Mobilising Global Bioenergy Supply Chains: Keys to unlocking the potential of bioenergy

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Abstract

This work is underlain by broad-based expectations that policy interventions such as EU 2020 goals for renewable energy will continue to drive increased international trade in biomass for energy. This work focuses on *where and how* large volumes of biomass for bioenergy may be brought to the market in the short to medium term and sought insights in the following areas:

- the manner in which demand for biofuels can be driven by political goals;
- the realism of expectations that biofuels can achieve political goals;
- the nature of production/consumption structures and potential in different regions;
- competence and resource needs for international bioenergy trade;
- the nature of synergies and competition with incumbent industries.

The work first examines immaturity and diversity in the bioenergy industry, and then presents and dissects policy cases to examine policy-making strengths and weaknesses. Management literature for emerging industrial sectors and policy literature are then used to support analysis of challenges posed by diversity in geographical, socio-economic conditions, and by energy carrier and supply chains differences. Arguments are then developed that a significant contribution to progress can be made by enhancing collective action; 'standardisation' of 'bioenergy offerings'; building the profession and professionalism; by improved interplay with other industries and stakeholders, and by improved input to policy-making processes.

The report then presents quantifications for biomass resources potentially available in the near to medium term. These include residue flows from agriculture and forestry, and new dedicated agriculture-derived feedstock supply systems. Importantly, modelling supporting this analysis indicates that there is substantial scope for land-minimizing growth of world food supply. This is feasible through efficiency improvements in the food chains from existing land-in-use. Scenarios presented here indicate that it is feasible to reduce global agricultural requirements some 230 Mha from current levels while still meeting dietary requirements (mainstream FAO estimates indicate expansion by 280Mha). This provides significant scope for expansion of dedicated energy crops. If higher productivity is combined with dietary changes toward less land-demanding food, then agricultural area available for biomass-for-energy could increase to some 1000 Mha.

The discussions in this report – institutional, supply chain, and biomass-bioenergy potential – all find common themes that point towards needs for enhanced sectoral action. These include: increased bioenergy-industry professionalism, aligned and consistent forms of collective action, strategic efforts to markedly increase public and political acceptance, more synergistic alliances with incumbent industries, careful application of third-party assessment schemes, the building of resilient technology strategies, and the consistent sourcing of biomass via pathways that remain accepted (legitimate) in the eyes of critical stakeholders.

This analysis concludes that many of the constraints or 'barriers' being experienced by the sector can be anticipated by examination of ongoing events through management and policy assessment lenses. This in turn indicates that guidance is available for action, both in theory, and by building upon the documented experiences of other emerging sectors. However, it is also concluded that more evidence from the field is vital to enrich this work and the value it may offer the sector. The report closes with brief delineation of research work required to better document where, how and when the industry might act to more effectively – and legitimately – unlock the potential of bioenergy on a global scale. It also calls for dissemination of this report in global bioenergy networks as a seed for future work for the international bioenergy community.

Executive summary

This work is underlain by broad-based expectations that policy interventions such as EU 2020 goals for renewable energy will continue to drive increased international trade in biomass for energy. This analysis builds upon existing bodies of work that examine international biomass production potential with input from international informants and their networks. This report is the principal output of the Swedish Energy Agency funded project Bioenergiscenarier (Project # 30897).[1]

Approach The work contains both qualitative and quantitative analyses that help identify examples of important actors and institutional structures with potential to influence biomass for energy supplies in the medium term. It documents the outcome of a three stage process: initial scoping work and preliminary analysis was generated in early 2008 and was reported International Energy Agency (IEA) task groups (Tasks 30, 32 and 40) workshops in an IEA side-event at the international bioenergy conference *World Bioenergy 2008* in Jönköping Sweden;[2] a detail analysis was then developed during 2008-9 incorporating workshop input and reflecting key areas noted by that review process; a full draft of the report was then circulated to the project Reference Group (including representatives of the Swedish Energy Agency, and IEA Tasks 40 and 43) during 2010 for additional input and review. This final report incorporates feedback from these international bioenergy actors.

Pursuant to a brief consideration of technical potentials, the study provides theoretical and practical insights into a number of institutional, organisational, economic and cognitive issues relevant to successful growth for both bioenergy trade and the sector in general. At its outset, the work had dual aims: to cast light on (i) whether the global availability of biomass for energy is sufficient to meet demands and (ii) the most important factors that influence the availability of fuel.[3] Subordinate to these, the report had objectives[4] to provide assessments of, or insights, in a number of areas:

1. the nature of production and consumption structures in different regions [1(a)] – and transportation flows in several regions for two/three scenarios [1(b)];
2. competence and resource needs for international bioenergy trade;
3. the nature of synergies and competition with incumbent industries;
4. how demand for biofuels can be driven by political goals;
5. the realism of expectations that biomass-for-energy availability is sufficient to achieve political goals.

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[1] As delineated in the Swedish Energy Agency (SEA) document – Bioenegiscenarier: Beslut programprojekt [Decision programme project]: Dnr 2007-04926 issued by the SEA, energy technology department (2007-12-11).

[2] IEA Bioenergy "T40: How to speed up the process to make it happen" Side event workshop, World Bioenergy 2008; and "T30/32/40: Future European supplies – domestic short rotation crops or free trade?". The first workshop had circa 30 attendees, and the second 50+. A keynote presentation was put forward with initial results of this work: *From Visions and political Statements to substantial Activities Realizing the Potentials of Bio-energy Trade – how much, when and by whom?* Bo Hektor, May 28, 2008.

