes as biofuel production increases (IEA, 2004).

Box 3-3 Case study: Energy crop cultivation in Sweden

**Energy crop cultivation in Sweden**

The EU Biofuels Directive prescribes that a 5.75% share of the market for petrol and diesel in transport must be biomass-derived by 2010. In order to achieve this target, 18.6 Mtoe of biofuel is required. However, the European Commission recently concluded that the biofuels directive target is not likely to be achieved (Commission Proposal COM(2006)845 final). Most progress towards achieving the target has been reached by Sweden and Germany who have several common factors contributing to their achievement, mainly policy related. These include:

1. They have been active in the biofuels field for several years.
2. They promote high-blend or pure biofuels (giving the policy visibility) and low blends compatible with existing distribution arrangements and engines (maximising the policies reach).
3. They have given biofuels tax exemptions without limiting the quantity eligible to benefit.
4. They have combined domestic production with imports (e.g. from Brazil).
5. They are investing in biofuel RTD and have treated first-generation biofuels as a bridge to second-generation.

The area of rapeseed crops for biodiesel production cultivated in Sweden last year was 84 000 ha, the biggest since EU admission, but what will it take for Sweden to reach the Biofuels Directive 2010 target? Approximately 1 ha of land is required to cultivate enough rapeseed to produce 1m<sup>3</sup> of rape methyl ester (RME) for diesel production. Therefore, if there is to be a 2% increase of RME for diesel production, Sweden will require an additional 70 000 ha of cultivated area. An increase of 5% of RME corresponds to a staggering 175 000 ha of additional land required.

The Academy of Agricultural Sciences (KSLA) advocates that it is technically and biologically possible to double the cultivation of rapeseed in Sweden to 170 000 ha. However, the KSLA believes that it will not happen due to inertia of the sector.

*Source: Commission Proposal COM(2006)845 final and Jordbruksaktuellt Sverige AB (2004, November 29)*

Within the EU, large scale production of energy crops began in the 1990s when revision of the Common Agricultural Policy (CAP) first encouraged farmers to grow non-food crops for income on set-aside land (Henniges and Zeddies 2006). The CAP revision was not undertaken to specifically encourage the production of energy crops, but more to reduce excess food production through the reconversion of agricultural areas towards the cultivation of non-surplus crops (Vannini, et al., 2006). Further revisions of the CAP in 2003 were aimed at decoupling income support from production and also promoting the production of

energy crops as a means of increasing farm incomes, as Henniges and Zeddies (2006) claim by:

1. Allowing farmers to grow energy crops on set-aside land, giving them the opportunity to earn an additional €100-150/ha, depending on the location, compared with retaining that land in fallow;
2. Providing farmers with a special aid for energy crops of €45/ha with a maximum guaranteed area of 1.5 million hectares as the budgetary ceiling;
3. Providing a cost-effective and environmentally acceptable way of disposing of manure by using it as a fertiliser in areas with significant animal production; and
4. Increased biofuel production has led to stronger prices for energy crops used as feedstock (for example, the price of rapeseed increased from €180/tonne in 2000 to €220/tonne in 2006).

Despite these measures to increase farm incomes and support energy crop production in the EU, Henniges and Zeddies (2006) claim that the income affects on agriculture has been small. Case studies also suggest that the special aid for producing energy crops on set-aside land is not encouraging farmers to cultivate energy crops. Vannini, et al. (2006) claims that there are two critical reasons for this:

1. Growing short term rotation forestry for energy purposes means that farmers need to commit for several years and at least four years must pass before the first harvest, as opposed to traditional annual harvesting of food crops; and
2. Using forestry products for energy purposes needs to be fostered through specific measures within the forestry action plan, as forest material will play an important role in the production of second generation biofuels.

While studying the economics of Salix (willow) production in Sweden, Poland and Ireland, additional factors governing the observed failure of growing energy crops under the CAP were identified (Rosenqvist, et al., 2005; 2006a; 2006b). These studies demonstrate that the following crop management problems were the main factors contributing to the observed failures, rather than any insufficient subsidies:

1. Farmers displayed a preference for keeping traditional cereal crops on their best soils and choosing their least productive land as 'set-aside', which led to farmers ignoring best-practice advice and planting Salix on these poor quality soils;
2. Policies have been extremely volatile, which is a strong antagonistic for any long-term commitment of land, especially in the case of Salix given that its period of cultivation is 20 years. For example, the unpredictability of the specific subsidy for Salix planting which was introduced in 1991 at €1100/ha, reduced in 1997 to €330, then increased again in 1999 to €550, pushed farmers away from the risk of Salix production and towards the stability of annual crops; and

3. Pioneer farmers considering the production of crops that are in their early stages of development, such as Salix, incur higher cost penalties. These costs decrease over time with new technologies and increasing areas that are planted with the new energy crop.

Large global scale production of biofuels has led to concern that agricultural land is increasingly being devoted to fuel crops and diverted away from other traditional uses, such as food and feed production, forestry, animal grazing or land conservation. According to some authors of *The Emerging Biofuels Market: Regulatory, Trade and Development Implications* (UN, 2006a) engaging in large scale energy crop production may require a loss of food security in exchange for greater energy security. Clear signs that biofuel feedstock supplies are struggling to keep up with demand and are thus impinging on food security are evident in the price increase of crops that are used for both food and fuel (such as maize, corn and sugar cane). Brown (2007) reports that the price of corn has doubled over the past year and wheat is now trading at its highest price in 10 years. A recent article in *The Economist* (2007, March 8) suggests “the demand for food based biofuel feedstocks are driving up the prices for everything from animal feed to cola products and biscuits”. *The Economist* (2007, March 8) goes on to say that the president of Mexico took the extreme measure of capping the price of corn tortillas because prices had skyrocketed as a result of the demand on corn for bioethanol production in the US.

Other authors of *Challenges and Opportunities for Developing Countries in Producing Biofuels* (UN, 2006b) claim that agricultural production does not use all available land, therefore energy crop production does not necessarily have to be at the expense of an already cultivated crop. Some even go as far as theorising that 70% of the worlds’ agricultural land can be made available for energy crop production without jeopardising future food security (Faaij, et al., 2004). However, one thing that all authors seem to be in consensus over, is the fact that all biofuels are not equal and this competition for land emphasises the importance of obtaining high energy crop yields (i.e. the best yield crops) and energy outputs (i.e. the best conversion efficiency to useful work or heat).

### **3.5.5 Employment and rural development**

The EEA (2006) highlights that along with the energy security and CO<sub>2</sub> emission reduction advantage of using biomass, it also has other advantages over conventional and even other renewable energy sources. The continued expansion of biofuel production will increase the need for energy crops as feedstock, which the Worldwatch Institute (2006) claim will result in the creation of new jobs during every stage of the biofuel chain from crop production and harvesting to processing and distribution. However, other authors hold that any biofuel related industry is more likely to guarantee benefits to a rural community if it is locally oriented to encourage farmers to produce fuel for their own use (Worldwatch Institute, 2006; UN, 2006; Dufey, 2006).

The Biomass Action Plan (Council Directive 2003/30/EC) estimates that an increase of biomass use to approximately 150 Mtoe in 2010 could lead to direct job creation in rural areas of up to 250 000 to 300 000 full time employees per year (Commission Proposal COM(2005)105 final). As a consequence, the enhancement of bioenergy throughout Europe has the potential to directly contribute to the economic stability of its rural areas.

### 3.5.6 Environment and land use issues

Biofuels can have several environmental benefits beyond the aforementioned reduced GHG emissions – one is increased urban air quality. However, as has already been suggested, there are also environmental dangers relating to the additional use of fertilisers and pesticides during the production of energy crops, and risks to biodiversity and soil degradation and erosion. The environmental implications of biofuel production, such as soil erosion and the conversion of forest to agriculture, still remain unquantified, but will likely become more important as biofuel production increases. Results of life-cycle assessments (LCAs) comparing fossil fuels with biofuels, show that while bioethanol and biodiesel are expected to offer advantages with respect to GHG emissions and fossil fuel depletion, they have similar if not higher impacts on public health and the environment (i.e. impacts on water, eutrophication, acidification and photochemical oxidant formation) (de Nocker, et al., 1998; Tan and Culaba, 2003; Kim and Dale, 2005).

The growth of energy crops in developing countries for export to the EU could also lead to deforestation and the socio-economic disadvantages that go hand in hand with such unsustainable practices. Kim and Dale (2005) warn that unless careful consideration is taken regarding land degradation, utilisation of biomass on a large scale would also lead to increased acidification and eutrophication mainly due to the massive amounts of land clearing necessary to accommodate additional crops, or from the environmental burdens associated with large nutrient load released from soil during cultivation. In an attempt to enhance the legitimacy of biofuels imported from developing countries, the EU planned a sustainability certification scheme for biofuels that would “allow Member States to provide incentives for the use of sustainably produced biofuels” (Environmental Data Services (ENDS), 2007, May 2). Although this attempt was deemed to be incompatible with WTO rules, the EU is considering ways to create incentives for the use of sustainable produced biofuels.

Even with the possibility of these adverse environmental impacts, the production of energy crops also afford some positive affects on biodiversity and nature conservation. For example, the IEA (2004) claims that moving away from conventional “first generation” liquid biofuel crops such as grain and sugar to “second generation” feedstocks such as cellulosic biomass (e.g. Salix, forestry residues, etc), leads to a much greater variety of potential feedstock sources including waste biomass and forestry residues, thus increasing the variety of crops that can be used and the land types upon which they can be grown.

A study conducted by the EEA (2006) shows that Sweden and Finland are countries with the highest potential to support bioenergy from forestry residues due to their high proportion of forest area. The same study also shows the nature conservation potential of biomass production due to the creation of new uses for currently uneconomic outputs of traditional agriculture and/or forest residues. However, the Finnish Forest Industries Federation clearly believes that forestry raw material should not be included as bioenergy feedstock if it has the potential to be processed into a higher value product (ENDS, 2007, March 13). They further advocate that the forestry industry has a very important socio-economic status, creating “13 times more employment and 8 times more value-added input” by processing wood into higher value products that would occur if the forestry raw material was merely burnt for the purposes of energy creation (ENDS, 2007, March 13).



### **3.5.7 Economy**

The European Commission's Renewable Energy Roadmap (Commission Proposal COM(2006)848 final) claims that the EU's renewable energy sector already has a turnover of €20 billion and employs around 300 000 people, mostly in rural areas. As previously discussed, the estimated increase in biomass use alone by 2010, is projected to create up to 300 000 additional jobs per year.

The market price of renewable energies however, generally exceeds that of conventional energy sources. Currently, biofuels are more expensive to produce than fossil fuels in the absence of support measures, making tax exemptions or other policy interventions (such as the placement of a value on CO<sub>2</sub> emissions or avoided emissions) necessary to make biofuels competitive (Vannini, et al., 2006). However, energy market prices have remained distorted in favour of fossil fuels due to the continued failure to systematically internalise the external costs of fossil fuel production and use (Hill, et al., 2006; Commission Proposal COM(2006)848 final). Moreover, this work has not found any studies examining the overall cost benefit associated with biofuels.

Up until recently, generating energy from biomass has been expensive due to both technological limits related to lower conversion technologies and logistics constraints (Palagagge, 2005) and as previously discussed, the cost of bioenergy varies greatly according to the feedstock and technologies used for conversion. However, in contrast to energy produced from fossil fuels, the cost of renewable energy has decreased significantly over the last 20 years (Commission Proposal COM(2006)848 final) with second generation biofuels from cellulosic feedstocks promising even greater environmental benefits with the less expense in the near future (EEA, 2006).

### **3.5.8 Genetically modified crops**

By far, the biggest challenge for biomass production is the development of crops with a suite of desirable physical and chemical traits that also produce greater biomass yields. Even though traditional techniques such as 'selective breeding' continue to play the main role in improving crop yields, significantly increasing the global productivity of energy crops will depend largely on "identifying the fundamental constraints on productivity and addressing those constraints with modern genomic tools" (Ragauskas et al., 2006). Genetic modification "can lead to the development of new, high-yield, pest-resistant crop varieties" (IEA, 2004) that would be almost impossible to achieve through 'selective breeding'. Some of these potential modifications are illustrated in Figure 3-8.

Genetic modification of food crops is already resulting in new high-yielding varieties of corn, wheat and sugar cane (IEA, 2004). However, the most significant advances in genetics will be to provide the means by which plant biomass can be increasingly exploited in a way that enables the next generation of bio-energy and bio-chemicals to become more competitive against fossil fuels and first generation technologies (Boudet, et al., 2003). At a recent Swedish seminar on the genetic potential of forestry crops in Stockholm (Biobrännse – Efter Olijekommissionen, 2006), it was estimated that advanced hybrids of genetically modified crops could be available within 10 years and the first genetically modified organisms (GMOs) within 20 years (Nilsson, 2006).

The use of GMOs is however, a highly sensitive social issue sparking concerns related to food safety, impacts on biodiversity, and the livelihoods of farmers (Dufey, 2006). GMO

crops are already widely cultivated throughout the US, Canada, and South America; however GMO development within the EU is heavily regulated with only 20 varieties approved (which are mostly corn and soy) (Dufey, 2006).

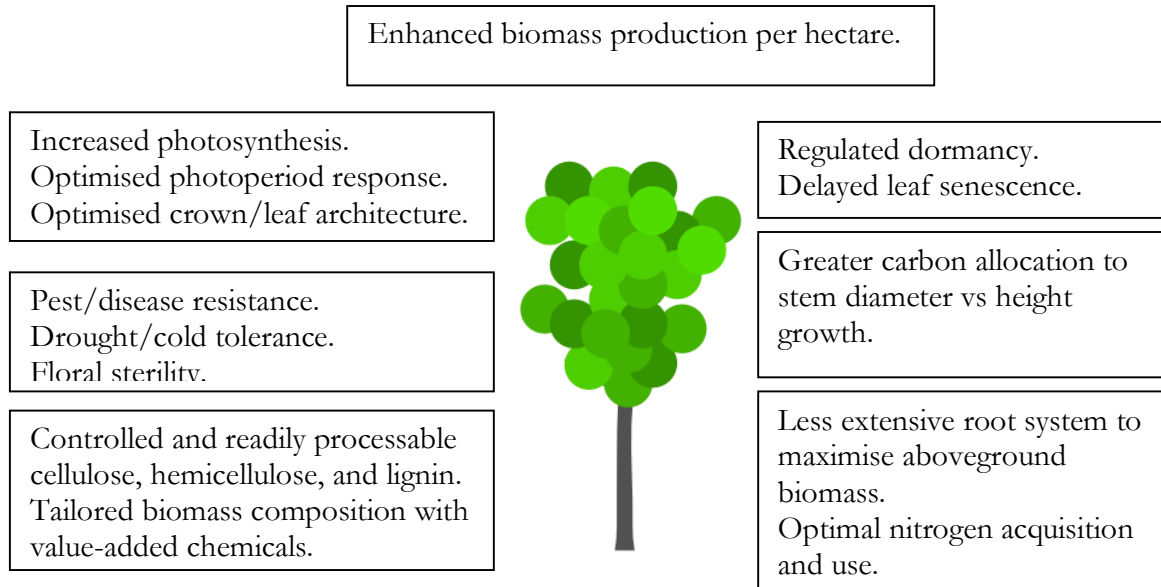


Figure 3-8 Overview of plant characteristics that can be targeted by genetic modification for enhanced biomass

Source: Adapted from Ragauskas, et al., 2006

### 3.5.9 Sustainability

There are obvious links between the use of renewable resources and achieving sustainable development, which requires us to live “within the regenerative capacity of the biosphere” (Wackernagel, et al., 2002). However, these links are variable and sometimes only tenable under particular circumstances. As previously discussed, in some cases biofuels can provide greater energy security, CO<sub>2</sub> emission reductions, increased employment and rural development, and economic benefits. However, energy crop production varies dramatically depending on the cultivation methods and type of technology used to convert the crop into a fuel (Dufey, 2006). Therefore, the production of energy crops could result in a range of adverse effects repudiating sustainability such as deforestation, risks to biodiversity, decreased food security, risks associated with genetic modification, soil degradation and erosion, and water pollution from additional use of pesticides and fertilisers.

Making a shift away from our dependence on fossil fuels towards resources of renewable biomass is generally seen as an important step to the development of a sustainable industrialised society (Ragauskas, et al., 2006). However, the sustainability debate surrounding biofuels will in the future revolve around new technologies and practices, such as sustainable agriculture and the development of second generation (e.g. cellulosic) biofuel production. When coupled with increased vehicle efficiency, a greater biofuels industry could play a major role in meeting the energy needs of the EU while complying with strict environmental goals (Farrell, et al., 2006) and moving further towards a sustainable society.

### **3.6 Conclusion**

This chapter explored the key areas that the author identified as important to the political legitimacy of biorefineries in Europe. The key areas included: the EU regulatory framework, energy security, CO<sub>2</sub> emission reduction, agriculture and forestry, employment and rural development, environment and land use, economy, genetically modified crops, and sustainability. Each of these key areas has been described and analysed in detail in order to determine how they will relate to the progression of biorefineries.

Although the framework for measuring political legitimacy that is being used within this thesis distinguishes between cognitive and political legitimacy, these two concepts are closely intertwined and often difficult to separate. Therefore, in order to adapt this framework to the concept of biorefineries, the author deemed it necessary to first understand the cognitive essence of biorefineries (i.e. the technicalities of what a biorefinery is or could be), a task that has been undertaken in Chapter 4.

## 4 Defining the biorefinery concept

### 4.1 Introduction

Kamm, et al. (2006a) demonstrates that biorefineries offer the combination of the necessary technologies, biomass raw materials, industrial intermediates, and final products to enable the rearrangement of petroleum based economies to more sustainable ones. Realf and Abbas (2004) concur that industrial biorefineries have been identified as the most promising route to the creation of a more sustainable bio-based economy, using safe, renewable resources for industrial production. To enable the future development of biorefineries, Kamm and Kamm (2004) emphasise that completely new approaches in research and development, production and economy are necessary. In particular, they emphasise the vital role that the amalgamation of chemical and biochemical conversion technologies will play.