[3] Derived from §2, p2. Bioenegiscenarier: Beslut programprojekt [Decision programme project].

[4] These points translate and paraphrase the components of the Projektmål [Project objective] as defined on page 4(7) in the Swedish Energy Agency (SEA) document – Bioenegiscenarier: Beslut programprojekt [Decision programme project]: Dnr 2007-04926 issued by the SEA, energy technology department (2007-12-11). It was chosen to deliver outputs against each of these items – as such they have been treated as objectives.

In addressing the work outlined above, the analysis presented here departs with a view that insufficient attention has been paid to how large volumes of biomass for bioenergy may be brought to the market; or where it may be most feasible to mobilise supply chains in the short to medium term. In seeking to add new insights in such areas, this analysis has been guided by the following guiding questions that are intended to reflect the overall aim of the project:

How can we mobilise global bioenergy supply chains?

What are the keys to unlocking the potential of bioenergy?

In the body of the report, a major part of the discussion builds from the output against objective 1(a) above to address objectives 2-5. The discussion develops insights into important "keys to unlocking the potential of bioenergy" in a number of areas. These themes[5] include:

(i) how and where biomass supply chains are developing – and the forms they take;

(ii) where institutional weaknesses are apparent, and the manners in which bioenergy proponents may seek to overcome them;

(iii) how might a professional system serving the bioenergy sector arise and serve global biomass supply chains;

(iv) how policy positively and negatively affects bioenergy development – and where bioenergy proponents can better influence policy;

(v) which potential sources and forms of biomass (bioenergy carriers) appear most interesting or feasible for "acceleration".

The final quantitative section of the report delivers against objective 1(b).

General Structure: The report is structured in six parts: the first introduces the context of the report, the problem, and the intended audience, while the second elaborates on the challenge faced by the sector, then defines a number of theoretical considerations. These address two distinct areas: firstly institutional considerations for emerging industrial sectors and professions, and secondly considerations for sound policy interventions. The third section provides the first substantive analysis section of the work – here viewed from the institutional viewpoint outlined in the previous section. The discussion provides detail of the diversity and heterogeneity of international biofuels trade (e.g. the nature of production and consumption structures) and then provides a number of approaches that can be taken into account when seeking to overcome barriers posed by such diversity. The fourth section shifts from bioenergy flows/structure to examination of important factors that influence how demand for biofuels (and production of such), are driven by policy interventions. Four policy case studies are used to demonstrate pertinent issues. The penultimate section provides a number of quantifications for biomass supply potential. The scenario/projection work encompasses *inter alia*: forecasts for global ethanol supply; estimates of future (unprotected) land suitable for production of selected bioenergy crops; potentials for biomass supply from rain fed lignocellulosic crops on unprotected lands; three scenarios evaluating contrasting potential developments in such areas (with the key variable being human diets); documentation of scenarios for food production residue and by-products availability, and a discussion of forest biomass supply. Section six summarises the report against the key thematic query areas listed above.

[5] Clarification of approaches that can be pursued to achieve such 'keys' can also be considered sub-objectives that relate directly to objectives 1-5.

Observations from the field and theoretical considerations: in order to underpin findings and increase the generalisability of project work, a foundation for the analysis is supplied built in three parts. Firstly, a series of observations drawn from industry circles help define a number of general challenges that constrain the sector and its ability to deliver against policy goals, social expectations and market aspirations. Secondly, a review of institutional considerations documented in management literature provides guidance for analysis work addressing *competence and resource needs for international bioenergy trade*[6] (that meets such goals and aspirations) and a basis for *assessing the nature of synergies and competition*.[7] Thirdly, a basis for better understanding *how demand for biofuels can be driven by political goals*[8] (and thus by policy interventions) is built from a branch of policy assessment theory.

Observed production and consumption structures: In stage I project work and from outputs of IEA workshops[9] that embraced the project it was concluded that international production and trade in biomass was a formational branch with poorly developed norms and institutions. Important observations recorded include that it has:

- different parts, links, chains and sub-chains that have not yet developed sufficiently so as to function together;
- developing chains that do not yet function internally (e.g. technology, finance, socio-economic status and performance, etc.);
- developing chains that do not yet function externally (e.g. information and resource exchange with stakeholders/society; collective action/industry organisations, outreach etc.; legitimacy outreach to garner support, acceptance, provide good citizen role, etc.; mature interaction with policy-sphere, etc.);
- a regionally and trans-nationally heterogeneous nature with significant differences in laws, business/operational culture, morals, ethics and norms, pedo-climatic conditions, calculation models, etc.;
- widely varying degrees of knowledge and capacity (or lack of knowledge/capacity) and often takes the form of a relatively narrow group of industry specialists interacting largely with one another, a challenge that amplifies when knowledge or understanding is required of other links in international biomass trade chains – and when communication is required with the outside world;
- significant degrees of uncertainty regarding goals for trade, possibilities available for trade, and the relevance of varying physical or market factors to such goals and possibilities.

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[6] Reflecting objective 2 and also as a starting point for addressing theme (ii) *where institutional weaknesses are apparent, and the manners in which bioenergy proponents may seek to overcome them* and theme (iii) *how might a professional system serving the bioenergy sector arise and serve global biomass supply chains.*

[7] Reflecting objective 3, and again themes (ii) and (iii).