Fundamental to progression of the biorefinery concept is that the theory, processes, inputs and production capabilities of biorefineries are clearly defined, understood and articulated. However, neither a general vision nor structural overviews of applicable concepts of biorefineries (including general technical, economic and environmental) are completely understood by many stakeholders within the European political sphere (Zwart, 2006). Therefore, the cognitive essence of biorefineries (i.e. what they are or could be) and the lack of clarity surrounding them also need to be defined, a task that was undertaken within this chapter. The key areas identified as important to the legitimacy of biorefineries include: the biorefinery concept itself, feedstocks and products of biorefineries, technologies required for biorefineries, having a working definition of a biorefinery, the lack of clarity of stakeholders in understanding what a biorefinery is or could be, and defining who the “innovative entrepreneurs” of biorefineries are. Each of these key areas was described and analysed in detail in order to determine how they will related to the progression of biorefineries in Europe. From these key areas, a number of contentious issues were identified as having the potential to dramatically affect the political legitimacy of biorefineries including: cost effective 2<sup>nd</sup> generation conversion technology is complicated and still under development, the general concept of a biorefinery is unclear as there is no convergence around one dominant design, and biorefinery definitions vary significantly between experts.

### 4.2 The biorefinery concept

Like petroleum, biomass has a complex composition, but with a different C:H:O:N ratio that can be separated into groups of functional and valuable substances. Successive treatment and processing of those substances produce a diverse range of products. The chemistry of the petroleum industry is based on the principle of generating specific, transportable chemically pure products from crude oil (which is essentially a mixture of hydrocarbons) in petroleum refineries. This systematic process is based on the formation of chemical product family trees, in which basic chemicals, intermediate products, and sophisticated products are produced (Kamm, et al., 2006b).

In essence, the concept of the modern biorefinery is analogous to the concept of a petroleum refinery (Figure 4-1). A diverse and abundant raw material consisting of renewable biomass (primarily polysaccharides and lignin) enters the biorefinery and, through a series of different processes, is fractionated and converted into a mixture of products including transportation fuels, direct energy and biochemical/biomaterial co-products (Kamm, et al., 2006a;

Ragauskas, et al., 2006). The biorefinery will first extract the high-value chemicals already existing in the biomass feedstock such as “fragrances, flavouring agents, food related products and nutraceuticals that provide health and medical benefits” (Morandini et al., 2005). Once these relatively valuable products are extracted, the biorefinery process will concentrate on processing plant polysaccharides and lignin into feedstocks for several low-value but high-volume biochemical products (such as resins and nylons) and fuels (Ragauskas, et al., 2006). The technologies required to perform some of the chemical and biochemical conversion processes described above are still under development, as briefly described in Chapter 2.1 and further elaborated in Chapter 4.2, and will become one of the key drivers to development of biorefineries in the future.

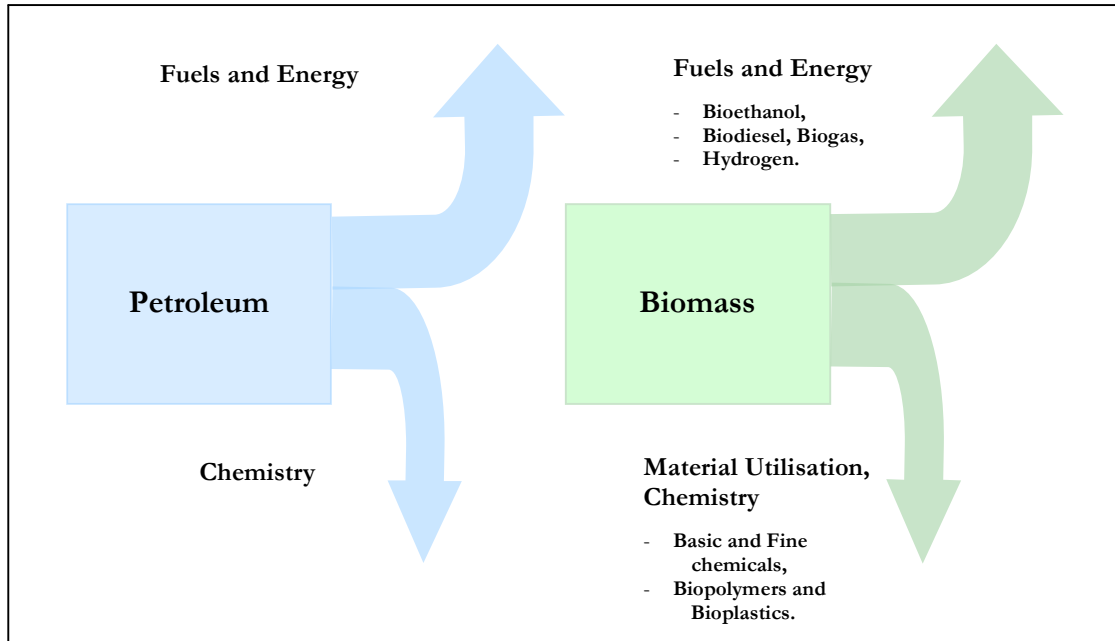


Figure 4-1 Comparison of the basic principles of the petroleum refinery and the biorefinery

Source: Adapted from Kamm, et al., 2006b

Just as a petroleum refinery takes advantage of the differences in crude oil components and intermediates, a biorefinery as defined here also utilises the differences in biomass components and intermediates to produce a multitude of biomaterials while maximising the value derived from the feedstock (Kamm, et al., 2006a). This notion of “value maximisation” is central to the biorefinery concept, as is the coupling of various separation and conversion technologies. Figure 4-2 shows a schematic of the basic biorefinery concept where biomass conversion processes and equipment are integrated to co-produce a diverse range of bio-based products from diverse biomass sources. Primary separation can be a simple land-based procedure (e.g. grain combine) to very complex methods (e.g. refining analogous to a sugar factory). Primary products consist of specific components (e.g. proteins, fibres, fats, carbohydrates or combinations thereof). The conversion process can be thermo/chemical or biotechnological and can result in various products and intermediates that, after separation, can be sold individually or turned into an end product after secondary conversion.

Although there are differing views regarding the most appropriate feedstocks, conversion technologies and product categories, one point where all authors seem to be in agreement is that a *successful biorefinery must have a symbiotic relationship to all facets of the associated production chains*. For example, the production process must minimise land degradation, labour cost and competition with existing land for food/feed production. It must also be able to return net energy gains as well as net positive environmental impacts. The biorefinery will need to integrate economies of scale and scope similar to those for which petroleum refineries benefit by offering the possibility of producing a variety of compounds including chemical building blocks and intermediates (Kamm and Kamm, 2004). These needs are fundamental to the biorefinery concept.

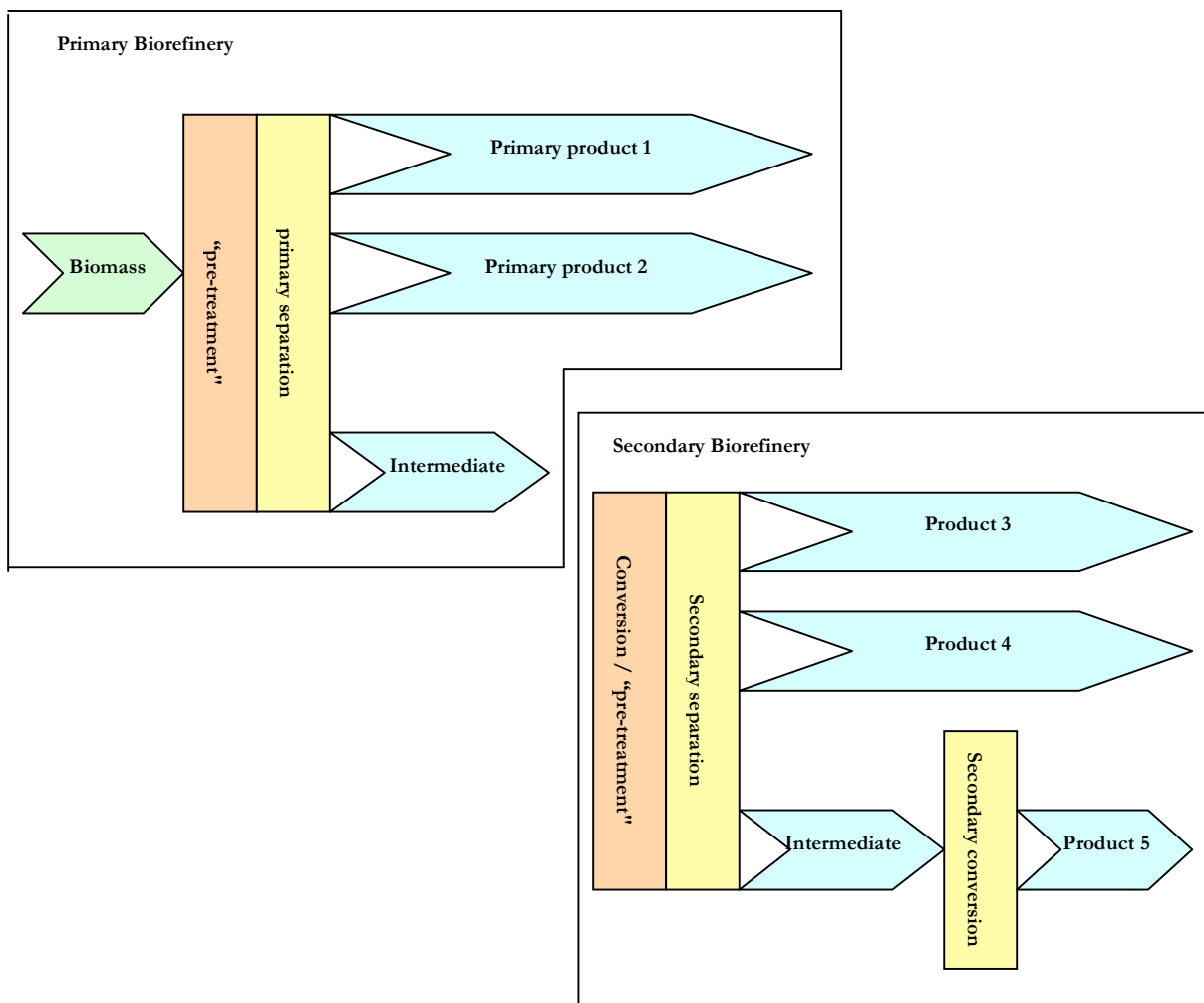


Figure 4-2 Schematic overview of the general biorefinery concept

Source: Adapted from de Jong, 2005

### 4.3 Feedstocks and products of biorefineries

Central to the biorefinery concept is the maximisation of value from the biomass feedstock. In an engineering sense, the concept involves the emulation of a petroleum refinery to produce a very wide range of products that include:

- one or several low-volume but high-value chemical products;
- a low-value but high-volume platform chemical; and/or
- a liquid transportation fuel.

Further, a biorefinery will also generate electricity and process heat for its own use and likely enough for sale of electricity, which is critical to its economic viability. The high-value products enhance profitability; the high-volume chemicals and/or transportation fuels help to meet European energy needs and CO<sub>2</sub> emission reduction goals; whereas the power and/or heat both reduce overall production costs and GHG emissions (BIOPOL, 2006). Some practical applications of biomass feedstocks are already being used, such as solvents, plastics, lubricants, fragrances, and some bio-derived plastics are also gaining popularity (Ragauskas, et al., 2006).

Werpy (2004) reports that the US governments' key national laboratories released a list of potential bio-based building blocks<sup>8</sup> and chemicals, using a literature review process based on the petrochemical model of building blocks, chemical data, known market data, properties, performance of the potential candidates potential markets and the technical complexity of the synthesis pathways. The investigation revealed the following biomass precursors, platforms, building blocks, secondary chemicals, intermediates, products and uses shown in Figure 4-3 (Kamm, et al., 2006). Further, they reported building block chemicals can be produced from sugar by means of biological and/or chemical conversions, and then consequently converted into a range of high value biochemicals or biomaterials.

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<sup>8</sup> Building block chemicals are "molecules with multiple functional groups that possess the potential to be transformed into new families of useful molecules" (Kamm, et al., 2006a).

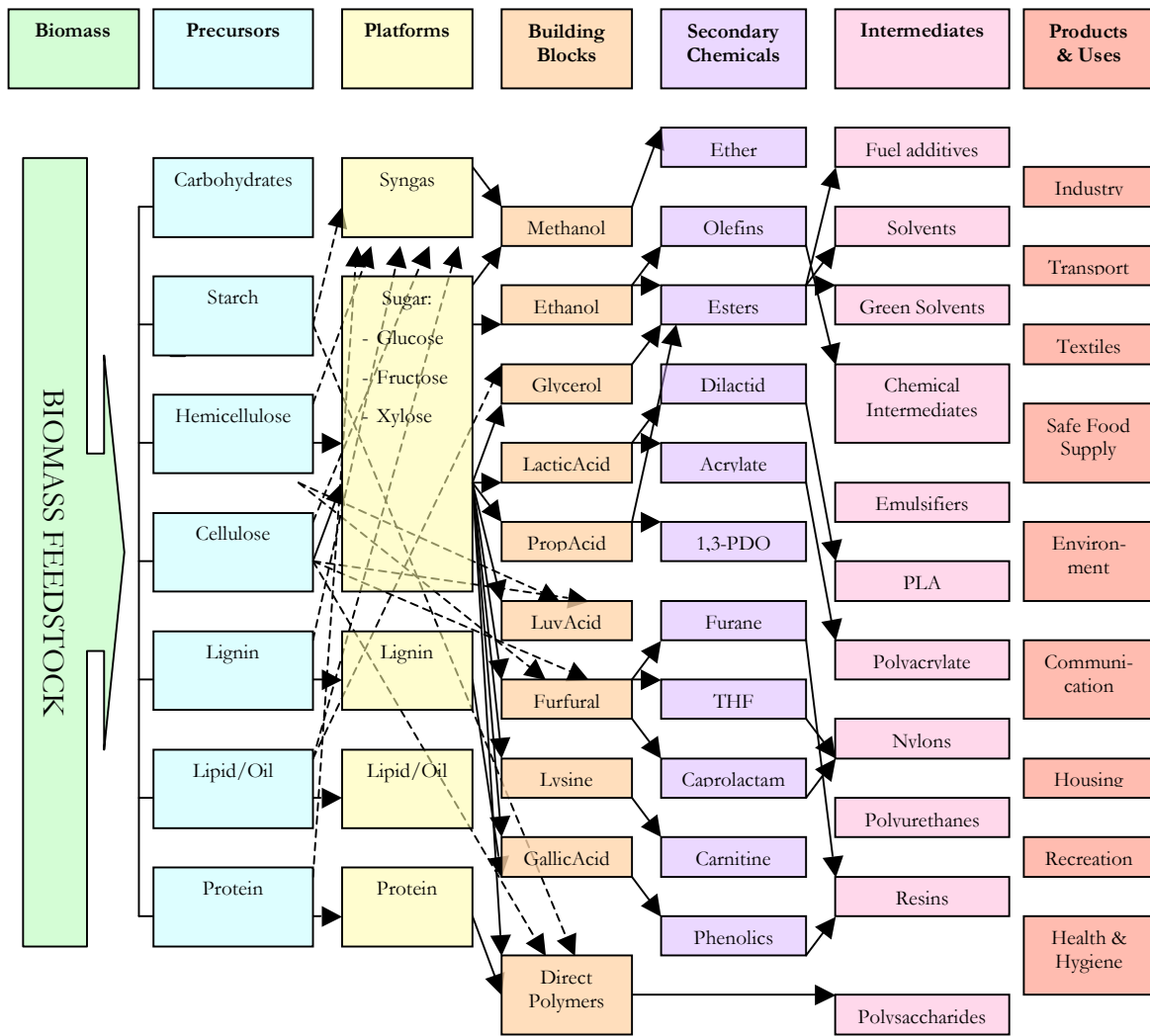


Figure 4-3 Model of a bio-based products flowchart for biomass feedstock

Source: Adapted from Werpy, et al., 2004

Note: PropAcid=Propionic Acid; LuvAcid=Luvulinic Acid, 1,3-PDO=1,3-propanediol, THF=tetrahydrofuran, PLA=Polyacetic acid.

As a result of the above study, hydrogen and methanol were found to encompass the best short-term prospects for bio-based commercial chemical production, because obtaining simple alcohols, aldehydes, mixed alcohols, and Fischer-Tropsch liquids from biomass is currently not economically viable (Werpy, et al., 2004).

Ragauskas, et al. (2006) confirms that the sugars in the biorefinery process can be transformed into building-block chemicals by fermentation as well as by enzymatic and chemical transformations, which will include ethanol, C3-C6 carboxylic acids and alcohols such as glycerol and sorbitol. Optimistically, Lichtenthaler (2002) notes that the “current cost of many carbohydrates and their derivatives is already competitive with petrochemicals and solvent such as toluene, aniline, and acetaldehyde”.

Major research projects within the chemicals industry (such as Hydrostar, an EU and ICI Paints partnership) have been conducting research into the synthesis of industrial polymers



based on renewable resources, such as starch derivatives, as a direct reaction to the rising cost of fossil fuel resources (European Commission, 2007b). In a series of interviews with Hydrostar representatives from ICI, Peck (2003) established that for some industrial polymers (polyurethane, for example) renewable feedstocks are outperforming fossil fuels in terms of environmental performance. Brooks<sup>9</sup> (1998) confirmed that over ten years ago, there was “a move towards different feedstocks: non-oil derived feedstocks, partial reliance upon agricultural based sources”. He went on to say that this move was based on the assumption that renewable feedstocks “is the way of the future and that it will prove to be superior in the longer term” as they “outperform fossil resources”. When discussing LCA comparisons of starch latex compared to petroleum based latex, Taylor<sup>10</sup> (2001) stated that there were obvious “benefits for the starch latex in terms of lower energy utilisation across the total supply chain and lower green house, acidification and eutrophication gas emissions across the total supply chain”.

#### **4.4 Technologies required for biorefineries**

Climate stabilisation will require a massive transition to CO<sub>2</sub> emission-free energy technologies (Caldeira, 2003). However, “sustainable economic growth requires safe, sustainable resources for industrial production” (Kamm and Kamm, 2004). The development and rapid implementation of renewable technologies for the energy, transportation fuels and chemical industry is an important route towards this goal and there now exists the opportunity for energy crops and biorefining technologies to develop sustainable biopower and biomaterials that will lead to a new manufacturing paradigm (Ragauskas, et al., 2006). However, the major obstacle to the realisation of biorefinery technology is the development of technological methods to separate, refine and transform the biomass feedstocks and intermediates into useable bio-based products.