[8] Reflecting objective 4 and theme (iv) *how policy positively and negatively affects bioenergy development – and where bioenergy proponents can better influence policy.*

[9] The workshops were co-led by project members (Göran Berndes/Bo Hektor) and preliminary work conducted in the project was presented at these workshops. Discussions and feedback were recorded as part of the project. Findings were documented and the ongoing work in the prospective work tasks outlined at the start of the project were aligned with responses received to the preliminary project findings, the content of the workshop, and the plenary session discussions involving key stakeholders.

Moreover, the work found that bioenergy development also face difficulties connected to that strategic investment decisions have to take place in a context of many uncertainties related to:

- market risks, not the least in relation to new technologies that are not yet proven in commercial applications
- political uncertainties, impacting both the investment climate in many countries having good biophysical bioenergy potential, and national/international policy regimes influencing the competitiveness of bioenergy on energy markets
- political capture and market power held by incumbent industries

Emerging industrial sectors: building upon the significant observed evidence of immaturity and institutional difficulty, and in order to support delineation of pathways forward for the sector, theoretical considerations for emerging industrial sectors are summarised from management literature. This analysis argues that few parts of the technological and institutional system for the global trade in bioenergy are mature. Rather, it is held that the technological systems related to some biofuels are formative at this juncture. The discussion then outlines a number of factors typically expected that can constrain the uptake of a new field of industrial activity. These include perceptions of technical, market and economic risk; lack of technical and intellectual capacity; weakness of stimulating and supporting actor networks; inadequate supply chain coordination; and limited customer understanding (both industrial and retail) of technical possibilities. Significant evidence was found that the bioenergy industry and the supply chains that support it constitute such a new field of industrial activity and that both management theory, and experiences from other sectors are relevant. This discussion found that progression of the sector will likely require efforts to enhance:

- convergence of supply chains to (more) standardised forms;
- convergence of product portfolio's, contracts and market dynamics to (more) standardised forms;
- market understanding and acceptance;
- relationship to incumbent industries;
- professionalization of the field (e.g. including items such as the development of professional corps, associations, and formal educational programmes);
- political understanding and acceptance (e.g. evidence of tangible support from politicians and political structures that indicate acceptance and approval of the sector);
- public/stakeholder understanding and acceptance (e.g. evidence of activities becoming 'trusted' or 'taken for granted' by stakeholders in the general public and in markets)

These way these concepts are used in this analysis follows from the logic that if important stakeholders – particularly those controlling fiscal resources,[10] rule-making,[11] or both – accept and place value on a technological endeavour, then it consequently

[10] e.g. here key groups could be financiers or research funders

[11] While a key group is policy-makers, a broad suite of social stakeholders also exert influence.

should have a higher probability of prospering and becoming established in society. Moreover, it is argued that enhancement of such factors is also linked to how 'mature' or 'embedded in society' an industry is. A mature industry may be more self-determining or able to influence its external environment but bioenergy is a relative newcomer – and has limited ability to do so in many contexts.

The form of sound policy interventions: Important to this discussion is that all of the factors listed thus far are affected by, or underlain in some way by the policy framework that enfolds the industry. This discussion argues that inadequate or unstable policy frameworks can contribute to the relative seriousness of such barriers to the progress of bioenergy. Indeed, it is held that they may also encourage reticence or even resistance among those targeted by policy interventions. Similarly, negative market experiences, including those that are the result of unwise investment or flawed strategies on the part of industrial actors, can serve to increase the doubts of those assessing the industry as an investment target.

As such, when evaluating the effectiveness and/or appropriateness of a policy it is important to have a set of policy evaluation criteria. In recognition of the strong environmental undertones of much of the debate surrounding biofuels and bioenergy trade, the implications of large scale biomass harvesting, and related implications of global biomass trade, this discussion applies an environmental policy intervention viewpoint. To delineate the form of 'better' policy, to support policy discussion later in the paper, and to again enhance the generalisability of the work, an assessment framework from Mickwitz (2003) with minor modification to better suit the context of biofuels, bioenergy and bioenergy supply-chains is supplied. It includes 11 assessment parameters grouped across three categories (general, economic, and democracy related).

Challenges for the sector: Utilising the institutional viewpoints outlined for the work, the theme of heterogeneity in biomass supply chains as a significant challenge for the industry is developed. Arguments are posed that building the legitimacy of the industry is a key pathway towards unlocking the potential of bioenergy. A descriptive discussion helps delineate the nature of production and consumption structures[12] and then analysis outlines how focused application of collective action, moves towards a 'meta-standardisation' of the bioenergy concept, the building of professional resources for the industry,[13] and the manner in which *synergies and competition with incumbent industries* are being addressed.[14]

Diversity among bioenergy supply chains: A review of a significant selection of international biofuels chains is utilised to demonstrate both diversity of form and of maturity across the sector. Fuels addressed included: ethanol, value-added solid wood fuels (e.g. 'pellets' and briquettes), agricultural by-products, woodchips, roundwood (logs), foodstuffs industry – by-products, methanol, DME, FT-diesel, and methane/biofuels produced via biomass gasification routes.