According to Ragauskas, et al. (2006) a vision of the biorefinery will epitomise a sustainable system of biomass conversion into biofuels, bioenergy, and biomaterials that depend only on sustainable resources, and waste recycling that is entirely carbon neutral. The innovative challenge exists far beyond energy crop development and refinery process development, to one that incorporates novel chemistry industries to develop applications for the variety of new biological precursors (e.g. novel polymers and their use) that will become available through the biorefining process.

Cost effective biomass fractionation (e.g. supercritical fractionation, advanced gasification, enzymatic hydrolysis) and conversion (advanced gasification, chemical conversion, enzymatic conversion, fermentation) technology is complicated and still under development for second generation bio-based products. Significant opportunities for the chemical processing industry will be created when highly oxygen-functionalised, bio-based feedstocks will become readily available. Ragauskas, et al. (2006) highlights the example of the use of carbohydrates as chemical raw materials, which will eliminate the need for several capital-intensive, oxidative processes used in the petroleum industry. This will thus reduce the need for expensive syntheses that are currently required to selectively install chemical functionality in petrochemicals.

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<sup>10</sup> Research and Development Manager, ICI Paints

## 4.5 Working definition of a biorefinery

The field of biorefinery research and development is still relatively young. This is reflected in the search for an appropriate definition amongst researchers, scholars, and political and industrial stakeholders. Kamm, et al. (1998) first defined the term “green biorefinery” as “complex (to fully integrated) systems of sustainable, environment- and resource-friendly technologies for the comprehensive (holistic) utilisation and the exploitation of biological raw materials in the form of green and residue biomass from a targeted sustainable regional land utilisation”. Kamm and Kamm (2004) also iterate that biorefineries should be able to use various types of feedstocks and conversion technologies to produce bio-based products; this flexibility is the highest priority for adaptability towards changes in demand and supply for feed, food and industrial commodities.

The first steps in the biorefining process are to physically separate the functional group containing biomasses, and then subsequently treat by microbial or chemical methods to create primary products and by-products (intermediates). These by-products are then further converted into secondary products and secondary by-products (intermediates), and so on. According to Kamm, et al., (2006b), the essential elements of new basic biorefinery technologies that separate the raw biomass feedstock through a selection of treatment and processing methods are as follows:

1. Multiple feedstock capability and a tolerance of wide variation for these feedstocks;
2. Enzymatic feedstock fermentation to sugars (and by-product streams);
3. Biocatalyst conversion of sugars to desired bio-based products; and
4. Reuse, recycling, or sale of co-products.

Currently, there are four complex biorefinery systems under research and development (Kamm, et al., 2006b):

1. The “lignocellulosic feedstock biorefinery” which uses “nature-dry” raw material such as cellulose-containing biomass and waste;
2. The “whole crop biorefinery” which uses raw material such as cereals or maize;
3. The “green biorefinery” which uses “nature-wet” biomass such as green grass, alfalfa, clover, or immature cereal; and
4. The “biorefinery two platforms concept” which includes the sugar platform and the syngas platform.

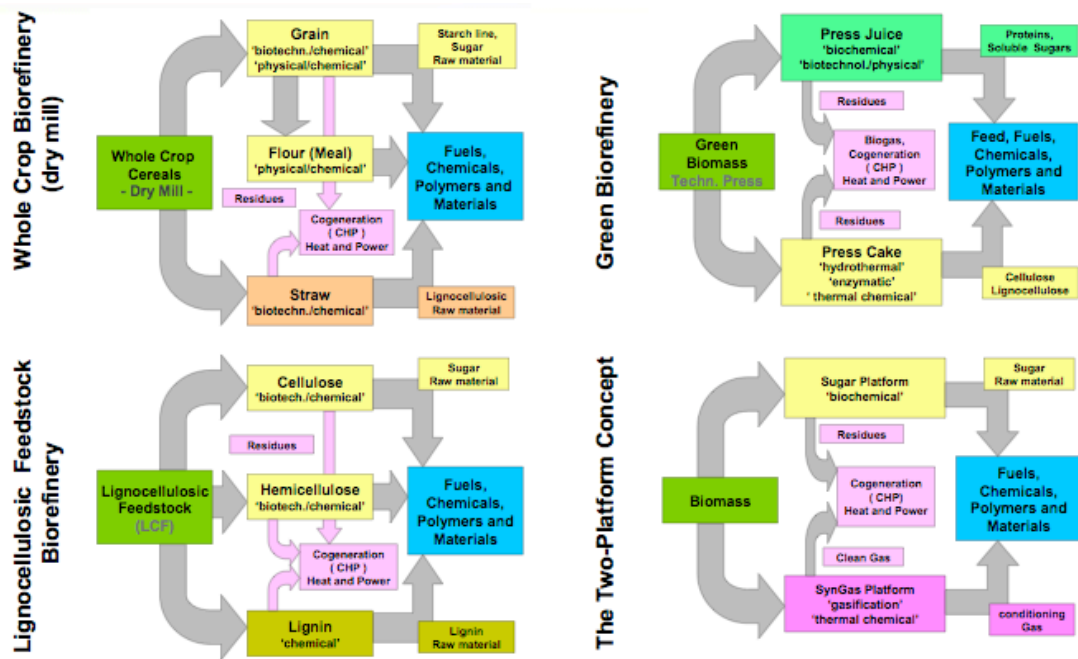


Figure 4-4 Schematic overview of the four complex biorefinery systems currently under research and development

Source: Adapted from Kamm, et al., 2006b

Kamm, et al. (2006b) claim that the “*lignocellulosic feedstock biorefinery*” will be progressed with the highest success because the biomass feedstock is optimal (straw, reeds, grass, wood, paper-waste, etc) and the potential products already have a strong position on the traditional petrochemical and future bio-based product market. There are still some underdeveloped technological aspects of the “*lignocellulosic feedstock biorefinery*” that currently make it a sub-optimal system, such as its inability to utilise lignin as a fuel, adhesive or binder (Kamm and Kamm, 2004). However, Sanders, et al. (2007) claims that the price of enzymes used in the conversion process have dropped considerably in the past 5-6 years, making this biorefinery concept more attractive.

In the “*whole crop biorefinery*” based on dry milling uses raw biomass feedstock cereals such as rye, wheat, triticale, and maize are used. The first step in the refining process is to physically separate the corn and straw, of which straw makes up 90% that can then be sent to the “*lignocellulosic feedstock biorefinery*” for further processing into product intermediates such as syngas (Kamm, et al., 2006b). The corn component can then be used directly as flour meal, or converted into starch. Further processing by chemical modification or biotechnological conversion leads to the synthesis of a number of products such as pharmaceuticals, adhesives, protective coatings, electrical insulations, etc (Webb, 2006). Wet milling of the “*whole crop biorefinery*” is a slight variation where the grain is swelled and then pressed to release high-value oils. This process can lead to the synthesis of fuels, feed, fats and oils, chemicals, and pharmaceuticals; however, high costs of the raw materials and technologies required, compared with dry milling, are disadvantageous (Kamm, et al., 2006b).

The “*green biorefinery*” utilises such feedstocks as grass (from the cultivation of permanent grassland, fields, nature preserves) and green crops (such as Lucerne and clover). The system uses wet-fractionation technology to isolate the green biomass substance to produce lactic

acid and amino acids, plus other fine chemicals, fibres and fibre products, while biotechnological methods are required to produce syngas, biofuels, heat and electricity (Halasz, et al., 2005). Kamm et al. (2006) describes that the “*green biorefinery*” has the advantage of high biomass profit per hectare and a good synergy with agricultural production. However, they go on to say that economy is still a hurdle as the price of the bulk products is affected mainly by the cost of raw materials.

The “*2-platform biorefinery*” integrates both the sugar and syngas platforms after the initial separation process (BioTOP, 2006). The sugar platform as a biochemical conversion processes that concentrates on the fermentation of sugars extracted from biomass feedstocks, while the syngas platform is a thermochemical conversion process that concentrates on the gasification of biomass feedstocks (Kamm, et al., 2006b).

Although some biorefinery applications are ready today, their impact remains limited with the current biomass feedstocks and technologies (Ragauskas, et al., 2006). To enable the successful development of any of the variations to the “*industrial biorefinery*”, many issues are still to be resolved. These include increasing the production capabilities of intermediate products (cellulose, sugar, oil) from basic biomass feedstocks, promoting the establishment of biorefinery demonstration plants, promoting the combined biotechnological and chemical conversion of substances, and the development of “*systematic approaches to new synthesis and technologies required to meet the sustainable principles of green chemistry and process engineering*” (Kamm, et al., 2006b).

## 4.6 Lack of clarity over biorefineries

Although the field of biorefinery research and development is still relatively young, the expression ‘biorefinery’ is one that is being thrown around in many circles of society and is used by many stakeholders – many non-technical and/or non-expert. For instance, BIOPRO (2007) reports that by March 2007, Google had logged 250 000 hits for the word in English and 43 000 hits in German (‘bioraffinery’). Also, literature on the topics of biorefinery concepts, feedstocks, technologies and products are appearing within a number of academic journals and other media; the first book devoted to biorefinery processes and products was even published late last year.

The fact that biorefineries are beginning to be so frequently spoken and written about, provides initial evidence that the “*integrated industrial biorefinery*” concept is flourishing. However, there is currently a lack of clarity amongst various community, agricultural, forestry, industrial and political circles regarding the complexity of issues surrounding the biorefinery concept. Most lay people’s understanding of a biorefinery is one that is limited to the production of liquid biofuels only, which is perhaps understandable considering the complexity of the issues involved and the fact that these “*partial biorefineries*” (for instance, for the co-production of bioethanol and heat from forestry residues) have been in existence for a number of years.

This lack of clarity around what biorefineries actually are also exists within the ‘expert’ field. Biorefinery systems incorporate several different industries (including agriculture, forestry, petrochemicals and food) that clearly have different points of departure when considering what a biorefinery is or could be. The first European Conference on Biorefinery Research, organised by the European Commission, was held in Helsinki in 2006 bringing together industrial perspectives of biorefineries and identifying opportunities for and synergies among European stakeholders. One attendee reported “at this leading EU event on biorefineries,

there was a huge range of differences in interpretations of what actually constitutes a biorefinery and what it could be in the future. Essentially, most presenters based their definitions on their own disciplinary background” (McCormick, 2007).

Understanding where this lack of clarity around biorefineries originates is a vital step in determining the “cognitive legitimacy” of biorefineries. However, there is no wonder that this lack of clarity abounds when presented with just a few of the biorefinery definitions available:

- Vertes, et al. (2006) refer to biorefineries as a “cluster of integrated biotech industries to produce compounds to serve both the energy and chemical commodities market, and high value product industries”;
- BIOPRO (2007) refers to biorefineries as an “integrative overall concept referring to the biochemical and thermochemical conversion of renewable materials into chemicals and other materials as well as fuels and combustibles as part of a *sustainable* economic development in which biomass is utilised to the greatest extent possible”;
- Ragauskas, et al. (2006) refers to biorefineries as a “new manufacturing concept for converting renewable biomass to valuable fuels and products”; and
- BIOPOL (2007) refer to biorefineries as “a facility that integrates biomass conversion processes and equipment to co-produce fuels, power, materials and chemicals from diverse biomass sources. By producing multiple products, a biorefinery can take advantage of the difference in biomass components and intermediates and maximise the value derived from the biomass feedstock”.

Modifying any of these descriptions into a simple working definition becomes inherently difficult. Even the most recent definition provided by leaders in the field of biorefinery research, Kamm, et al. (2006b), can only narrow the definition down into four separate biorefinery categories with their own complicated descriptions: the “lignocellulosic feedstock biorefinery”, the “whole crop biorefinery”, the “green biorefinery”, and the “biorefinery two platform concept”. Various other definitions have also been conceived, but there is at least consensus amongst authors over the main goal of a biorefinery, which is to begin with a biomass feedstock mix, and by using a technology mix, produce a plethora of bio-based products (Van Dyne, et al., 1999). Therefore, for the purpose of determining the political legitimacy of biorefineries and to capture the essence of biorefining whilst allowing differentiation from “partial biorefineries”, the author will define and work with the term “*integrated industrial biorefinery*”. Once the factors for enhancing political legitimacy have been examined with respect to *integrated industrial biorefineries*, a conceptual definition that will better allow the political legitimacy of biorefineries to be measured will be proposed, a task that has been undertaken in Chapter 5. However, throughout this thesis, the terms ‘*biorefinery*’ and ‘*integrated industrial biorefinery*’ are synonymous.

#### 4.7 Defining the ‘innovative entrepreneurs’ of biorefineries

The theoretical framework described in Chapter 2 introduces the concept of “innovative entrepreneurs”, sets out a number of strategies that they can adopt to overcome legitimacy obstacles during the formative period of a new business concept, and describes a method for measuring political legitimacy. However, before we can extend this framework to the

*integrated industrial biorefinery* within a European context, the author perceived it necessary to first define who the innovative entrepreneurs are for this work.

Jacobsson and Bergek (2004) describe the innovation process as both an individual and collective operation that may include such actors as firms (e.g. suppliers, users or venture capitalists) or other organisations”. They go on to stress the importance of other significant actors, such as non-commercial organisations who may act as advocates of specific technologies, and networks who may be beneficial in the “identification of problems and the development of new technical solutions, or to an ability to influence the institutional step-up”. In Chapter 1.3, the author described that there are currently a number of consortiums, national groups, researchers and private investors, that are working to facilitate the progression of integrated industrial biorefineries from its current research phase towards the demonstration (pilot) phase, particularly within Europe and the US for example. Such actors include, but are not limited to, the following:

- BIOPOL – a Pan-European research network, established through the EU’s 6<sup>th</sup> Framework Program for Research and Technological Development (for which the work undertaken in this thesis is intended to contribute) (BIOPOL, 2007);
- Biorefinery.nl – a joint initiative between the Wageningen University and Research Centre (WUR), and the Energy Research Centre of the Netherlands (ECN), supported by SenterNovem (an agency of the Dutch Ministry of Economic Affairs), with the intention of forming a roadmap for research on and development of biorefinery processes (Biorefinery.nl, 2007);
- Bio2Value – a programmatic operation between WUR and ECN to support the substitution process of fossil fuels by biomass (Biorefinery.nl, 2007);
- IEA42 – an International Energy Agency (IEA) bioenergy task (number 42) to open up the biorefinery-related potential, international system, and technology development (Biorefinery.nl, 2007);
- IP Biosynergy – a joint initiative between several partners including WUR, ECN, the Technical University of Delft, BTG (a private company specialising in biomass conversion processes) and DOW Chemical Company, to promote biomass for the market competitive and environmentally friendly synthesis of bio-based products, together with the production of secondary energy carriers, through the biorefinery approach (IP Biosynergy, 2007);
- VTT – is an impartial expert organisation in Finland that has the objective of creating new technologies and innovations for the public sector, companies and international organisations. VTT has recently launched a test operation to refine syngas from biomass for the production of biofuels (2<sup>nd</sup> generation conversion technology) (VTT, 2006);
- Bioethanol – is a joint venture between several partners including ECN, WUR, and SHELL Global Solutions, to research the co-production of bioethanol and lactic acid, power and heat from lignocellulosic sources (Biorefinery.nl, 2007);

- Cargill Dow – a US based joint venture between Cargill and Dow Chemical is exploring the use of lignocellulosic conversion technology for the production of, amongst other things, PLA (see Figure 4-3) in its emerging biorefinery (Zwart, 2006); and
- The US Department of Energy (DOE) has recently announced that it will invest over US\$385 million to fund six biorefinery projects within the next four years. The projects are expected to use DuPont’s “unique integrated lignocellulosic conversion technology” to produce approximately 500 litres of bioethanol for transportation fuel, electricity, and other bio-based products (Chemical Week, 2007, March 7).

From this modest list of the potential entrepreneurs of biorefineries, it is obvious that this new business concept is not confined only to bioenergy scientists. Each of these seemingly disparate actors comprise a network of technical, financial, educational and/or political individuals (including also some of the scholars referenced in Chapter 4.6) are working to facilitate the progression of the *integrated industrial biorefinery* from its current research phase towards the demonstration (pilot) phase. Therefore, the author considers these types of actors to be the innovative entrepreneurs for *integrated industrial biorefineries* within the context of this work.

## 4.8 Conclusion

Even though this thesis concentrates on the measurement of political legitimacy, the author discovered that cognitive legitimacy is so closely intertwined into the potential for political leaders to accept and support a new business concept, that the cognitive essence of *integrated industrial biorefineries* (i.e. what they are or could be) and the lack of clarity surrounding them also need to be defined, a task that was undertaken within this chapter. The key areas identified as important to the target audience include: the biorefinery concept itself, feedstocks and products of biorefineries, technologies required for biorefineries, having a working definition of a biorefinery, the lack of clarity of stakeholders in understanding what a biorefinery is or could be, and defining who the “innovative entrepreneurs” of biorefineries are. Each of these key areas was described and analysed in detail in order to determine how they will related to the progression of *integrated industrial biorefineries* in Europe.

Now that the various components contributing to the legitimacy of *integrated industrial biorefineries* have been understood and defined, the author will apply them to the theoretical factors influencing the legitimacy of new business concepts, a task that has been undertaken in Chapter 5.

## 5 Determining a Method to Measure the Political Legitimacy of Biorefineries in Europe

### 5.1 Introduction

This thesis aims to understand how existing knowledge, indicators and literature can be used to determine a logical and streamlined way to measure the “political legitimacy” of biorefineries in Europe.

In order to achieve this, the following objectives have been undertaken:

1. A framework for understanding the factors that influence and enhance the political legitimacy of new business concepts was described in Chapter 2.
2. The political importance and implications of the production and use of bio-based products (encompassing transportation fuels, solvents, detergents, plastics, resins, etc) was explored and the various impediments or drivers for the progression of *integrated industrial biorefineries* were analysed in Chapter 3.
3. A clear definition of what an *integrated industrial biorefinery* is, or could be, was established in Chapter 4.
4. An understanding of where the lack of clarity surrounding *integrated industrial biorefineries* originates was established in Chapter 4.