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[12] Reflecting Objective 1 and developing theme (i) *how and where biomass supply chains are developing- and the forms they take.*

[13] All reflecting Objective 2, theme (iii) *how might a professional system serving the bioenergy sector arise and serve global biomass supply chains.*

[14] Reflecting Objective 3 and theme (ii) *where institutional weaknesses are apparent, and the manners in which bioenergy proponents may seek to overcome them*; and theme (iii).

The study finds there is extreme variation in structure, underlying logic, and nature of logistics and markets for the large number of different biofuels. General remarks recorded include that:

- while some areas of bioenergy are well established, many others are very new or developmental;
- there are a wide range of cultivation forms, pedo-climatic contexts, and production scales;
- logistics systems for some energy carriers are 'standard' or well developed, other are only emerging;
- end-user markets vary from large scale utilities and international corporations all the way down to domestic-dwelling scale;
- energy carriers sources can be waste streams or dedicated crops – or a combination;
- for some biomass forms, bioenergy utilisation constitutes a new form of competition for material or land, or both – for others, markets are new and relatively competition free;
- a number of bioenergy carriers are subject to significant environmental concerns or sensitivities while others remain (at least for now) largely free of controversy.

This material presents a dilemma that in some cases the very diversity and flexibility associated with 'bioenergy' can also present a significant institutional challenge to the emergent industry. That bioenergy is available nearly everywhere and has many forms and levels of complexity also introduces considerable confusion in the eyes, minds and debates of society.

Key factors for progress of the new industry Arguments are developed that action in four areas will be important. The first addressed was the role of collective action in the form of industry councils, cooperative alliances, trade associations, and the like, in pursuit of effective trust-building and reliability-enhancement. It is proposed that such representatives of the industry must communicate for: public trust and acceptance; to ensure that domestic and industrial consumers trust the 'systemic performance' of the energy carriers they purchase; and the building/maintenance of a 'good reputation' for the industry relative to other industries – particularly in environmental and social spheres. Moreover, that undue discord within the industry over product/service designs and standards may well add to the existing confusion and uncertainty among external stakeholders. It is argued that there is very clearly a role for collective action in reducing such institutional barriers and that the Swedish context provides a leading example. In Sweden, where the bioenergy sector appears to be very soundly grounded, a large group of bioenergy interest groups do appear to be pursuing such strategies. In the context of this report however – with a global supply chain focus – it is proposed that there is much more that can be done.

A second theme addresses the need for some 'implicit agreement on a dominant design and common standards'. It was stressed that while examples at a lower level of complexity, such as quality and performance standards for solid biofuel pellets, or even evolution of supply chains and contract forms into standard forms, may be relatively straightforward, a key issue is much more likely to be about establishing standards for 'the total social and environmental benefit of a fuel in comparison to the fossil alternative' (in practice more likely to be the 'total impact acceptable from the supply chain system'). This is an issue that closely related to efforts towards so-called 'sustainability certification' of biofuels. Indications were found that a broad industry resolution and management of this area is potentially pivotal for the potential of bioenergy being leveraged.

A third area required to support the industry was presented as building of the professionalism of the sector. In addition to skilled professionals and vocational workers, the industry needs to create information regarding the competencies of the new business area and assist in its dissemination. In this light, links to formal education programmes is an important component in defining the language, concepts etc. that other external opinion builders such as the mass media use in their interpretation/representation of the sector.

Finally, the management of relationships with other industries can help maintain the availability of resources and the conditions on which they are available. It is argued that bioenergy production systems and supply chains overlap and interact with other sectors and there are a wide range of potential synergies or conflicts with different industries. Moreover, while this sometimes involves direct competition for important resources or markets, in other cases the 'conflict' may be more obscure. An example developed in this context was the apparently antagonistic stance of some environmentally and socially oriented NGOs. While challenging, experience from other fields suggests that the sector must create reliable relationships with other established groups in order to overcome challenges associated with other actors controlling resources critical to the bioenergy sector.

Institutional implications for mobilisation of global bioenergy supply chains
The insights into institutional factors affecting the bioenergy sector – and thus the mobilisation of its supply chains – that have been presented, also provide guidance for the formulation of strategies towards the generation and sustenance of trust, reliability, reputation and finally, institutional legitimacy. Gaining the trust of stakeholders within and around the sector can provide a basis from which to build a knowledge base both in the industry and society. Moreover, it can provide for cooperative and/or collaborative exchange with other similar organizations. Such interactions in turn make it easier for the sector to organize itself collectively and to build a sound reputation for their industry.

Political interventions in markets The analysis addresses four bioenergy/policy cases where policy regimes or interventions have contributed to greater demand, production, or trade in bioenergy[15] – or alternatively, how they have disrupted such developments.

Australian plantation forestry and wood-biofuel pellets views an intervention that resulted in the rapid mobilisation of a large scale bioenergy supply chain. The events demonstrate how a policy intervention to stimulate forestry investment has underpinned the emergence of a multi-million tonne per year biofuels export industry based on plantation forest harvest waste. The case also describes a number of unintended socio-economic outcomes – some of them undesired.

Ethanol imports to Sweden examines a situation where a range of government incentives for renewable energy transport fuels combined with low tariffs on imported ethanol

[15] Reflecting Objective 4 and developing theme (iv) *how policy positively and negatively affects bioenergy development – and where bioenergy proponents can better influence policy*

stimulated a major trade regime, but then how confidence and trade were disrupted by a number of factors. These are related to both internal industry discord and pressure from external EU actors.