Now that the various components contributing to the cognitive and political legitimacy of *integrated industrial biorefineries* have been outlined and defined, this Chapter will seek to apply them to the theoretical factors that influence and enhance the legitimacy of innovative business concepts, so that the following final objective can be undertaken:

5. A framework for understanding and measuring the political legitimacy of *integrated industrial biorefineries* in Europe will be developed.

### 5.2 How to measure political legitimacy

The literature regarding organisational theory provides a framework around which the political legitimacy of new business concepts can be analysed and enhanced. As demonstrated in Chapter 2, frameworks such as those established by Aldrich and Fiol (1994), Ranger-Moore et al. (1991), Meznar and Nigh (1993), and Jacobsson and Bergek (2004), that link cognitive and socio-political legitimacy to industrial creation, can be adapted to also enable the legitimacy of innovative new business concepts to be measured. In order to adapt these frameworks to the context of the biorefinery concept, the political importance and implications of the production and use of *integrated industrial biorefinery* products needs to be understood, a task that has been undertaken in Chapter 3. However, because socio-political and cognitive legitimacy are so closely intertwined, the cognitive essence of *integrated industrial biorefineries* (i.e. what an *integrated industrial biorefinery* is or could be) and the lack of clarity surrounding them also needs to be defined, a task that was undertaken in Chapter 4.



Now that the various components contributing to the legitimacy of *integrated industrial biorefineries* have been understood and defined, the next step will be to apply them to the theoretical factors influencing the legitimacy of innovative business concepts. Therefore, this Chapter seeks to examine the theoretical factors identified as requirements for a new business concept to gain legitimacy in the formative period of its lifecycle. Establishing how these factors fit within the *integrated industrial biorefinery* context will allow us to determine criteria upon which their legitimacy can be measured.

The major concepts surrounding the theoretical framework established in Chapter 2 include:

**Cognitive legitimacy** refers to the spread of “knowledge about a new activity and what is needed to succeed in an industry” (Ranger-Moore, et al., 1991). Cognitive legitimacy can be assessed by “measuring the level of public knowledge about a new activity”, of which the highest level is achieved when “a new product, process, or service is taken for granted” (Aldrich and Fiol, 1994).

**Socio-political legitimacy** refers to “the process by which key stakeholders, the general public, key opinion leaders, or government officials accept a venture as appropriate and right, given existing norms and laws” (Aldrich and Fiol, 1994). Socio-political legitimacy can be assessed by “measuring (the) public acceptance of an industry, government subsidies to the industry, or the public prestige of its leaders” (Aldrich and Fiol, 1994).

As described in Chapter 2.5, this body of work will concentrate on determining a method to measure ‘political’ as opposed to ‘socio-political’ legitimacy. Therefore, a distinction will be made when referring to theoretical ‘socio-political’ legitimacy, and strategies the author identifies for measuring ‘political’ legitimacy.

**Innovative entrepreneurs** are defined in Chapter 4.7 for the purpose of this work, as a number of Pan-European consortiums, national groups, researchers and private investors that are working to facilitate the progression of *integrated industrial biorefineries* from its current formative (research) phase towards the demonstration (pilot) phase.

As discussed in Chapter 2, determining the level of government interventions to enable *integrated industrial biorefineries* is tangible at least; however, measuring public acceptance or the public prestige of the leaders of *integrated industrial biorefinery* is much more ambiguous. Nevertheless, by examining the extent to which the eight propositions established by Aldrich and Fiol for enhancing legitimacy are being achieved for *integrated industrial biorefineries*, a measure of their legitimacy can be undertaken.

Hence, we can determine the political legitimacy of *integrated industrial biorefineries* by:

- STEP 1. Examining the government interventions directly affecting them; and
- STEP 2. Examining whether the eight propositions established by Aldrich and Fiol for enhancing legitimacy are currently hindering or supporting the progression of *integrated industrial biorefineries* from their current formative (research) phase to the demonstration (pilot) phase.

STEP 1: It is envisaged that a desktop exercise could be undertaken in order to fulfil the first step. A procedure for undertaking this will be outlined in Chapter 5.3. This exercise will also highlight the main actors for deriving and implementing these policy interventions, which will then become the ‘target audience’ for the second step.

STEP 2: The next step will be to examine the theoretical factors influencing legitimacy, establish how they fit within the *integrated industrial biorefinery* context and determine criteria and a number of specific strategies upon which the legitimacy of *integrated industrial biorefineries* can be measured. This task has been undertaken in Chapter 5.4. It is envisaged that these questions will underpin the development of a set of questionnaires and in-depth interviews within a Pan-European research activity, the answers to which will enable the political legitimacy of *integrated industrial biorefineries* in Europe to be determined.

### 5.3 Measuring government interventions to the integrated industrial biorefinery concept

The first step in measuring the political legitimacy of *integrated industrial biorefineries* in Europe will be to examine the government interventions directly affecting them. This section will outline a procedure for undertaking such an exercise and also highlight the main actors for deriving and implementing the relevant policies, which the author perceived as necessary to identify the target audience for the second step (i.e. adapting the theoretical framework to the biorefinery concept).

#### 5.3.1 Identifying the political actors

Fowler (2002) demonstrates that the target audience for any study must be identified in the early stages of the questionnaire/interview/survey design process. Therefore, the author deems that it is necessary to first identify the political levels within Europe that can provide support or hindrance to the development of *integrated industrial biorefineries*. The basic levels of governance assumed within this work are shown in Figure 5-1. In order to undertake this work in a short, succinct, cost effective “streamlined” manner, the widely used ‘judgment’ approach to sampling (Fowler, 2002; Fink, 2005; Statistics Canada, 2006) was chosen to identify the target audience (i.e. the research sample). Judgement sampling is used where certain judgements about the overall population are made (such as their role in the political decision making process), with the advantage of reducing the cost and time involved in obtaining the sample. Following this approach, Chapters 5.3.2 to 5.3.7 indicate that EU and Member State (National) level policy interventions are expected to potentially have a huge impact on the progression of *integrated industrial biorefineries*. Thus, the strategy for measuring political legitimacy, which is expected to be the main outcome of this thesis, will be targeted towards them. Although it is envisaged that this strategy will be applicable to any political sphere, this thesis concentrates on Europe, namely the EU. Due to the commitments of the BIOPOL network, the strategy developed in this work will first focus on an assessment of political legitimacy in Sweden. It is envisaged that the work will then be replicated throughout the other BIOPOL network countries (i.e. the Netherlands, Germany, the UK, Poland and Greece).

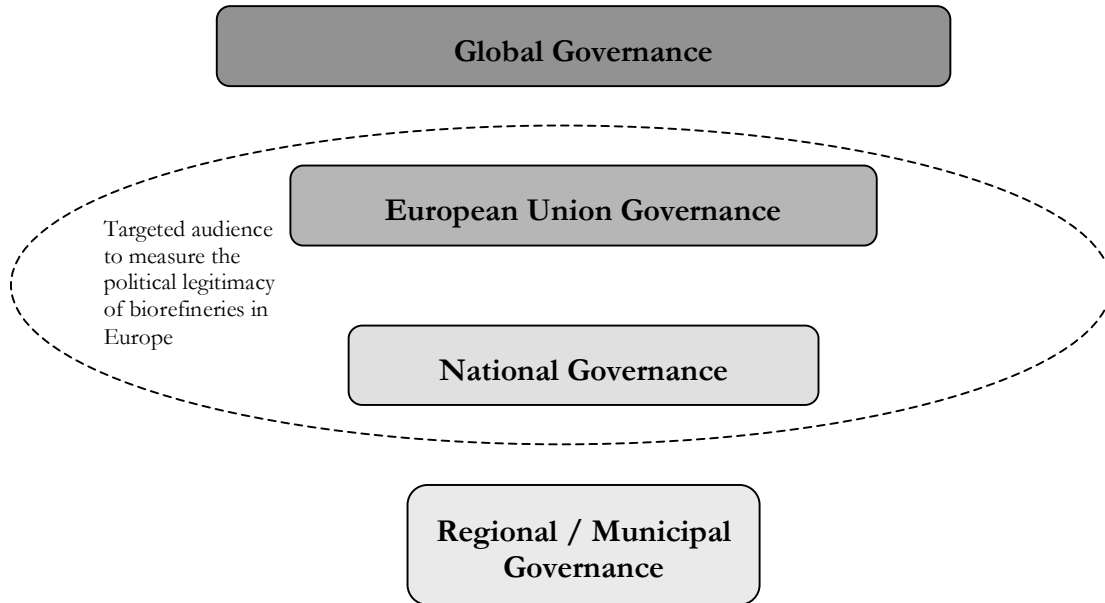


Figure 5-1 EU Governance Framework to measure the political legitimacy of biorefineries in Europe

### 5.3.2 Global governance interventions

Global governance interventions play a crucial role as overarching mechanisms to “coordinate and control interdependent social relations” (Rosenau, 1999). The obvious example of a global governance intervention with direct impact on the progression of *integrated industrial biorefineries* is the Kyoto Protocol. The EU ratified its participation in the Kyoto Protocol in 2002 committing Member States to collectively reduce their GHG emissions by 8% between 2008 and 2012 (Council Decision 2002/358/EC). Compliance with the Kyoto Protocol was one of the key driving forces behind the EU’s efforts to reduce CO<sub>2</sub> emissions from transport, since transport was deemed to be responsible for an estimated 21% of all GHG emissions that are contributing to global warming (Commission Proposal, COM(2006)34 final). However, the Biofuels Research Advisory Council (2006) expect that the EU will not meet its Kyoto targets due to its growing transport sector that is currently 98% dependent on fossil fuels. They go on to say that 90% of the expected increase in CO<sub>2</sub> emissions between 1990 and 2010 will be attributed to transport.

While clearly recognised as an intervention and set of commitments that lend significant legitimacy to the production of biofuels and the whole potential *integrated industrial biorefinery* product range, there is a distinct “absence of overarching political authority” with the global governance system (Rosenau, 1999). Therefore, there are no “global politicians” that can be targeted in order to measure political legitimacy. Since this level of governance does not have a direct or clear target audience, it is not considered to be a political level that warrants the measurement of legitimacy for this streamlined piece of work. Therefore, global governance is only referred to for context setting and background information and will not be targeted for measurement of the political legitimacy of *integrated industrial biorefineries* in Europe.

### 5.3.3 European Union level governance interventions

The regulatory framework for the progression of bio-based products has already been discussed in Chapter 3.5.1. From the number and diversity of direct policy interventions at the EU level, it can clearly be seen that there is a ground swell of support for the production and use of bio-based products (albeit mainly for biofuels production) due to the many positive aspects they induce (for example, in CO<sub>2</sub> emission reduction, energy security, rural development and employment). Examining them in more detail will be a vital step in the process to actually measure legitimacy, work that will follow on from this thesis. Therefore, the strategy for measuring political legitimacy in this thesis will be targeted towards the political sphere at the EU level. Some of the key policies include:

- The EU Biofuels Directive (Council Directive 2003/30/EC) adopted in 2003 as part of the EU Strategy for Biofuels established the target that 2% of all petrol and diesel transport fuels were to be biomass-derived by December 2005, increasing to 5.75% by the end of 2010.
- The EU Biomass Action Plan (Council Directive 2003/30/EC) sets out the measures to achieve the targets in the EU Biofuels Directive, by creating market-based incentives and removing barriers to develop the market.
- The Electricity Production from RES Directive (Council Directive 2001/77/EC) adopted in 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market.
- A European Strategy for Sustainable, Competitive and Secure Energy (Commission Proposal COM(2006)105 final).
- Renewable Energy Roadmap, Renewable Energies in the 21<sup>st</sup> Century: Building a More Sustainable Future (Commission Proposal COM(2006)848 final).
- The CAP that now aims at decoupling income support from agricultural production and also promoting the production of energy crops as a means of increasing farm incomes.
- The European Biofuels Technology Platform is a high-level group on biofuels established by the EC which is intended to provide and implement a common European vision and strategy for the production of biofuels:
  - Biofuels in the European Union: A Vision of 2030 and Beyond (Final Draft) (Biofuels Research Advisory Council, 2006), outlines the current situation of biofuels and presents a long-term view on how to overcome the technical and non-technical barriers for biofuels deployment in the EU and worldwide, and specifically mentions the importance of developing “integrated refining concepts” and “through its Intelligent Energy Europe Program, the Commission will support market introduction and the dissemination of proven technologies” (COM(2006)34 final).

- The European Technology Platform for Sustainable Chemistry is a European partnership for research and development in industrial/white biotechnology, materials technology, and reaction and process design to encourage the production of industrial goods while respecting the environment (SusChem, 2007).
- The European Forest-based Sector Technology Platform is a European partnership for research and development in the forest-based sector:
  - The European Lead Market Initiative on Bio-based Products is a new mechanism to promote the use of bio-based products (Burel, 2007).
- The EU Packaging Directive (Directive 94/62 EC) is driving research into compostable and biodegradable bio-plastics (European Bioplastics, 2007).
- The EU regulatory framework for the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (Commission Proposals COM(03)664(01) and COM(03)664(02)) is promoting innovation and the development of safer substitutes in industrial chemical production.

Since this level of governance clearly has a direct impact on the intervention policies that may directly affect the progression of *integrated industrial biorefineries*, EU level governance is considered to be a political level that warrants the measurement of legitimacy for this purpose. Therefore, EU level governance will be targeted.

### 5.3.4 National level governance interventions

Theoretically, EU Member States should implement the mirror image of EU level policies in their own national legislation. However, the degree to which Member States support various EU policy requirements varies considerably. Also, there are a number of additional policy interventions occurring on national levels. Due to the commitments of the BIOPOL network, the strategy developed in this work will in the future, first focus on an assessment of Sweden. It is envisaged that the work will then be replicated throughout the other BIOPOL network countries (i.e. the Netherlands, Germany, the UK, Poland and Greece) as part of a Pan-European research activity. Therefore, some of the policy interventions affecting biorefinery progression that are occurring in Sweden are listed below:

- Green taxes, such as the CO<sub>2</sub> tax, which promote biofuels in an indirect way.
- The tax relief system for renewable fuels (biofuels, solid waste and peat are tax-exempt for most energy uses).
- Tradable Green Certificates to promote renewable energy production amongst electricity suppliers.
- “CHRISGAS” is a project established under the EU Biofuels Technology Platform to develop a biomass gasification process (see Box 3-2) to produce clean hydrogen-rich synthesis gas, through a consortium of 19 parties (including the Swedish government (with the Swedish Energy Agency - STEM), industry, other Member States, universities, etc) (Waldheim, 2006). This project can tentatively be seen as one that incorporates national, EU and regional level governance intervention, although the division of support between the partners is unclear to the author.

- The BioFuel Region in northern Sweden, is a research pilot system for producing ethanol from lignocellulosic sources in an attempt to become self-sufficient in transport fuels, using biofuels, by 2030 (BEST, 2007). The project involves the Swedish government, country councils, municipalities and industry, and is therefore another example of a project that incorporates national, regional and municipal level governance intervention.

Since this level of governance clearly has a direct impact on the intervention policies that may directly affect the progression of *integrated industrial biorefineries*, national level governance is considered to be a political level that warrants the measurement of legitimacy for this purpose. Therefore, national level governance will also be targeted. Due to the commitments of the BIOPOL network, this thesis will be geared toward measuring political legitimacy in Sweden. In particular, for work that follows on from this thesis, it is envisaged that the following Swedish Ministries and Agencies, who have a direct influence on these policies, will be targeted to fill in a detailed questionnaire or conduct an in-depth interview (see Figure 5-2).

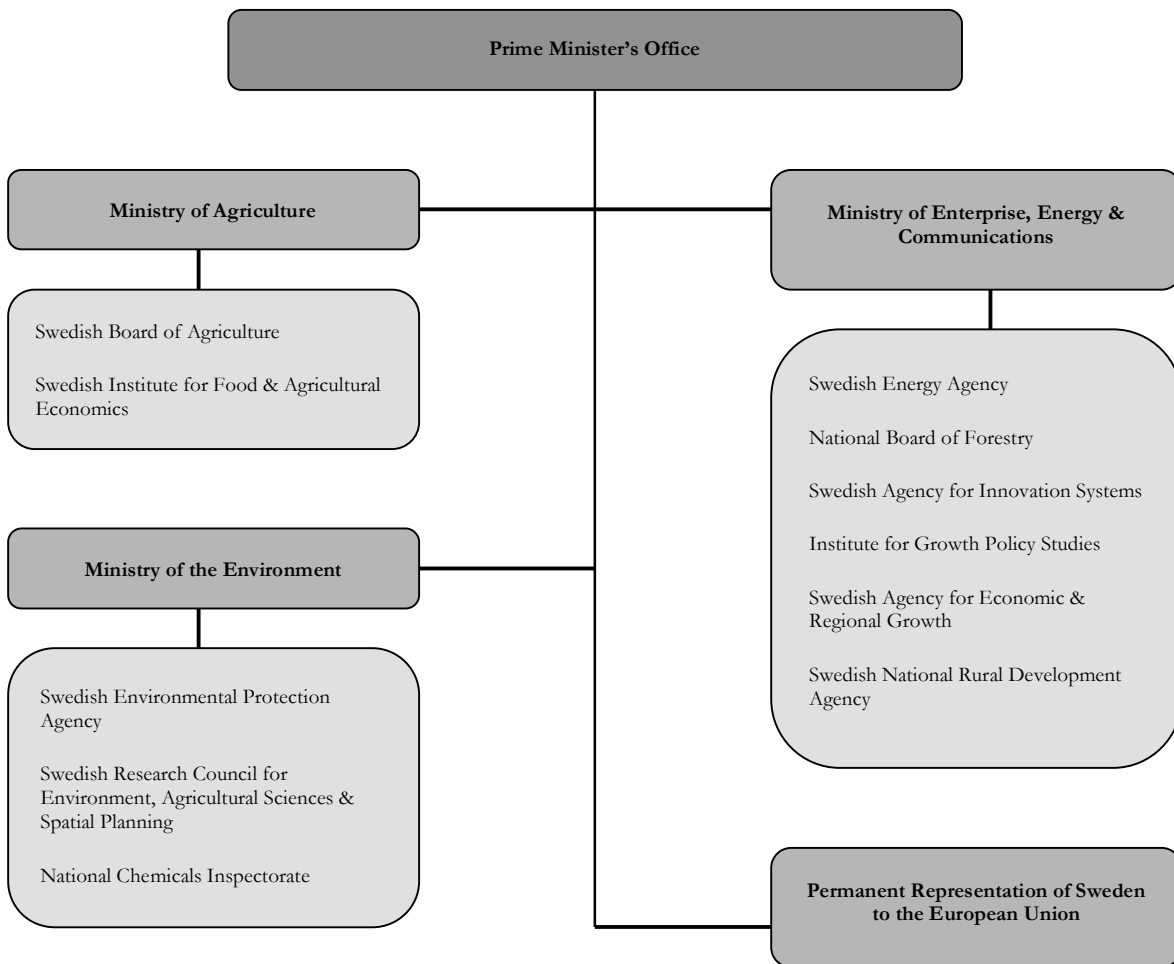


Figure 5-2 Targets of Swedish National Government for measuring the political legitimacy of integrated industrial biorefineries

Source: Adapted from Government Offices of Sweden, 2007

### 5.3.5 Regional level governance interventions

As already demonstrated with the examples of the CHRISGAS and BioFuel Regions development, regional level governance within EU Member States can play a very important role in delivering legitimacy and support to the underlying “concrete” policy interventions surrounding *integrated industrial biorefineries*. Regional level governance can also be a very strong lobbying force and provide tax relief for desirable development. For example, the Ghent Bio-energy Valley project (Belgium) and the Medicion Valley project (Øresunds Region, Sweden) are existing industries that are building a level of highly localised Industrial Symbiosis<sup>11</sup> and slowly moving towards the creation of *integrated industrial biorefineries* in a step-wise process, with the support of the regional governments.

Since this level of governance clearly has the potential to support intervention policies that may directly affect the progression of *integrated industrial biorefineries*, regional level governance is considered to be a political level that warrants the measurement of legitimacy for this purpose. Therefore, selective “special regions”, such as those already mentioned, will be targeted.

### 5.3.6 Municipal level governance interventions

It is not considered that local (municipal) government has the political decision making capability necessary to stimulate the emergence of *integrated industrial biorefineries*, although there are still some local issues that can be facilitated by them (e.g. approvals for some of the regional developments already mentioned). Since this level of governance does not have a direct impact on the intervention policies that may affect the progression of *integrated industrial biorefineries* in Europe, but rather a very local case-by-case development/building approval role, municipal governance is not considered to be a political level that warrants the measurement of legitimacy for this work. Moreover, the scope of the work that will follow on from this thesis does not have the resources to measure the political legitimacy of *integrated industrial biorefineries* in every municipality in Europe. Therefore, municipal governance is only referred to for context setting and background information and will not be targeted.

### 5.3.7 Identifying the target audience

Various levels of EU and Member State (national) government will be targeted in order to capture the complete policy making process:

- Political level (e.g. individual politicians being influenced and lobbied by the public, industry, NGOs, etc);
- Departmental level (e.g. Ministers or Heads of Departments who explicitly have connections with *integrated industrial biorefineries* within their portfolios); and

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<sup>11</sup> Industrial Symbiosis “engages traditionally separate industries in a collective approach to add competitive advantage involving physical exchange of materials, energy, water and/or by-products together with collaboration on the shared use of assets, logistics and expertise” (Chertow, 2000).

- Bureaucratic level (e.g. individual middle level bureaucrats who have a direct influence on the policies relating to *integrated industrial biorefineries*).

Whilst it is important to define the political sphere of influence for the progression of *integrated industrial biorefineries* in Europe, each of these levels of government is influenced and lobbied by various other stakeholders (such as the general public, NGOs, mass media, the petrochemical industry, etc). Since the aim of this thesis is to determine streamlined approach to measuring political legitimacy, it will be necessary to include specific questions to the target political sphere to identify these stakeholders; who act as informants (either enhancing or hindering political legitimacy) to the target political sphere, or who demand that the norms of society be implemented by them.

Operational constraints, such as the high cost of collecting data and the difficulty of identifying and contacting certain components of the target audience, mean that some members of the population have to be excluded (Statistics Canada, 2006). This will be the case for stakeholders such as the general public, NGOs, mass media, the petrochemical industry, etc. However, since some of these stakeholders can have a lobbying or important opinion building role, they should be included as part of the target audience. Therefore, as Fowler (2002) states, multi-phase sampling can be used to capture these important stakeholders. This method will involve collecting basic information from the main target audience on which lobby groups are important to capture within this process, and then the identified lobby groups will be targeted for more in-depth interviews.

#### 5.4 Adapting the theoretical framework to the biorefinery concept

As discussed, the next step in determining the political legitimacy of an innovative business concept is to examine whether the theoretical factors influencing their legitimacy are currently hindering or supporting the progression from the founding of the completely new activity, in an institutional void, through to its development as a legitimate industry. However, legitimacy in the case of this work, will be measured in order to determine the best way to progress *integrated industrial biorefineries* from their current formative (research) phase into the demonstration (pilot) phase; a process that could take hundreds of millions of euros to achieve.

The established framework for enhancing legitimacy that was discussed in Chapter 2 includes eight propositions that enable *trust*, *reliability*, and *reputation* of a new business concept to be enhanced, so that it can finally gain *legitimacy* within four levels of progressively broadening social context (organisational, intra-industry, inter-industry and institutional). In order to extend this framework to the biorefinery concept, each proposition will first be analysed in detail to enable a set of questions to be developed to 'activate' the proposition. These questions will then be applied to the key areas affecting the political importance (from Chapter 3) and cognitive understanding (from Chapter 4) of *integrated industrial biorefineries*. These key areas have been presented in Table 5-1. Through this method, a logical and streamlined strategy for creating a questionnaire or a number of in-depth interview questions for the target audience will be determined; the answers to which will enable light to be cast on how to best stimulate the progression of *integrated industrial biorefineries* in the Europe.



Table 5-1 Key areas identified in this thesis as affecting the legitimacy of integrated industrial biorefineries

Key Areas Affecting the Legitimacy of Integrated Industrial Biorefineries			
Thesis Chapter	Cognitive Legitimacy	Thesis Chapter	Political Legitimacy
3.2	Overview of biofuels	3.4.1	EU regulatory framework
3.3	Overview of biomaterials & biochemicals	3.4.2	Energy security
4.2	Biorefinery concept	3.4.3	CO <sub>2</sub> emission reduction
4.3	Feedstocks & products of biorefineries	3.4.4	Agriculture & forestry
4.4	Technologies required for biorefineries	3.4.5	Employment & rural development
4.5	Working definition of a biorefinery	3.4.6	Environment & land use issues
4.6	Lack of clarity over biorefineries	3.4.7	Economy
		3.4.8	Genetically modified crops
		3.4.9	Sustainability

### 5.4.1 Symbolic language

Proposition 1: Innovative entrepreneurs who utilise encompassing symbolic language and behaviours will gain *cognitive legitimacy* more quickly than others.

Innovative entrepreneurs cannot easily convince stakeholders to follow their directives, as their inherent “newness” means that they have no reliable information or evidence of their competence, thus they need other methods on which to base trust-building strategies (Singh, et al., 1986; Aldrich and Fiol, 1994). When external evidence of reliability is not available (e.g. results of comprehensive testing, or assurance from reliable third parties), legitimacy can be established if issues are “simplified, stylised, symbolised, and given ritual expression: if, that is, they are coded in convention” (Hawthorn, 1988). Therefore, Aldrich and Fiol (1994) propose that if innovative entrepreneurs “frame their new business concept broadly enough to encompass existing knowledge, they will appear more credible”.

Scholars of neo-institutionalism (DiMaggio and Powell, 1983; Meyer and Rowan, 1977; Hannan and Freeman, 1989) agree that the highest level of cognitive legitimacy is achieved when a new industry or activity is taken-for-granted beyond the discretion of individual stakeholders. Evidence for this can be seen in the symbolic language that people use to describe a certain technology or product that has reached this height of cognitive legitimacy. Hamilton (2003) asserts that modern consumers no longer even consume the ‘utility’ of goods and services, but rather their symbolic meanings, which have been designed by “meticulous commercial calculation”. Cars, for example, are designed to send signals and their value becomes taken for granted through their symbolic meaning. They can be “masculine”, “sexy”, “rugged”, “vibrant”, “tough”, “safe”, “fast”, “ecological” or “suave”, without having to refer to any physical components or properties that enhance performance in a quantifiably measurable manner, such as ‘variable cam timing’, ‘dynamic stability traction control’, ‘variable turbine superchargers’, or ‘electronic cross-linked air suspension’.

By creating questions to activate the proposition, the author considers that symbolic language and behaviour is imperative to gaining cognitive legitimacy of many of the overarching concepts related to *integrated industrial biorefineries*, such as bio-based products and feedstocks,

the biorefinery concept, and the potential lack of clarity over *integrated industrial biorefineries* and their encumbered systems, as shown in Table 5-2.

Table 5-2 Application of Proposition 1 to the *integrated industrial biorefinery* concept

Proposition 1: Innovative entrepreneurs who utilise encompassing symbolic language and behaviours will gain <i>cognitive legitimacy</i> more quickly than others	
Questions to activate the proposition	Key areas affecting the legitimacy of biorefineries
Has simplified, stylised & symbolised language been used to describe the new business concept?	Overview of biofuels Overview of biomaterials & biochemicals
Has conventional language been used to describe the new business concept?	Biorefinery concept Working definition of a biorefinery
Has the new business concept been described broadly enough to encompass existing knowledge?	Lack of clarity over biorefineries Feedstocks and products of biorefineries

### Example: Lack of clarity over biorefineries

Fundamental to progression of the biorefinery concept is that the theory, processes, inputs and production capabilities are clearly defined, understood and articulated. Therefore, cognitive understanding is imperative and any definition of an *integrated industrial biorefinery* should be developed using simplified, stylised and symbolic language, encompassing existing knowledge and comparable with existing industries. Therefore, to extend the first proposition to this body of work, the author considered it necessary to develop the following conceptual definition that would enable the target audience to understand the context of the questions posed to them regarding *integrated industrial biorefineries*:

The *integrated industrial biorefinery* is analogous to the petroleum refinery where an abundant raw material composed of a diverse range of renewable biomass is converted (through an array of processes) into a number of products including transportation fuels (e.g. bioethanol, biodiesel, etc), other bio-based products (e.g. paints, solvents, plastics, resins, agricultural chemicals, industrial surfactants, etc), and energy.

This definition encompasses the key factors of Proposition 1, which is to develop a knowledge base via symbolic language and behaviour. Table 5-3 describes the types of symbolic language and behaviour that have been used in the definition to articulate the key areas (from Table 5-2) affecting the cognitive legitimacy of *integrated industrial biorefineries*.

Table 5-3 Application of Proposition 1 to the conceptual definition of an integrated industrial biorefinery

Factors to develop a knowledge base via symbolic language and behaviour	Analogous term used in definition
Simplified, stylised and symbolic language	“abundant”, “renewable”, “energy”.
Conventional language	“transportation fuels”, “bioethanol”, “biodiesel”.
Broad enough to encompass existing knowledge	“paints”, “solvents”, “plastics”, “resins”, agricultural chemicals”, “industrial surfactants”.
Comparable with existing industries	“analogous to the petroleum refinery”.

To enable the cognitive, and hence political, legitimacy of *integrated industrial biorefineries* to be measured, questionnaires and in-depth interview questions for the target audience should be centred on this definition and these types of symbolic descriptors.

#### 5.4.2 Internal consistency

Proposition 2: Innovative entrepreneurs who communicate internally consistent stories regarding their new business concept will gain *socio-political legitimacy* more quickly than others.

Innovative entrepreneurs must construct a knowledge base that stakeholders will accept as valid. Given the lack of information and evidence regarding their new activity, Aldrich and Fiol (1994) advocate that they must draw on alternate forms of communication such as narratives (in the form of suggestion and identification) to establish that their new activity is compatible with more extensively established activities. Other philosophers of science have also observed that narratives provide a way to explain a complex idea without having to refer to explicit external criteria, and thus enable effective communication to the wider public (Nagel, 1961; Kaplan, 1986). In this way, Fisher (1985) advocates that the validity of the narrative is based upon how well it “coheres and is free of contradictions”, rather than any external criteria. Aldrich and Fiol (1994) therefore conclude that innovative entrepreneurs need to conceal the truly radical nature of their new business concept and the challenges it may cause to established industries within the language of stories, while at the same time establishing “that they are different enough to hold a comparative advantage”.

By creating questions to activate the proposition, the author considers that *integrated industrial biorefineries* should be described in coherent ways that are comparable with established industries, and free of contradictions. As shown in Table 5-4, the key areas where this type of description is important for *integrated industrial biorefineries* is within the depiction of the major concepts, but also within the areas where there are strong conflicts of opinion (i.e. the biorefinery concept itself, the benefits and detriments of feedstock cultivation, the variable CO<sub>2</sub> emission reductions of different energy crops, the transition from 1<sup>st</sup> to 2<sup>nd</sup> generation biomass conversion technologies, etc).

Table 5-4 Application of Proposition 2 to the integrated industrial biorefinery concept

Proposition 2: Innovative entrepreneurs who communicate internally consistent stories regarding their new business concept will gain <i>socio-political legitimacy</i> more quickly than others	
Questions to activate the proposition	Key areas affecting the legitimacy of biorefineries
Has the new business concept been described in a way that is comparable with established industries (e.g. petroleum refineries, pulp & paper mills, sugar refineries, bio-alcohol distilleries, CHP & district heating plants)?	<ul style="list-style-type: none"> <li>Overview of biofuels</li> <li>Overview of biomaterials and biochemicals</li> <li>CO<sub>2</sub> emission reduction</li> <li>Genetically modified crops</li> <li>Overview of biofuels</li> </ul>
Has the new business concept been described in a way that is coherent and free of contradictions?	<ul style="list-style-type: none"> <li>Biorefinery concept</li> <li>Feedstocks and products of biorefineries</li> <li>Working definition of a biorefinery</li> <li>Lack of clarity over biorefineries</li> </ul>

Therefore, in order to measure the political legitimacy of *integrated industrial biorefineries*, questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience understands the benefits and detriments of key areas of conflict. This will enable comparisons to be made between target audiences to determine whether consistent stories about *integrated industrial biorefineries* are being communicated at a political level. Also, it is necessary to determine whether the target audience can relate the key areas of the biorefinery concept to analogous established industries (i.e. the biorefinery concept is analogous to the petroleum refinery, or energy crop cultivation for biofuel production is analogous to feedstock cultivation for *integrated industrial biorefineries*). Some examples of how these areas can be manifested into questionnaires or in-depth interview questions are given below:

**Example: Biorefinery concept / Working definition of a biorefinery**

In order that the *integrated industrial biorefinery* is described coherently in a manner that is comparable with established industries, much of the complexity of possible biorefinery varieties described in Chapter 4.5 will necessarily be omitted from any questions directed to the target audience. Chapter 4.5 describes a number of differing possibilities and types of biorefineries that if used in a questionnaire, may actually hinder the target audience’s cognitive understanding of *integrated industrial biorefineries* and even decrease their willingness to participate in the survey (due to the additional complexity and time taken to compete). Therefore, the author considers that it is necessary to only refer to conceptual models and descriptions of *integrated industrial biorefineries*, such as that described in Chapters 4.2 and 5.4.1. This strategy also enhances the possibility for the target audience to be able to understand the analogy between the biorefinery concept and the petroleum refinery, which the author has already established to be an important aspect in the measurement of legitimacy.

**Example: Overview of biofuels**

The issue of biomass conversion technologies described in Chapters 3.3 and 4.4, and particularly the transition from 1<sup>st</sup> to 2<sup>nd</sup> generation biofuels, is also a complex technical issue that may unnecessarily confuse the target audience or scare them into not completing the questionnaire. However, it is a very important issue that needs to be referred to as a measure of whether the target audience understands the benefits of the transition to 2<sup>nd</sup> generation technologies, and the research and policy support that is required for their rapid

development. Therefore, the author considers it necessary to form questions relating to the benefits of 2<sup>nd</sup> generation technologies, as this is an important technical and economic factor for the progression of *integrated industrial biorefineries* (and hence their legitimacy), but in a manner that ‘glosses over’ the complexity of the issue.

### 5.4.3 Convergence around a dominant design

Proposition 3: New business concepts in which innovative entrepreneurs encourage convergence around a dominant product/service design will gain *cognitive legitimacy* more quickly than others.

The immediate environment of organisations is structured by intra-industry processes that may constrain legitimacy if, for instance, a lack of standard designs block the diffusion of knowledge and understanding (DiMaggio and Powell, 1983; Aldrich and Fiol, 1994; Jacobsson and Bergek, 2004). Once innovative entrepreneurs establish an intra-organisational level of trust, they can then begin to establish stable interactions with government institutions and begin to build socio-political legitimacy.

Intensely competitive individual strategies hinder a united collective front by an industry. Until new business concepts converge around a discreet set of established standards or designs, innovative entrepreneurs will unavoidably encounter difficulty establishing themselves and will make recurrent mistakes (DiMaggio and Powell, 1983; Aldrich and Fiol, 1994). Under these conditions, the establishment of new organisations will be repressed and failures will also be recurrent. The framework described in Chapter 2 also emphasises that a lack of agreement on a dominant design hinders the legitimacy of innovative entrepreneurs by increasing the confusion of institutions about what standards should be set, and of other entrepreneurs about what standards should be followed. Therefore, “implicit agreement on a dominant design and common standards... increase(s) the level of shared competencies within an emerging industry” (Aldrich and Fiol, 1994).

During studies of highly technological industries, Van de Ven and Garud (1989) have also shown that innovative entrepreneurs tend to be made up of a small group of independent actors who although work individually, come to know one another by travelling in the same technical circles. They also stated that this level of interaction often leads to the generation of networks that result in actions that increase socio-political legitimacy. Therefore, innovative entrepreneurs that can overcome the barriers to effectual collective action will gain socio-political legitimacy more quickly than others (Van de Ven and Garud, 1989).