Biofuels quota in Germany addresses a marked policy shift in Germany in 2007, when the newly elected Government significantly altered the tax exemption regimes for liquid biofuels that had constituted the principal driver for the growth of transportation biofuels in Germany. The policy shift, although strongly grounded in economic efficiency arguments, sparked a heated debate within the biofuels community that largely focused on its detrimental impact on the industry (particularly in Germany).

UK Renewables Obligation (RO) assesses a number of facets of the scheme introduced in 2002 to promote renewable energy in the UK. This scheme entered force in an atmosphere of great pressure on the British Government from industry to minimise costs involved in reducing greenhouse gas emissions. Instead of a price-based support, such as the feed-in tariffs in Germany, the UK opted for a quantity-based scheme with 'green' certificates. While the RO scheme was intended to stimulate competition between companies and technologies, and meet targets at the least-cost, several policy flaws were experienced. A series of adjustments to the scheme introduced considerable uncertainty to the market.

The cases present three important (interwoven) common themes for the bioenergy sector. The first is deemed the 'quality' of the policy intervention in its role to support categories of bioenergy technology pathways. An inference being that if the *policy system* has too many flaws then there is higher potential for industry/policy dysfunction. In these cases, negative effects were promoted as the policy frames in place supported systems that: may be outdated or soon outdated by some emerging or potentially disruptive technology system; had limited potential for improvement in comparison to alternatives; that did not offer demonstrable gains in (some) key policy areas (e.g. GHG emissions); or supported goals that themselves may not have long term stakeholder legitimacy (e.g. increased plantings of oil seed crops). The need to make policy that will be legitimate among stakeholders in the longer term is clearly an area that requires work in a number of the cases addressed.

The second point relates to the areas where investments from the side of industry seem to have gone wrong; not just because they were reliant upon the policy for economic viability, but also because, to varying degrees they failed to fulfil the categories of 'technology system quality' defined within the description of 'quality' policy interventions. The inference in this case being that if the *technology system* has too many flaws, then policy support may disappear. Industry must test its systems better in this regard.

The third area relates to the diligence of industrial and political sphere research and intelligence gathering as carried out by industry actors. The cases indicate that industry should have seen some of these problems coming much earlier than they did. The inference in this third point is that the *due diligence processes* undertaken by actors in the bioenergy field were insufficient in the areas of a) assessing the vulnerabilities of their technologies to varying market influences, and b) the vulnerabilities of their businesses to policy shifts

Quantifications – mobilizing biomass Shifting from the qualitative and institutionally focused content, a number of quantifications for biomass supply and/or bioenergy potential are presented. These provide insights to both *potential production structures* and potential biomass *flows from various regions.*[16] These address forecasts for global ethanol supply; estimates of future (unprotected) land suitable for production of selected bioenergy crops; potentials for biomass supply from rain fed lignocellulosic crops on unprotected lands, and forest biomass supply. In addition, three scenarios evaluating contrasting potential developments in such areas (with the key variable being human dietary developments) were developed. These are complemented by documentation of projections for food production residue and by-products availability across several regions. These outputs add to the body of knowledge that can be used to judge the *realism of expectations that biomass-for-energy availability is sufficient to achieve political goals.*[17]

> **Agricultural biomass** A prime focus was placed upon biomass resources judged as 'potentially' available in the short to medium term and based upon residue and waste flows in agriculture and forestry – and the development of dedicated feedstock supply systems from these sectors. The point of departure for the work was that, in the near-term at least, major supply flows will be based on plants that are already cultivated at significant scale.
>
> Projections documented here indicate that there is large potential for new biomass for bioenergy flows to be achieved via 'intensification' and 'efficiency' strategies on agricultural land that is currently producing much less than it could. Importantly, these strategies would <u>not</u> be based upon the simple expansion of plantings to take up 'all land where energy crops theoretically can be produced'. Indeed, it has been argued that plans to follow such strategies, or even discussions of such, have significant potential to defray the legitimacy of sector.[18]
>
> As with most topics addressed in this study, it is again found that there are two important sides biomass/bioenergy supply in the short to medium term. First, there is the securing of the technical production potential for energy purposes. Secondly, there is the need to maintain, or gain the legitimacy of such production in the eyes of critical stakeholders. The promotion of deliberate approaches to ensure supply of biomass from sources more acceptable to key stakeholders will be central to this.
>
> Within agricultural systems, the expansion of recent years has been driven by both investment inflows from new investors and by growth and internally funded expansion in response to increasing demand – and belief in growing market potential. A prime example provided within this category is the Brazilian ethanol sector. While not without critique, there is a broad consensus that this industry can perform well against the criteria that external stakeholders are increasingly demanding for biofuels (such as sustainability criteria). Other agricultural sectors have also shown that they can rapidly expand (e.g. crops such as oil palm, maize, soya bean and rape seed) – however, such energy carriers are markedly more contentious and a broad observation would be that the legitimacy of their application in the energy sector is reducing as time passes, and as scientific knowledge of the environmental and social implications grows.

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[16] Reflecting Objective 1(a) and 1(b) and developing theme (v) *which potential sources and forms of biomass (bioenergy carriers) appear most interesting or feasible for "acceleration".*

[17] Reflecting Objective 5.