By creating questions to activate the proposition, the author considers that *integrated industrial biorefineries* should be described in a way that determines if the target audience advocates a dominant product/design, or will consider the establishment of a discreet set of standards in relation to that product/design. As shown in Table 5-5, the key topic areas where this type of description is important for *integrated industrial biorefineries* is within the description of the major concepts and technologies, and within the regulatory framework.

Table 5-5 Application of Proposition 3 to the biorefinery concept

Proposition 3: New business concepts in which innovative entrepreneurs encourage convergence around a dominant product/service design will gain <i>cognitive legitimacy</i> more quickly than others	
Questions to activate the proposition	Key areas affecting the legitimacy of biorefineries
Is there a dominant product/service design?	EU regulatory framework CO <sub>2</sub> emission reduction
Are there competing technologies?	Agriculture & forestry Environment & land use issues
Is there a discreet set of established standards?	Genetically modified crops Sustainability
Have networks been formed by technical experts?	Biorefinery concept Working definition of a biorefinery Feedstocks and products of biorefineries Technologies required for biorefineries Lack of clarity over biorefineries

Therefore, in order to measure the cognitive, and hence political legitimacy of *integrated industrial biorefineries*, questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience understands the complexity of the technological issues, whether they advocate a particular technology or design, and whether they are willing to establish a discreet set of standards to specifically enable the progression of *integrated industrial biorefineries*. It will also be necessary to determine whether any network formed by technical experts has lobbied the target audience over a particular product/design. Some examples of how these areas can be manifested into questionnaires or in-depth interview questions are given below:

**Example: Working definition of a biorefinery / Lack of clarity over biorefineries**

Chapter 4.5 sets out a number of different possibilities and types of biorefineries that highlight the complexity of possible design varieties. Chapter 4.6 emphasises the array of definitions that various researchers and technologists have used to try to best describe the function of biorefineries. Added to this complexity, is the number and diversity of innovative entrepreneurs of biorefineries that were described in Chapter 4.7 (including, not only bioenergy scientists, but also some large multinational corporations such as Shell Global Solutions and Dow Chemicals). Such a disparate array of product designs, product definitions and entrepreneurs serves as an indicator that there is no convergence around a dominant product or design and that it is likely that if the target audience is being lobbied, this lobbying is being conducted at an individual level by each entrepreneur. Therefore, the author considers it necessary to form questions relating to whether any specific entrepreneur, or network of entrepreneurs, has lobbied the target audience and, if so, what type of biorefinery design they are advocating and the reasons for this. This will also enable the survey to detect whether the target audience has a deeper understanding of the complexity of the biorefinery concept.

**Example: CO<sub>2</sub> emission reduction / Environment and land use issues**

The issue of CO<sub>2</sub> emission reduction and environment and land use issues associated with the production of potential biomass feedstocks for biorefineries was highlighted in Chapters

3.5.3 and 3.5.6, using the example of energy crop production for biofuels. Although there are differing opinions as to the CO<sub>2</sub> emission reduction capabilities of biomass, one area where authors seem to agree, is that not all energy crops are the same in terms of CO<sub>2</sub> emission reduction potential or environmental degradation potential, but vary considerably based on production costs, crop yields, energy outputs (such as the amounts of fertilisers required) and choice of biomass conversion technology. Therefore, the author considers it necessary to form questions relating to whether the target audience is firstly aware of these issues, and secondly if they are willing to establish guidelines of standards for renewable feedstock, handling, process technology, and/or product performance standards.

#### 5.4.4 Collective action

Proposition 4: New business concepts in which innovative entrepreneurs mobilise to take collective action will gain *socio-political legitimacy* more quickly than others.

Within the framework for enhancing legitimacy described in Chapter 2, there are two factors common to new business concepts that hinder the collective action required to gain socio-political legitimacy:

1. Fierce competition over product/service designs and standards may thwart any particular organisation from developing any faster than the rest of the industry, thus reducing the chances that an industry champion will emerge to strengthen efforts towards collective action; and
2. If competing product/service designs emerge and sub-groups form around them, conflict amongst the sub-groups may cause confusion and uncertainty for potential stakeholders.

Bolton (1993) supports this proposition by agreeing that dissent and multiplicity within an industry is likely to be emulated externally, thus hindering an innovative entrepreneurs ability to promote the new business concept.

By creating questions to activate the proposition, the author considers that entrepreneurs of *integrated industrial biorefineries* should take collective action and converge over a dominant product/design, in order to enhance their political legitimacy. As shown in Table 5-6, the key topic areas where this type of action is important for *integrated industrial biorefineries* is within the description of the major concepts and technologies, and within the regulatory framework (e.g. forestry and agriculture (which includes field and forest energy crop production), overview of biofuels (which includes descriptions of 1<sup>st</sup> and 2<sup>nd</sup> generation biomass conversion technologies), working definition of a biorefinery (which includes descriptions of the four major concept designs, the “lignocellulosic feedstock biorefinery”, the “whole crop biorefinery”, the “green biorefinery” and the “biorefinery two platforms concept”).

Table 5-6 Application of Proposition 4 to the biorefinery concept

Proposition 4: New business concepts in which innovative entrepreneurs mobilise to take collective action will gain <i>socio-political legitimacy</i> more quickly than others	
Questions to activate the proposition	Key areas affecting the legitimacy of biorefineries
Is there fierce competition for product development?	CO <sub>2</sub> emission reduction
Is there fierce competition for standard development?	Agriculture & forestry
Is there fierce competition for technology design?	Environment & land use issues
Are there differing opinions emerging amongst political leaders over the concept in general or over particular product/service designs?	Overview of biofuels Feedstocks and products of biorefineries Technologies required for biorefineries Working definition of a biorefinery

Therefore, in order to measure the legitimacy of *integrated industrial biorefineries*, questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience understands the complexity of the key areas and whether they advocate a particular technology or design. Also, it is necessary to determine whether any particular individual or network is lobbying the target audience to force the progression of a particular product/design, and whether there are differing opinions emerging amongst their political, departmental, or bureaucratic colleagues over the concept in general, or over a particular product/service design. An example of how these areas can be manifested into questionnaires or in-depth interview questions is given below:

**Example: Environment and land use issues / Technologies required for biorefineries**

Environment and land use issues, together with agriculture and forestry issues, that relate to biomass feedstock production were raised in Chapters 3.5.4 and 3.5.6, using the example of energy crop cultivation for biofuel production. These chapters highlighted strong conflicts arising between intervention policies such as the CAP, which is attempting to promote the production of traditional 1<sup>st</sup> generation “field” energy crops as a means of supporting farmers, versus the drive towards 2<sup>nd</sup> generation conversion technologies that utilise “forest” lignocellulosic crops (e.g. forestry products and short rotation coppices) as a means of producing bio-based products more efficiently with greater CO<sub>2</sub> emission reduction potential. This is an extremely important issue for Europe, and Sweden in particular, as it has vast amounts of field and forest area for the potential cultivation of 1<sup>st</sup> and 2<sup>nd</sup> generation technology feedstock. The conflict is further exasperated when strong lobby organisations, such as the Finnish Forest Industries Federation, begin lobbying against the use of forestry raw material as a bioenergy feedstock (as discussed in Chapter 3.5.6). This type of fierce competition (between technologies and feedstocks) may hinder the collective action of the innovative entrepreneurs of biorefineries required to gain political legitimacy, especially since the development of 2<sup>nd</sup> generation technologies (e.g. lignocellulosic based biorefineries) will be vital to making European biofuels cost competitive on the global market (BIOPOL, 2006). Therefore, the author considers it necessary to form questions relating to whether any specific entrepreneur, or network of entrepreneurs, has lobbied the target audience and, if so, what type of technology or feedstock they are advocating and the reasons for this. This will also enable the survey to detect whether the target audience has a deeper understanding of the complexity of the technical issues surrounding *integrated industrial biorefineries*, or if lobbying from disparate groups has caused confusion and uncertainty.



### 5.4.5 Third-party actors

Proposition 5: New business concepts in which innovative entrepreneurs promote their new activity through third-party actors will gain *cognitive legitimacy* more quickly than others.

Inter-industry relations, whether hostile or collaborative, affect the availability of resources and the conditions on which they are available to entrepreneurs (Stinchcombe, 1968; Aldrich and Fiol, 1994; Mezner and Nigh, 1995). If an established industry feels threatened by a new business concept, they can question the value of the new industry or their level of conformity to the existing norms and laws, through rumours, information suppression or inaccurate dissemination (Aldrich and Fiol, 1994). This can give them the ability to control the conditions on which the resources are available to them. Therefore, the framework described in Chapter 2 proposes that inter-industry relations can unite and build the reputation of the new business concept as visible and taken-for-granted, thus making the achievement of socio-political legitimacy more likely.

Naj (1991) demonstrates a prime example of this factor where medical equipment manufacturers attempted to reduce the cognitive legitimacy of small new enterprises that wanted to service and repair the machines that the manufacturers were selling. The manufacturers argued that these new enterprises lacked the technical competence to perform this task, hence undermining their legitimacy and hindering the growth of a new business concept, until the courts overturned their claims. Other examples of this type of legitimacy thwarting have also been established by Peck (2003). In a study of the aluminium industry in the UK, he demonstrated that the formative phase of the “secondary” recycled aluminium industry was suppressed by the established “primary” aluminium sector. He goes on to say that this phenomenon also occurred in the plastics industry, where the “primary” established plastic industry undermined “secondary” plastics with persuasive lobbying power.

One way that innovative entrepreneurs can overcome this factor is to unite in building a reputation of reality, of something that “naturally should be taken for granted by others” (Aldrich and Fiol, 1994). In order to this, they propose that new vocabularies, labels and beliefs must be created by linking the new business’ culture (underlying beliefs and values) with the behaviours of its members (and what stakeholders may perceive as their identities). Entrepreneurs can do this individually, but they also indicate that a more influential image can emerge when entrepreneurs work through trade associations. They go on to demonstrate that trade associations can promote cognitive legitimacy by assisting new business concepts to “formulate new product/process standards through trade committees, trade journals, marketing campaigns (to enhance the industry’s standing), and trade fairs (where customers and suppliers can gain a sense of the industry’s stability)”, and also to promote socio-political legitimacy by representing the interests of the new business concept to government agencies. Rao (1993) demonstrated this in his study of the early years of the American automobile industry, that as they struggled for acceptance, firms that won victories in reliability and speed competitions organised by third parties were more likely to survive than those that did not win or participate.

By creating questions to activate the proposition, the author considers once again that entrepreneurs of *integrated industrial biorefineries* should take collective action and converge over a dominant product/design, in order to enhance their political legitimacy. As shown in Table 5-7, the key topic areas where this type of action is important for *integrated industrial*

*biorefineries* is within the description of the major concepts and technologies, and within the regulatory framework (e.g. forestry and agriculture, and genetically modified crops).

Table 5-7 Application of Proposition 5 to biorefinery concept

Proposition 5: New business concepts in which innovative entrepreneurs promote their new activity through third-party actors will gain <i>cognitive legitimacy</i> more quickly than others	
Questions to activate the proposition	Key areas affecting the legitimacy of biorefineries
Is the new business concept threatening an established industry?	Overview of biofuels Overview of biomaterials & biochemicals
Is a threatened industry questioning the value of the new business concept or their level of conformity to the existing norms and laws?	Energy security CO <sub>2</sub> emission reduction Agriculture and forestry
Has the new business concept established a third-party representative? Is there collective action? Is there convergence?	Environmental & land use The biorefinery concept Feedstocks & products of biorefineries
Is a third-party representing the interests of the new business concept to government agencies?	

Therefore, in order to measure the political legitimacy of *integrated industrial biorefineries*, questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience is being lobbied by competing industries that may be spreading rumours that particular aspects of the *integrated industrial biorefinery* is unsafe, exorbitantly costly, or will not bring about the political gains that it alleges (e.g. in the areas of CO<sub>2</sub> emission reduction, rural development, energy security, etc). Also, an important factor in the quest for legitimacy is the level of acceptance of the seniority and weight of industry leaders by the target audience. Therefore, questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience accepts leaders of the progression *integrated industrial biorefinery* to be credible and influential. Some examples of how these areas can be manifested into questionnaires or in-depth interview questions are given below:

### Example: Feedstocks and products of biorefineries

The possible products of *integrated industrial biorefineries* were discussed in Chapter 4.3, as were indications that renewable biomass feedstocks were creeping back into the production processes of potential competitors, such as the polymer industry. Competition for biomass feedstock resources and bio-based product markets, could promote actions by rival industries to suppress the legitimacy of *integrated industrial biorefineries*, which would be a major threat to their progression. Competition could also come from established petrochemical industries, who will have to compete for market shares of like products based on petroleum feedstocks, and who may also attempt to reduce the legitimacy of *integrated industrial biorefineries* by spreading rumours regarding their production processes, feedstock cultivation effects on the environment, quality of products, CO<sub>2</sub> emission reduction capabilities, etc. This type of fierce competition may hinder the collective action of the innovative entrepreneurs of *integrated industrial biorefineries* required to gain political legitimacy through third-party representatives. Therefore, the author considers it necessary to form questions relating to whether any third-party representative has lobbied the target audience and, if so, what type of product, design

or feedstock they are advocating and the reasons for this. Questions should also be developed to determine if the target audience accepts that leaders of these lobby groups are credible and influential, and if they are willing to establish guidelines for standards for the promotion of the demand for natural resources based chemicals and materials?

**Example: Environment and land use issues**

Another key area affecting the progression of *integrated industrial biorefineries*, where third-party representation could enhance legitimacy, is related to the potential detrimental effects of biomass production. Chapter 3.5.6 describes such adverse effects as deforestation, land degradation, acidification and eutrophication from the cultivation of predominantly 1<sup>st</sup> generation energy crops (such as grain, corn, rapeseed, etc) for the production of biofuels, particularly in developing countries. In an attempt to enhance the legitimacy of biofuels imported from developing countries, the EU planned a sustainability certification scheme for biofuels that would “allow Member States to provide incentives for the use of sustainably produced biofuels” (ENDS, 2007, May 11). Although this attempt was deemed to be incompatible with WTO rules, the EU is considering ways to create incentives for the use of sustainable produced biofuels. Thus, another area where innovative entrepreneurs could enhance the legitimacy of *integrated industrial biorefineries*, is to have a third-party lobbying for a similar certification scheme or subsidy for the production of sustainably produced biomass feedstocks. Therefore, the author considers it necessary to form questions relating to whether any third-party representative has lobbied the target audience to support any such certification scheme, incentive or subsidy relating to *integrated industrial biorefineries* and, if so, what type of product, design or feedstock they are advocating and the reasons for this. Questions should also be developed to determine if the target audience accepts that leaders of these lobby groups are credible and influential.

**5.4.6 Negotiation and compromise**

Proposition 6: New business concepts in which innovative entrepreneurs negotiate and compromise with other industries will gain *socio-political legitimacy* more quickly than others.

The framework described in Chapter 2 propose that a lack of cognitive legitimacy causes a new business concept to be vulnerable to inter-industry processes, such as strong opposition from other related industries seeking to exploit similar resources, which may jeopardise its acceptance amongst the existing norms and laws. This may even go so far as the opposing industry inducing legal and regulatory barriers. Therefore, the growth of new business concepts beyond the formative phase is partly dependent on the severity of attacks from established industries that may oppose the competition.

In order to overcome this kind of opposition, Aldrich and Fiol (1994) propose that new business concepts need to create reliable relationships with other established industries and also form trade associations or industry councils to strengthen the power of the new businesses. For example, Van de Ven and Gerud (1989) demonstrates the need for new medical industries to cooperate with third party actors (such as government institutions) to bear the costs of costly medical treatments (such as CAT scans or cochlear implants) that patients cannot afford. These industries need to cooperate, in order to educate and influence these third parties to include their product/service into their patient reimbursement schemes.

By creating questions to activate the proposition, the author considers once again that entrepreneurs of *integrated industrial biorefineries* should take collective action and converge over a dominant product/design in order to counter the potential adverse criticism of opposing industries and enhance their own legitimacy. As shown in Table 5-8, the key areas where this type of action is important for *integrated industrial biorefineries* is within the description of the major concepts and technologies, and in particular within the EU regulatory framework where opposing industries may try to institute regulatory barriers to *integrated industrial biorefineries*. This is also particularly important when considering the potential for research grant opportunities available to develop the technologies required for the progression of *integrated industrial biorefineries* from the formative research phase towards the demonstration phase; a process that could require hundreds of millions of euros. Policies such as the EU Biofuels Platform provide for some such financial support, but there are many other industries and technologies competing for the same grants.

Table 5-8 Application of Proposition 6 to the biorefinery concept

<b>Proposition 6: New business concepts in which innovative entrepreneurs negotiate and compromise with other industries will gain <i>socio-political legitimacy</i> more quickly than others</b>	
<b>Questions to activate the proposition</b>	<b>Key areas affecting the legitimacy of biorefineries</b>
Is the new business concept competing for resources with an established industry?	Overview of biofuels Overview of biomaterials and biochemicals
Is an opposing industry inducing legal and regulatory barriers for the new business concept?	EU Regulatory framework Energy security
Has the new business concept established reliable relationships with other established industries?	CO <sub>2</sub> emission reduction The biorefinery concept
Has the new business concept established a third-party representative?	Feedstocks & products of biorefineries Working definition of a biorefinery
Is a third-party representing the interests of the new business concept to government agencies?	Lack of clarity over biorefineries
Is the government willing to co-finance the demonstration phase of biorefineries?	

Some examples of how these areas can be manifested into questionnaires or in-depth interview questions are given below:

### **Example: EU regulatory framework**

As demonstrated in Chapters 5.3.2 to 5.3.6, there is clear evidence of an underlying ground swell of support in the form of policy interventions that favour the cultivation and use of biomass for the creation of energy, transportation fuels, and also some specifically aimed at other bio-based products and *integrated industrial biorefineries*. Top-level political support for *integrated industrial biorefineries* in Europe is not difficult to find (i.e. the Kyoto Protocol at a global governance level, and the plethora of EU level policy interventions at the European governance level). For example, the EU vision for biofuels - Biofuels in the European Union: A vision of 2030 and beyond - specifically mentions the importance of developing “integrated refinery concepts”. National level support will also be imperative for the progression of *integrated industrial biorefineries* from their present formative (research) phase to the quickly developing demonstration (pilot) phase, and beyond. Even though there is

evidence of political support (e.g. CHRISGAS and BioFuels Region projects), it is not obvious whether the level of financial support will be adequate to enable the timely progression of *integrated industrial biorefineries* to contribute to various EU policy targets (e.g. meeting the EU Biofuels Directive targets). Therefore, this is a very important factor that must be extracted from the target audiences as a result of the work that extends from this thesis. This will be imperative for the measurement of political legitimacy, as large-scale investments will be required for technologies that may take up to 10 years to develop – a time scale that is realistically beyond the period of any political stakeholder to be in power, which makes it highly unlikely that any political benefit will be gained by making decisions to progress biorefineries now. Therefore, questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience is being lobbied by competing industries or entrepreneurs for technical research grant opportunities that may be available for the progression of *integrated industrial biorefineries* (through policies like the EU Biofuels Platform) and whether these competing industries are attempting to institute regulatory barriers to *integrated industrial biorefineries* in order to reduce the competition.