[18] Examples of such issues involve cases that encompass where deforestation or conversion of natural grasslands. Nor are 'intensification' and 'efficiency' strategies discussed here based upon simple 'displacement strategies' (e.g. fuel grown in place of food or feed) – again a major issue for legitimacy.

When such viewpoints are taken into account, major constraints that appear likely to grow in strength, or emerge are related to the legitimacy of bioenergy carriers derived from such systems. This links to both discussion of 'certification' schemes taken up in the body of the report, and to expectations that social and political concerns will escalate in the future.

Further, this analysis works from the supposition that factors such as steady upward demand for food and land, combined with more focused and effective technology transfer will drive productivity increases in areas where land is already cultivated, but where the yields derived from it are low or relatively low. It is indicated here that it is realistic to generate projections with faster animal food productivity increases than in other forecasts (e.g. the FAO). As a result, this study reports markedly different results than such projections. Rather than requirements that the global agricultural area expand by some 280 Mha by 2030 in order to meet global needs – thus leaving little room for dedicated energy crops – the contrasting scenarios provided here, show that there is substantial scope for land-minimizing growth of world food supply by efficiency improvements in the food chain. The most marked differences are achieved by change in animal food production, and dietary changes toward less land-demanding food. Indeed, the work presented here indicates that it is feasible to reduce global agricultural requirements by some 230 Mha from current levels over the period to 2030. If this higher productivity is combined with an additional 20% substitution of pig and/or poultry for ruminant meat in human diets, then the agricultural area could decrease by an additional 480 Mha. These figures provide for a total land demand of some 1000 Mha less than that projected by the FAO.

However, this 'freeing up' of nearly a billion hectares of land for energy production will still require degrees of social change. While the scenarios presented here do not require radical change towards widespread vegetarianism (a trend shift that goes against mainstream expectations of dietary trends with development), they do demand shifts such as that from ruminants to pork and poultry, and much more attention to modernisation of agriculture in areas with low productivity (as against viable potential productivity). To achieve such, both social and political effort will be required to achieve both faster changes in land productivity – and shifts to less land demanding food patterns. Such changes do not however, need to rely solely upon choice or norm related issues in human society. Economic drivers are also feasible.

Forest biomass Shifting from the key focus of biomass from agricultural systems to that of forest biomass – while the overall scale of global roundwood production remains modest in comparison to fossil fuel production (e.g. the total EU roundwood production when considered in energy-content terms) is estimated to represent 5% of gross energy consumption), the accelerated pursuit of two strategies are shown to offer considerable additional volume potential. First reduction of felling losses combined with recovery/processing for bioenergy may add significantly to existing potential. Secondly the valorisation of silvicultural fellings for biofuels has significant potential. The latter offers the added bonus of increasing the conduct of the actual thinning activities – often neglected due to the required investment of additional resources – which in turn accelerates forest growth and increases overall forest productivity. As forestry is an established and ongoing industry, the accomplishment of markedly expanded harvest and thinning waste recovery activities should be viewed as a short term strategy of prime importance.

> Moreover, the analysis indicates that plantation forestry systems on low yield or marginal lands (including land in use for grazing etc.) can expand rapidly. These can provide significant thinning, harvest waste and processing streams for bioenergy (as well as roundwood-based fuel in some circumstances). Structural wood and wood fibre recovery systems exist and expansion capacity is considerable – as shown in EU countries with regulatory regimes that require separation and recovery. This is also an avenue that bioenergy collectives should pursue as the industry offers advantageous valorisation of waste material. Moreover, despite the different first-use lifecycles for fibre (e.g. from weeks for some paper fibre to many decades or even centuries for structural timbers) there is no temporal delay in these situations. These materials are in circulation already. In many jurisdictions it is simply the set up of recovery, separation and valorisation systems that is required.

Concluding remarks The report finds that while for some issues, the complexity and dynamism of the field may only allow indications of the directions that might be taken to be provided, for others, concrete recommendations can be made. The final discussion delivers summarising commentary against each of the five 'themes' introduced at the outset of the work. The content of responses to the queries posed below is reflected in the discussion presented throughout this report summary and hence is not reiterated here.

> *How and where are biomass supply chains developing that can serve global bioenergy markets and which forms are they taking?*
>
> *Where are important institutional weaknesses apparent and how might bioenergy proponents seek to overcome them?*
>
> *How might a professional system serving the bioenergy sector and global biomass supply chains arise?*
>
> *How policy affect bioenergy development – and how might policy be influenced?*
>
> *Which potential sources and forms of biomass (bioenergy carriers) appear most interesting or feasible for "acceleration"?*

While more difficult to reconcile with 'short term mobilisation' of biomass, this analysis has pointed out that longer term concerns (particularly technical) should also guide shorter term decision-making. There are already a number of cases where the industry must consider the medium to longer term risks of lock-in when seeking to scale up the sector. The examination of policy cases in this report highlight technical issues that limit system efficiency. These can be result from the nature of the fuels themselves (e.g. first generation biodiesel), or limitations of the systems of production (e.g. carbon intensive crop production systems). To take an example in this regard, the functionality of fuels themselves can place an important constraint when they appear poorly aligned with longer term technology strategies. While products such as soya and palm oil can produce large volumes of oil (and at relatively large per hectare yields in the case of palm), they will largely supply the production of esterified diesel fuels. It appears unlikely that such fuels will fit well with mainstream diesel infrastructure (particularly engines) while 2nd generation biofuels fit significantly better.

Further, while specific parts of the sector may indeed have potential to rapidly expand, issues developed in this discussion such as public expectations indicate that constraints related to acceptance can act in the shorter term. Such issues need to be recognised now and must then factored into longer term technology plans for development of the industry. The potential of certain parts of the sector to mobilise at large scale may not be optimal. A key example being south-east Asian palm oil; while this sector has significant capability to expand to deliver biofuels to markets such as the EU and the US, key legitimacy concerns are very likely to significantly constrain the markets in these jurisdictions – pursuit of this pathway of biofuel delivery has potential to damage the industry in the medium-to-longer term.

While definitive guidance for action in the areas defined as 'keys' lies far beyond the scope of this exploratory study, the discussions in this report repeatedly find common themes that point consistently towards the types of actions required. Efforts towards increased bioenergy-industry professionalism, work towards markedly increased public and political acceptance, aligned and consistent forms of collective action, synergistic alliances with incumbent industries, careful application of third-party assessment schemes, the building of resilient technology strategies, and the sourcing of biomass via pathways that remain accepted in the eyes of a broad stakeholder group, have consistently been found to be important.

This report draws heavily upon management theory and examples to support the analysis. This in turn facilitates demonstration of how such issues are common to other industries that have grown through similar challenges. As such, the bioenergy sector can look to the experiences of others within all of these areas – and learn from the difficulties to be anticipated when they are not addressed adequately. Moreover, this approach allows demonstration that many of the components required for successful progress are indeed developing, albeit that there remains much to be done. It also provides immediate access to a number of rational and relatively proven strategies that can be used for guidance.

This analysis concludes that many of the constraints or 'barriers' being experienced by the sector can be anticipated by examination of ongoing events with the guidance of an extensive suite of management or policy assessment theory and practice. This in turn indicates that guidance is available for action, both in theory, and by building upon the documented experiences of other emerging sectors. However, it is also concluded that more evidence from the field is vital to enrich this work and the value it may offer the sector. The report closes with brief delineation of research work required to better document where, how and when the industry might act to more effectively – and legitimately – unlock the potential of bioenergy on a global scale. It also calls for dissemination of this report in global bioenergy networks as a seed for future work for the international bioenergy community.

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1 Introduction

Bioenergy provides about 10 percent of current global primary energy supply. This corresponds to nearly 50 EJ bioenergy of a total 480 EJ in 2005 (IEA, 2008). At that time, this represented almost 80 percent of the global renewable energy supply. Most of the biomass is used in the residential sector for heating and cooking and is produced locally. Indeed, biomass provides fuel for the cooking needs of approximately 2.4 billion people. Almost all (97 percent) of biofuels utilised are in the form of solid biomass. However, relative to global consumption the share of gaseous and liquid biofuels is small. Notably, growth in demand for liquid fuels in particular has been significant over the last ten years (FAO, 2008; GBEP, n.d.) These figures and proportions can be expected to change significantly in coming years as biofuel utilisation shifts more and more to commercial forms, and liquid and gaseous fuels become more common.

International bioenergy trade is growing rapidly and has far exceeded volumes that were deemed possible only a few years ago (Bradley, Diesenreiter, Wild, & Tromborg, 2009; Bradley, Kranzl, Diesenreiter, & Hess, 2009). Major drivers for international trade flows are the large resource potentials and relatively low production costs of some countries and high demand for biomass in a number of importing countries. In many instances, this high demand is stimulated by significant policy incentives or demands, or both. Importantly, large scale utilisation of bioenergy now encompasses both countries that have large quantities of indigenous biomass and well-established histories of use – <u>and</u> countries that have quite limited supplies and have <u>not</u> traditionally fired biomass in large quantities. This situation requires significant international trade. Trade in turn, requires the establishment of supply chains.

As examples of trade, wood pellets are currently <u>exported</u> in large volumes by countries such as Canada and Finland and <u>imported</u> in large quantities by countries such as Sweden, Belgium, the Netherlands, and the UK. In several European countries such as Belgium, Finland, the Netherlands, Sweden and the UK, imported biomass already forms a significant part of the total biomass use (between 20-50%). Moreover, in biomass deficient countries such as the Netherlands and Belgium, pellet imports already contribute to a major share to total renewable electricity production. Trade in bio-ethanol is another example of a rapidly growing international market. Exports of liquid biofuels from countries such as Brazil to Europe are already significant and are likely to rise (Bradley, Cuypers, & Pelkmans, 2009), especially with stimuli such as the EU-wide Renewable Energy Directive target demanding 5.75% biofuels for transportation by 2010 – and at present still having a policy target of 10% by 2020.

As an example of bioenergy growth – both terms of volumes and international trade – development of the pellets market is shown in Figure 1-1 overleaf.