#### **Example: The biorefinery concept / Lack of clarity over biorefineries**

Many industries have been identified as competitors to the biorefinery concept for the limited research and development funds that are available. These include, for instance, partial biorefineries such as those co-producing bioethanol and heat from forestry residues and pulp and paper mills. Chapter 3.5.6 highlighted the example of competition for biomass resources from the pulp and paper industry who are attempting to discredit the legitimacy of *integrated industrial biorefineries* by showing that it is more economically viable to use wood as a paper resource than for energy. There is also the potential for opposition from other industries that produce the same products as *integrated industrial biorefineries* potentially will, which puts them in direct conflict with the biorefinery concept. These industries include the petrochemical industry that incorporates a vast encumbering system of crude oil exploration and extraction, refining, shipping, bulk liquid storage, distribution etc, etc, etc. However, there are also many similarities between these groups of ‘competitors’ that could be used as a catalyst to the creation of third-party representatives to the benefit of all groups. For instance, progression of 2<sup>nd</sup> generation conversion technologies benefit all groups, even the ‘opposing’ petrochemical industry who has the foresight to understand that demand for bio-based products is rising and have even been shown in Chapter 4.7 to be part of a number of research consortiums for the progression of bio-based products, such as Shell Global Solutions and the Dow Chemical Company. Therefore, the author considers it necessary to form questions relating to whether any competitors or opponents of biorefineries have lobbied the target audience for financial support, and if so, was it via a third-party representative? It will also be necessary to understand who the lobbyists are and for what kinds of projects are they requesting support.

#### **5.4.7 Established educational curricula**

Proposition 7: New business concepts that create linkages with established educational curricula will gain *cognitive legitimacy* more quickly than others.

Aldrich and Fiol (1994) propose that the cognitive legitimacy of a new business concept, and hence the rate at which it develops from the formative phase of its lifecycle, may be

constrained by institutional conditions. They go on to say that before innovative entrepreneurs can obtain socio-political legitimacy, they must first pursue effective trust-building and reliability-enhancing strategies on an inter-industry level, and have established a reputation with respect to other established industries on an intra-industry level. Once this is achieved, innovative entrepreneurs no longer operate as isolated individuals, but as part of a team of “industry councils, cooperative alliances, trade associations, and other vehicles for collective action” that are in place to achieve institutional (i.e. political) legitimacy.

Whilst established industries have the benefit of the institutionalised dissemination of information about their activities, new business concepts are often lacking the critical mass required to begin increasing their level of cognitive legitimacy (Hannan and Freeman, 1984; Aldrich and Fiol, 1994). Mass media is not familiar with the language for describing the activity, and their interpretation/representation may be inaccurate and misleading (Phillips, 1960). Without an accepted language or framework for describing a new business venture, educational institutions may also encounter problems creating manuals and textbooks on the activity (Aldrich and Fiol, 1994). They go on to say that this is a lost opportunity for innovative entrepreneurs, as educational institutions can create information regarding the competencies of the new business concept and assist in its dissemination, which is a primary requirement for gaining legitimacy.

By creating questions to activate the proposition, the author considers that once again symbolic language and behaviour is imperative to gaining the legitimacy for many of the overarching concepts related to *integrated industrial biorefineries*, such as bio-based products (biofuels, biomaterials and biochemicals) and feedstocks, the biorefinery concept, and the lack of clarity over *integrated industrial biorefineries*, and in determining a working definition of a biorefinery, as shown in Table 5-9.

Table 5-9 Application of Proposition 7 to the biorefinery concept

<b>Proposition 7: New business concepts that create linkages with established educational curricula will gain <i>cognitive legitimacy</i> more quickly than others</b>	
<b>Questions to activate the proposition</b>	<b>Key areas affecting the legitimacy of biorefineries</b>
Are mass media, NGOs, & community groups familiar with the language for describing the new business concept?	Overview of biofuels Overview of biomaterials and biochemicals The biorefinery concept
Is mass media interpreting & representing the new business concept in an accurate way?	Feedstocks & products of biorefineries Lack of clarity over biorefineries
Has the new business concept established relationships with educational institutions?	Working definition of a biorefinery
Are educational institutions helping to disseminate information about the new business concept?	

Fundamental to progression of the *integrated industrial biorefinery* concept is that the theory, processes, inputs and production capabilities are clearly defined, understood and articulated. It has already been established that the target audience for measuring the political legitimacy of biorefineries in Europe will only include a very limited and specific survey of the actors influencing the targeted political audience (see Chapter 5.3.7). Therefore, questionnaires and in-depth interview questions should include triggers that gain an understanding of whether

stakeholders such as the media and educational institutions are using the same simplified, stylised and symbolic language, encompassing existing knowledge and comparable with existing industries that were referred to in Chapter 5.4.1, and whether they are affecting the target audience's cognitive awareness and political understanding of *integrated industrial biorefineries*. Some examples of how these areas can be manifested into questionnaires or in-depth interview questions are given below:

### **Example: The biorefinery concept (and education)**

The biorefinery concept incorporates many facets of our daily lives upon which we have come to depend; for instance, *integrated industrial biorefineries* will produce many of the products we use every day (transport fuels, detergents, paints, polymers), but it will also co-produce heat and electricity. These forms of bioenergy are becoming increasingly more prolific as nations struggle to meet their CO<sub>2</sub> emission reduction obligations under the Kyoto Protocol (see Chapter 3.5.1) and acknowledge that their reliance on fossil fuels is threatening their energy security (see Chapter 3.5.2). The Biomass Action Plan (Council Directive 2003/30/EC) estimates that meeting the EU's targets for increased biomass derived energy use by 2010 will create up to 300 000 jobs, which creates a demand for experts in the bioenergy field. A recent study undertaken by the Bioenergy Network of Excellence (Bioenergy NoE) demonstrated that Masters and PhD courses in bioenergy have increased dramatically over the past five years (Bioenergy NoE, 2007). The study goes on to show that 55 out of the 60 Masters courses surveyed in Europe began between 2000 and 2005. While the author could not detect any course material specifically devoted to *integrated industrial biorefineries*, many of the components relating the concept are evident in the diverse range of specialisations offered, including all aspects of biomass utilisation technologies, optimisation of energy crop production, socio-economic analysis of bioenergy systems, etc. Therefore, the author considers it necessary to form questions relating to whether the target audience is involved in, or willing to foster, innovation driven science and technology educational curricula for renewable feedstocks, and in particular for the biorefinery concept itself.

### **Example: The biorefinery concept (and media)**

During the research carried out as part of this work, a number of media based searches have been conducted. These have included ENDS Europe Daily (Europe's environmental news service), reputable media publications such as The Economist, and reputable think tanks and NGOs that diffuse information likely to reach the European political sphere, such as the Worldwatch Institute, the WWF and Greenpeace. A number of these articles have been referenced within this thesis and attest to the fact that quality information is being disseminated, albeit somewhat difficult to locate (for instance, a search on ENDS Europe Daily for "biorefinery" resulted in zero articles, while a search for "biofuel" resulted in 12 904 articles). The author also conducted a peripheral search on a number of search engines (such as Google, Europa, EurActive) just to get an idea of the incidence and diversity of information that was being disseminated. All of these searches greatly favoured "biofuels" over "biorefineries" in the quantity of information available (for instance, a search on Google for "biorefinery" resulted in 229 000 articles, while a search on "biofuel" resulted in 7 450 000 articles). However, it seems that the quality of information, on a very tangential analysis, regarding "biorefineries" seems to be quite high. Further analysis of mass media coverage of *integrated industrial biorefinery* issues was not undertaken, as it is not the purpose of this thesis to gain quantitative evidence for legitimacy, this will be part of the work that follows on from this thesis. However, since the interpretation and representation of *integrated industrial biorefineries* in mass media has the ability to enhance its legitimacy, so too does

inaccurate and misleading information has the ability to hinder legitimacy. Therefore, the author considers that it is necessary to form questions relating to whether the target audience is being influenced by mass media, and if so, from which sources. This method will involve collecting basic information from the main target audience on which media groups are important to capture within this process, the identified media groups may then be investigated further, or targeted for more in-depth interviews. This will also enable the survey to detect whether the target audience has a deeper understanding of the complexity of the technical issues surrounding biorefineries, or if media is causing confusion and uncertainty.

#### 5.4.8 Marketing and lobbying

Proposition 8: New business concepts that organise collective marketing and lobbying will gain *socio-political legitimacy* more quickly than others.

Lack of institutional support for the dissemination of information about a new business concept may also thwart innovative entrepreneurs efforts to secure socio-political approval (Carroll and Delacroix, 1982; Aldrich and Fiol, 1994). They go on to say that new business concepts whose activities are poorly understood may find it difficult to gain the approval of cautious, often risk averse, government agencies. This is especially the case when the new business concept, with unfamiliar or novel technology, challenges an older established industry, even to the point of government agencies displaying considerable resistance to the new activity. The problem becomes inherently more complex when political systems are divided into executive and legislative branches, with independent regulatory agencies.

Shan et al. (1991) demonstrated how this type of legitimacy hindering is exemplified by the slow development of the biotechnology industry in the 1970s-1980s. The industry developed in an environment of great uncertainty because there was no clear institutional guidance regarding safety testing. In an attempt to create a clearer regulatory environment, the Industrial Biotechnology Association lobbied the FDA, the EPA, and other government institutions, resulting in the first FDA approved diagnostic kit based on a monoclonal antibody, which Shan et al. (1991) believes significantly raised the founding rate of biotech firms in the years that followed. Van de Ven and Gerud (1989) also emphasises how important government agencies, such as the FDA and EPA, can be in gaining legitimacy for new business concepts whose products or services are expensive, technically complex, or whose use may cause adverse human effects. In order to overcome this factor, innovative entrepreneurs must transact and form alliances with government agencies (DiMaggio and Powell, 1983; Aldrich and Fiol, 1994).

By creating questions to activate the proposition, the author considers once again that entrepreneurs should take collective action in order to counter adverse criticism of opposing industries or groups (such as the petrochemical industry, the pulp and paper industry, the forestry industry, NGOs, the media, etc) to enhance their own political legitimacy or gain access to institutional support. As shown in Table 5-10, the key areas where this type of action is important for *integrated industrial biorefineries* is within the description of the major concepts and technologies, and in particular within the regulatory framework where innovative entrepreneurs of *integrated industrial biorefineries* can attempt to institute clear regulatory guidance to enhance their progression from the research phase to the demonstration phase.



Table 5-10 Application of Proposition 8 to the biorefinery concept

<b>Proposition 8: New business concepts that organise collective marketing and lobbying will gain <i>socio-political legitimacy</i> more quickly than others</b>	
<b>Questions to activate the proposition</b>	<b>Key areas affecting the legitimacy of biorefineries</b>
Is the new business concept threatening an established industry?	Overview of biofuels Overview of biomaterials and biochemicals EU regulatory framework
Are government agencies displaying considerable resistance to the new activity?	Energy security CO <sub>2</sub> emission reduction Agriculture and forestry Employment & rural development
Is the political system divided into executive and legislative branches, with independent regulatory agencies?	Environment & land use issues Economy Genetically modified crops Sustainability
Is the new business concept forming alliances with, otherwise come to terms with, and lobbying government agencies?	The biorefinery concept Feedstocks & products of biorefineries

As determined through the analysis of Proposition 6, there is clear top-level evidence of an underlying ground swell of support in the form of policy interventions that favour the cultivation and use of biomass for the creation of energy and transportation fuels. However, the operative support required at a National level will also be imperative for the progression of *integrated industrial biorefineries*. Therefore, questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience is displaying considerable resistance to the progression of *integrated industrial biorefineries*, by other political actors, government departments, individual bureaucrats, media, etc. Some examples of how these areas can be manifested into questionnaires or in-depth interview questions are given below:

**Example: Feedstocks and products of biorefineries**

The emerging ‘science’ of assessing the value of energy crops against the advantages that they claim (e.g. increasing energy security, CO<sub>2</sub> emission reduction, increasing farm incomes, and increasing employment and rural development) is a key area surrounding the legitimacy of the use of biomass for energy, fuel and other chemical product manufacture (see Chapter 3.5). As described in Chapter 3.5.3, estimating GHG savings from production of biofuels is very complex and varies considerably depending on the type of crop, cultivation method, conversion technology and disparities regarding reductions associated with co-products. Different studies revealed in Chapter 3.5.3 even go so far as to estimate that GHG savings can range from negative to more than 100%. This issue is vitally important to the legitimacy of *integrated industrial biorefineries*, as the potential for CO<sub>2</sub> emission reduction from the use of biomass, as opposed to fossil fuels, is the key driving force of the path towards *integrated industrial biorefineries*. A similar issue to the sustainability certification scheme for biofuels referred to in Chapter 5.4.6, is happening with palm oil used for the production of biodiesel. Unilever (a multinational producer of food products) claims that EU biofuels targets have increased the demand for palm oil used in the production of biodiesel, which in turn has led to unsustainable farming practices (ENDS, 2007, May 2). Most of the

detrimental effects are related to the conversion of forest with high conservation and biodiversity value into new oil palm plantations, which is causing detrimental environmental and social effects. Attempts such as the sustainability certification scheme by the EU and the 'roundtable on sustainable plan oil' by Unilever, WWF, and others, is an attempt to reinstate the legitimacy of cultivating biomass for the production of energy, transport fuels, and other bio-based products. This is vital to the legitimacy of *integrated industrial biorefineries* who, in the minds of those who don't understand the differences between 1<sup>st</sup> and 2<sup>nd</sup> generation crops and conversion technologies, will be using the same feedstocks and exacerbating these negative environmental and social impacts. Therefore, the author considers that it is necessary to form questions relating to whether the target audience is displaying considerable resistance to the new activity, and if so, why. This will enable the detection of specific areas where legitimacy is blatantly being hindered and if they are especially within areas of high public exhibition (such as the sustainable farming issue), or by certain media.

### **Example: EU regulatory framework**

The complexity of issues surrounding *integrated industrial biorefineries* has been highlighted throughout this thesis. The issues stretch across all facets of society; cutting edge technology and research, energy security, climate change, employment, rural development, environment, land use, economy, and sustainability. Thereby, making legitimacy procurement a formidable task that has to be fostered within each of these key areas and at each level of political decision making. The problem becomes inherently more complex when political systems are divided into executive legislative and policy branches, with independent regulatory agencies or research bodies. In order for the assessment of political legitimacy to be undertaken, as an extension of this thesis, it will be vitally important to examine the structure and division of the political systems being assessed, to enable an understanding of where political legitimacy is lacking and how it can be improved in the future. A starting point for this examination has been undertaken in Chapter 5.3. However, much greater detail can be extracted from the target audience by asking questions relating to their situation within the political hierarchy and reporting structure, their level of influence in decision making and their main sources of information (e.g. from the top down, bottom up, or from an external influencing sphere).

## **5.5 Conclusion**

Once the various components contributing to the legitimacy of *integrated industrial biorefineries* were understood and defined, the author applied them to the theoretical factors influencing the legitimacy of new business concepts within this chapter. Through this method the author examined these factors and established how they fit within the biorefinery context, thus determining criteria and a number of specific strategies upon which the legitimacy of *integrated industrial biorefineries* can be measured.

Now that various strategies for measuring the political legitimacy of *integrated industrial biorefineries* have been produced, the author will transcribe them into a matrix that describes an approach to devising questions around each of the key areas identified to be important to gaining political legitimacy for *integrated industrial biorefineries*, a task that has been undertaken in Chapter 6. It is envisaged that these questions will underpin the development of a set of questionnaires and in-depth interviews within a Pan-European research activity, the answers to which will enable the political legitimacy of *integrated industrial biorefineries* in Europe to be determined.

## 6 Findings and Implications

### 6.1 Background

The focus problem for this thesis was to understand how existing knowledge, indicators and literature can be used to determine a logical and streamlined way to measure the “political legitimacy” of *integrated industrial biorefineries* in Europe. By gaining a measure of the political acceptance for implementing *integrated industrial biorefineries* in Europe, we can better understand the manner in which this new area of business and industrial activity can emerge and many of the benefits associated with CO<sub>2</sub> emission reductions, energy security, rural development etc, anticipated by the proponents of *integrated industrial biorefineries* can be achieved.

The literature regarding organisational theory provides a framework around which the political legitimacy of new business concepts can be analysed and enhanced. As demonstrated in Chapter 2, frameworks such as those established by Aldrich and Fiol (1994), Ranger-Moore et al. (1991), Meznar and Nigh (1993), and Jacobsson and Bergek (2004), that link cognitive and socio-political legitimacy to industrial creation, can be adapted to also enable the legitimacy of innovative new business concepts to be measured. In order to adapt these frameworks to the context of the biorefinery concept, the political importance and implications of the production and use of *integrated industrial biorefinery* products needs to be understood, a task that has been undertaken in Chapter 3. However, because socio-political and cognitive legitimacy are so closely intertwined, the cognitive essence of *integrated industrial biorefineries* (i.e. what an *integrated industrial biorefinery* is or could be) and the lack of clarity surrounding them also need to be defined, a task that has been undertaken in Chapter 4.

Once the various components contributing to the legitimacy of *integrated industrial biorefineries* were understood and defined, the next step was to apply them to the theoretical factors influencing the legitimacy of new business concepts. Therefore, within Chapter 5, the author examined these factors and established how they fit within the *integrated industrial biorefineries* context, thus determining criteria and a number of specific strategies upon which the legitimacy of *integrated industrial biorefineries* can be measured. These strategies have been transcribed into a matrix that describes an approach to devising questions around each of the key areas identified to be important to gaining political legitimacy for *integrated industrial biorefineries*, a task that has been undertaken in Chapter 6.5. It is envisaged that these questions will underpin the development of a set of questionnaires and in-depth interviews within a Pan-European research activity, the answers to which will enable the political legitimacy of *integrated industrial biorefineries* in Europe to be determined.

### 6.2 General findings

A number of factors that are either supporting or hindering the political legitimacy of *integrated industrial biorefineries* in Europe were discovered during this course of this thesis research. The major factors have been summarised below.

## 6.2.1 Political importance and implications of the production and use of bio-based products

In order to adapt the identified framework to the context of the biorefinery concept, the political importance and implications of the production and use of *integrated industrial biorefinery* products needed to be understood, a task that has been undertaken in Chapter 3. The key areas identified as important to the target audience include: the EU regulatory framework, energy security, CO<sub>2</sub> emission reduction, agriculture and forestry, employment and rural development, environment and land use, economy, genetically modified crops, and sustainability. Each of these key areas was described and analysed in detail in order to determine how they will related to the progression of *integrated industrial biorefineries* in Europe. From these key areas, a number of contentious issues were identified as having the potential to dramatically affect the political legitimacy of *integrated industrial biorefineries* including: the disputes surrounding the CO<sub>2</sub> emission reduction capabilities of biomass feedstocks for the production of bio-based products, the contention between the development of 1<sup>st</sup> and 2<sup>nd</sup> generation biomass conversion technologies and feedstocks, the disputed success of CAP amendments to encourage energy crop production, and the social issues surrounding genetically modified energy crops.

## 6.2.2 Cognitive understanding of the biorefinery concept

Even though this thesis concentrates on the measurement of political legitimacy, the author discovered that cognitive legitimacy is so closely intertwined into the potential for political leaders to accept and support a new business concept, that the cognitive essence of *integrated industrial biorefineries* (i.e. what they are or could be) and the lack of clarity surrounding them also need to be defined, a task that has been undertaken in Chapter 4. The key areas identified as important to the target audience include: the biorefinery concept itself, feedstocks and products of *integrated industrial biorefineries*, technologies required for *integrated industrial biorefineries*, having a working definition of an *integrated industrial biorefineries*, the lack of clarity of stakeholders in understanding what an *integrated industrial biorefineries* is or could be, and defining who the “innovative entrepreneurs” of *integrated industrial biorefineries* are. Each of these key areas was described and analysed in detail in order to determine how they will related to the progression of *integrated industrial biorefineries* in Europe. From these key areas, a number of contentious issues were identified as having the potential to dramatically affect the political legitimacy of *integrated industrial biorefineries* including: cost effective 2<sup>nd</sup> generation conversion technology is complicated and still under development, the general biorefinery concept is unclear as there is no convergence around one dominant design, and *integrated industrial biorefineries* definitions vary significantly between experts. One important aspect of the work undertaken by this author was to devise a definition and description of *integrated industrial biorefineries* that would enable the target audience to understand the context of the questions posed to them regarding biorefineries, a task that was undertaken in Chapter 5.4.1.

## 6.2.3 Indicators of political legitimacy – government interventions

In general, many of the signals that scholars of organisational ecology, such as Aldrich and Fiol (1994) propose as indicators of cognitive and socio-political legitimacy are evident for *integrated industrial biorefineries* (albeit indirect in many cases). This is especially apparent in the underlying ground swell of support in the form of policy interventions that favour the cultivation and use of biomass for the creation of energy, transportation fuels, and also some specifically aimed at other bio-based products and *integrated industrial biorefineries*. Top-level

political support for *integrated industrial biorefineries* in Europe is not difficult to find (i.e. the Kyoto Protocol at a global governance level, and the plethora of EU level policy interventions at the European governance level). For example, the EU vision for biofuels - Biofuels in the European Union: A vision of 2030 and beyond - specifically mentions the importance of developing “integrated refinery concepts”. National level support will also be imperative for the progression of *integrated industrial biorefineries* from their present formative (research) phase to the quickly developing demonstration (pilot) phase, and beyond. Even though there is evidence of political support (e.g. CHRISGAS and BioFuels Region projects), it is not obvious whether the level of financial support will be adequate for the timely progression of *integrated industrial biorefineries*. Therefore, this is a very important factor that must be extracted from the target audiences as a result of the work that extends from this thesis. This will be imperative for the measurement of political legitimacy, as large-scale investments will be required for technologies that may take up to 10 years to develop – a time scale that is realistically beyond the period of any political stakeholder to be in power, which makes it highly unlikely that any political benefit will be gained by making decisions to progress *integrated industrial biorefineries* now.

### 6.3 Strategies for measuring the political legitimacy of integrated industrial biorefineries in Europe

The author examined the factors identified as either supporting or hindering the progression of *integrated industrial biorefineries* in Europe and then established how they fit within the biorefinery context. Through this process, the author determined general criteria and a number of specific strategies upon which the legitimacy of *integrated industrial biorefineries* can be measured. These strategies have been summarised below.

These strategies have also been transcribed into a matrix that describes an approach to devising questions around each of the key areas identified to be important to gaining political legitimacy for *integrated industrial biorefineries*, a task that has been undertaken in Chapter 6.5. It is envisaged that these questions will underpin the development of a set of questionnaires and in-depth interviews within a Pan-European research activity, the answers to which will enable the political legitimacy of *integrated industrial biorefineries* in Europe to be determined.

#### 6.3.1 Strategy 1: Identifying the target audience

The author deemed that it was necessary to first identify the political levels within Europe that can provide support or hindrance to the development of *integrated industrial biorefineries*, a task that has been undertaken in Chapter 5.3. The author determined that EU and Member State (National) level policy interventions are expected to potentially have a huge impact on the progression of *integrated industrial biorefineries*. Thus, the strategy for measuring political legitimacy was targeted towards them, with additional ‘special’ groups (i.e. regional governance groups, NGOs, media groups) to be identified by the target audience for in-depth interviews. It was also determined that legitimacy should be measured at three political levels within EU and Member State governance: the political level, departmental level and bureaucratic level. This will enable the strategy to capture the complete policy making process. Although it is envisaged that this strategy will be applicable to any political sphere, this thesis concentrates on Europe, namely the EU. Due to the commitments of the BIOPOL network, the strategy developed in this work will first focus on an assessment of political legitimacy in Sweden. It is envisaged that the work will then be replicated

throughout the other BIOPOL network countries (i.e. the Netherlands, Germany, the UK, Poland and Greece).

### **6.3.2 Strategy 2: Use simplified, stylised and symbolic language**

Even though this thesis concentrates on the measurement of political legitimacy, the author discovered that cognitive legitimacy is so closely intertwined into the potential for political leaders to accept and support a new business concept, that the cognitive essence of *integrated industrial biorefineries* (i.e. what they are or could be) and the lack of clarity surrounding them also need to be defined, a task that has been undertaken in Chapter 4. After considering Proposition 1 of the framework for enhancing legitimacy used during this thesis, it was determined that all questionnaires and in-depth interview questions should be developed using simplified, stylised and symbolic language, encompassing existing knowledge and comparable with existing industries. To this end, and one very important aspect of the work undertaken by this author a definition and description of *integrated industrial biorefineries* that would enable the target audience to understand the context of the questions posed to them regarding *integrated industrial biorefineries* was devised in Chapter 6.3.2 to better enable the political legitimacy of *integrated industrial biorefineries* to be determined:

The *integrated industrial biorefinery* is analogous to the petroleum refinery where an abundant raw material composed of a diverse range of renewable biomass is converted (through an array of processes) into a number of products including transportation fuels (e.g. bioethanol, biodiesel, etc), other bio-based products (e.g. paints, solvents, plastics, resins, agricultural chemicals, industrial surfactants, etc), and energy.

To enable the cognitive and hence political legitimacy of *integrated industrial biorefineries* to be measured, the author recommends that questionnaires and in-depth interview questions for the target audience should be centred on this definition and these types of symbolic descriptors.

### **6.3.3 Strategy 3: Determine the level of internal consistency**

After considering Proposition 2 of the framework for enhancing legitimacy used during this thesis, it was determined that all questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience understands the benefits and detriments of key areas of conflict (i.e. the transition from 1<sup>st</sup> to 2<sup>nd</sup> generation biomass conversion technologies). This will enable comparisons to be made between target audiences to determine whether consistent stories about *integrated industrial biorefineries* are being communicated at a political level. Also, it is necessary to determine whether the target audience can relate the key areas of *integrated industrial biorefineries* to analogous established industries (i.e. the *integrated industrial biorefinery* concept is analogous to the petroleum refinery, or energy crop cultivation for biofuel production is analogous to feedstock cultivation for *integrated industrial biorefineries*). Some examples of how these areas can be manifested into questionnaires or in-depth interview questions were given in Chapter 5.4.2.

#### **6.3.4 Strategy 4: Determine the existence of a dominant product/design**

After considering Proposition 3 of the framework for enhancing legitimacy used during this thesis, it was determined that all questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience understands the complexity of the technological issues (e.g. not all energy crops are the same in terms of CO<sub>2</sub> emission reduction potential), whether they advocate a particular technology or design, and whether they are willing to establish a discreet set of standards to specifically enable the progression of *integrated industrial biorefineries* (e.g. guidelines of standards for renewable feedstock, handling, process technology, and/or product performance standards). It will also be necessary to determine whether any network formed by technical experts has lobbied the target audience over a particular product/design. Some examples of how these areas can be manifested into questionnaires or in-depth interview questions were given in Chapter 5.4.3.

#### **6.3.5 Strategy 5: Determine the level of collective action**

After considering Proposition 4 of the framework for enhancing legitimacy used during this thesis, it was determined that all questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience understands the complexity of the major concepts and technologies, and within the regulatory framework (e.g. forestry and agriculture (which includes field and forest energy crop production), overview of biofuels (which includes descriptions of 1<sup>st</sup> and 2<sup>nd</sup> generation biomass conversion technologies), working definition of a biorefinery (which includes descriptions of the four major biorefinery concept designs, the “lignocellulosic feedstock biorefinery”, the “whole crop biorefinery”, the “green biorefinery” and the “biorefinery two platforms concept”). Also, it is necessary to determine whether any particular individual or network is lobbying the target audience to force the progression of a particular product/design, and whether there are differing opinions emerging amongst their political, departmental, or bureaucratic colleagues over the concept in general, or over a particular product/service design. An example of how these areas can be manifested into questionnaires or in-depth interview questions was given in Chapter 5.4.4.

#### **6.3.6 Strategy 6: Determine the level of third-party action**

After considering Proposition 5 of the framework for enhancing legitimacy used during this thesis, it was determined that all questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience is being lobbied by competing industries that may be spreading rumours that particular aspects of the *integrated industrial biorefinery* is unsafe, exorbitantly costly, or will not bring about the political gains that it alleges (e.g. in the areas of CO<sub>2</sub> emission reduction, rural development, energy security, etc). Also, an important factor in the quest for legitimacy is the level of acceptance of the seniority and weight of industry leaders by the target audience. Therefore, questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience accepts leaders of the progression *integrated industrial biorefinery* to be credible and influential. Some examples of how these areas can be manifested into questionnaires or in-depth interview questions were given in Chapter 5.4.5.

### **6.3.7 Strategy 7: Determine the level of negotiation and compromise**

After considering Proposition 6 of the framework for enhancing legitimacy used during this thesis, it was determined that all questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience understands the major concepts and technologies, and in particular within the EU regulatory framework where opposing industries may try to institute regulatory barriers to *integrated industrial biorefineries*. This is also particularly important when considering the potential for research grant opportunities available to develop the technologies required for the progression of *integrated industrial biorefineries* from the formative research phase towards the demonstration phase; a process that could require hundreds of millions of euros. Policies such as the EU Biofuels Platform provide for some such financial support, but there are many other industries and technologies competing for the same grants. Some examples of how these areas can be manifested into questionnaires or in-depth interview questions was given in Chapter 5.4.6.

### **6.3.8 Strategy 8: Determine the influence of media**

After considering Proposition 7 of the framework for enhancing legitimacy used during this thesis, it was determined that all questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience is being influenced by stakeholders such as the media and educational institutions, and if so, from which sources. This method will involve collecting basic information from the main target audience on which media groups are important to capture within this process, the identified media groups may then be investigated further, or targeted for more in-depth interviews. This will also enable the survey to detect whether the target audience has a deeper understanding of the complexity of the technical issues surrounding *integrated industrial biorefineries*, or if media is causing confusion and uncertainty. Some examples of how these areas can be manifested into questionnaires or in-depth interview questions were given in Chapter 5.4.7.

### **6.3.9 Strategy 9: Determine the level of organised collective lobbying**

After considering Proposition 8 of the framework for enhancing legitimacy used during this thesis, it was determined that all questionnaires and in-depth interview questions should include triggers that gain an understanding of whether the target audience is displaying considerable resistance to the progression of *integrated industrial biorefineries*, by other political actors, government departments, individual bureaucrats, media, etc. This will enable the detection of specific areas where legitimacy is blatantly being hindered and if they are especially within areas of high public exhibition (such as the sustainable farming issue), or by certain stakeholders or media. The author identified that opposing or competing industries or groups (such as the petrochemical industry, the pulp and paper industry, the forestry industry, NGOs, the media, etc) could lobby the target audience with adverse criticism of biorefineries in order to enhance their own legitimacy, or to gain access to institutional support.

The aspect of understanding political legitimacy also becomes inherently more complex when political systems are divided into executive legislative and policy branches, with independent regulatory agencies or research bodies. Therefore, detail of the structure and division of the political systems being assessed can be gained by asking the target audience questions relating to their situation within the political hierarchy and reporting structure, their level of influence in decision making and their main sources of information (e.g. from the



top down, bottom up, or from an external influencing sphere). Some examples of how these areas can be manifested into questionnaires or in-depth interview questions were given in Chapter 5.4.8.

## 6.4 Conclusion

The strategies identified for measuring the political legitimacy of *integrated industrial biorefineries* in Europe have been transcribed into the matrix shown in Table 6-1. This matrix lists the key topics relating to the political importance and cognitive legitimacy of *integrated industrial biorefineries* that should be addressed when measuring their political legitimacy. The matrix also describes the target audience and the key levels of governance upon whom political legitimacy should be measured. Finally, the matrix describes a logical and streamlined way to devise questions around each of the key topics for the target audience. It is envisaged that these questions will make up a set of questionnaires and in-depth interviews, the answers to which will enable the political legitimacy of *integrated industrial biorefineries* in Europe to be determined.

Table 6-1 Matrix of strategies to devise questions for the purpose of measuring the political legitimacy of integrated industrial biorefineries within the EU, national and regional governance spheres of Europe

Key Biorefinery Topics	Strategies for Developing Questions for the Purpose of Measuring Legitimacy	
	Cognitive	Political
Justification for research	Use simplified, stylised & symbolic language, encompassing existing knowledge & comparable with existing industries.	Determine whether key areas are being communicated in coherent ways that are comparable with established industries, & free of contradictions.
Bio-based products		
EU regulatory framework	Centre on the definition devised in Chapter 5.4.1 & these types of symbolic descriptors.	Determine whether the target audience can relate the key areas to analogous established industries.
Energy Security		
CO <sub>2</sub> emission reduction	Determine if the target audience understands the complexity of the technological issues, whether they advocate a particular <i>integrated industrial biorefinery</i> technology, & whether they are willing to establish of a discreet set of standards specifically to enable the progression of <i>integrated industrial biorefineries</i> .	Determine if the target audience understands the complexity of the political issues and whether they advocate a particular <i>integrated industrial biorefinery</i> technology or design.
Agriculture & forestry		
Employment & rural development		Determine whether the target audience accepts leaders of the progression of <i>integrated industrial biorefineries</i> to be credible & influential.
Environment & land use issues	Questions should be developed to determine whether any particular individual or network is lobbying the target audience to force the progression of a particular <i>integrated industrial biorefinery</i> product/design.	
Economy		
Genetically modified crops	Determine whether the target audience is being lobbied by competing industries spreading rumours that particular aspects of <i>integrated industrial biorefineries</i> are unsafe, exorbitantly costly, or will not bring about the political gains that it alleges.	Determine whether there are differing opinions emerging amongst their political/departmental/bureaucratic colleagues over the biorefinery concept in general, or over a particular <i>integrated industrial biorefinery</i> product/service design.
Sustainability		
Biorefinery concept		
Feedstocks & products		
Technologies required	Determine whether stakeholders such as the media & educational institutions are using the same simplified, stylised & symbolic language, encompassing existing knowledge & comparable with existing industries that were referred to in Chapter 5.4.1, & whether they are affecting the target audience's cognitive awareness of <i>integrated industrial biorefineries</i> .	Determine whether the target audience is being lobbied by competing industries for technical research grant opportunities that may be available for the progression of <i>integrated industrial biorefineries</i> , through policies like the EU Biofuels Platform, and whether these competing industries are attempting to institute regulatory barriers to <i>integrated industrial biorefineries</i> .
Working definition of a biorefinery		Determine whether the target audience is being lobbied, either for or against the progression of <i>integrated industrial biorefineries</i> , by other political actors, government departments or individual bureaucrats.

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## Abbreviations

BtL	Biomass-to-liquids (biofuel from Fischer-Tropsch synthesis)
CAP	Common Agricultural Policy
CHP	Combined heat and power
CO <sub>2</sub>	Carbon Dioxide
DOE	US Department of Energy
EEA	European Environment Agency
EPA	United States Environmental Protection Agency
ETBE	Ethyl-tertio-butyl-ether
European Commission	Commission of the European Communities
EU	European Union
FDA	United States Food and Drug Administration
GHG	Green House Gas
ha	Hectare
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KSLA	Swedish Academy of Agricultural Sciences
LCA	Life-Cycle Assessments
MJ	Mega joule
Mtoe	Million tonnes of oil equivalent
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
RME	Rape Methyl Ester
RTD	Research and Technological Development
UN	United Nations
US	United States of America
US\$	US Dollar
UNFCCC	United Nations Framework Convention of Climate Change
VOME	Vegetable Oil Methyl Ester