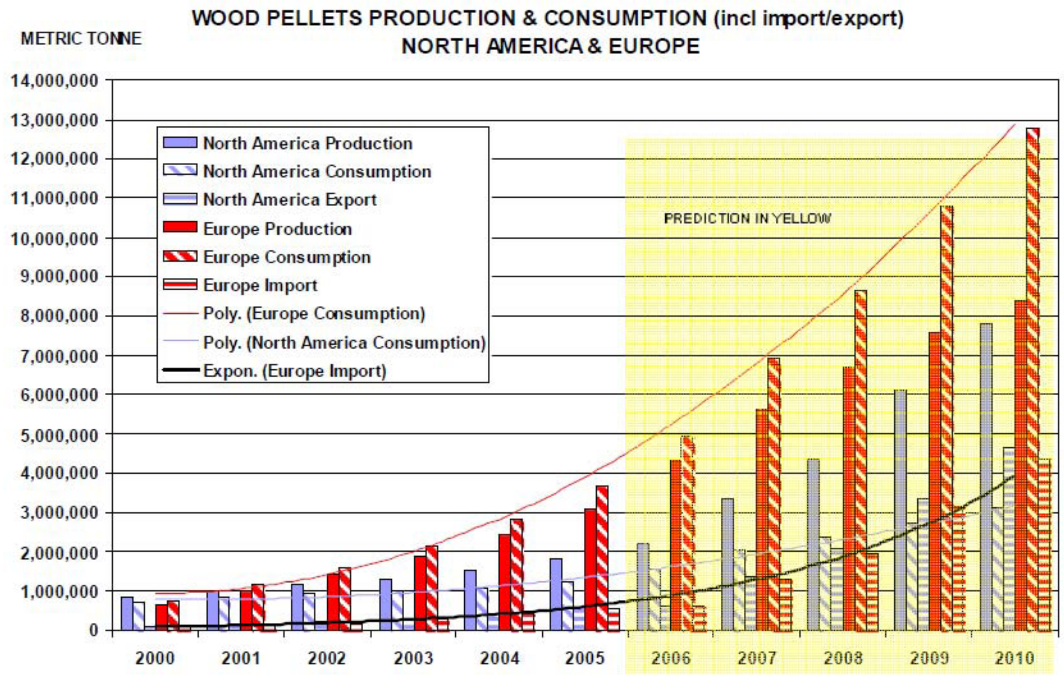

Figure 1-1 Overview of production, domestic consumption and exports of wood pellets in North America and Europe (Junginger, Sikkema, & Faij, 2009)

While growth in the global bioenergy trade has been impressive, it is broadly recognised that significant development of supply chains (i.e. comprising production, harvest, processing, and logistics infrastructure plus market mechanisms for trade) will be needed to transfer larger physical biomass volumes – and to reach a broader suite of end-consumers (not least smaller consumers) (Bradley et al., 2009 e.g. p. 44). At present, the contributions that biomass utilisation can make for greenhouse gas reduction – and towards weaning economies from insecure fossil oil – are nowhere near exploited to their potential.

This report seeks to address in a thematic area that is related to efforts of groups such as the IEA Task 40 (Sustainable International Bioenergy Trade), Task 43 (Biomass Feedstocks for Energy Markets), Task 30 (Short rotation crops for bioenergy systems) and Task 31 (Biomass Production for Energy from Sustainable Forestry) – all of which are to support the development of sustainable, international, bioenergy markets and related biomass production systems while recognizing the diversity in resources and biomass applications.

However, this work also seeks to contribute to areas that have not been given a great deal of attention in the extent body of academic, industrial and intergovernmental work enfolding the industry. This report also applies significant focus to a number of institutional factors related to the relative immaturity of the technological and institutional systems for the global trade in bioenergy and how these can impact the factors such as the refinement of supply and production chains and shaping and regulation of markets.

1.1 Problem definition

There is a general consensus that the development of a stable, international, and sustainable bioenergy market is a long-term process. It requires consideration of many parameters – not least development of relevant institutional frameworks, the processes and impacts of policy-making, the geographical and seasonal availability of biomass; and the dynamics of international trade and transport. Moreover, it must take into account the role of a wide and disparate set of market players, policy-makers, international bodies and other stakeholders such as NGO's. Such work in turn demands the availability of reliable information and analyses, overviews of ongoing developments in the rapidly changing (trade and production) environment, monitoring of the constantly fluxing bioenergy policy environment, and effective linkages between different arenas involved in the debate.

The future scale of biomass supply for energy depends on the relative priority accorded to bioenergy products versus other products that can be obtained from land – notably food and conventional forest products such as sawn timber and paper. Moreover, it is bounded by the total volume of biomass that can be mobilized from agriculture and forestry. Such bounds in turn depend upon natural conditions (climate, soils, topography) and on the agronomic and forestry practices used to produce the biomass and upon their relative dynamics. Importantly they are also inextricably linked to how society understands and prioritizes parameters such as nature conservation and soil/water/biodiversity protection and how biomass production systems are shaped to reflect these priorities, or constrained by them.

Socio-economic restrictions vary around the world, they change as societies develop. These socio-economic conditions also influence bioenergy potential by setting bounds upon how – and how much – biomass can be produced without causing unacceptable socio-economic impacts, or affecting social 'licence to operate', or both. Their dynamics are dependent upon how societies prioritize bioenergy in relation to other social and economic objectives – objectives that may have varying degrees of compatibility with bioenergy.

Studies that have sought to quantify the biomass resource potential have assessed the resource base in various ways. Most have considered the influence of a relatively consistent set of variables (and how these may change in the future): pedo-climatic conditions, socioeconomic factors, the character and development of agriculture and forestry activities, and restrictions connected to nature conservation and soil/water/biodiversity preservation. Notably however, they have come to divergent conclusions (see Table 1.1). This is in part due to them differing in scope – for example, some studies are limited to assessment of a limited suite of biomass categories. However, a major reason for divergence is that studies differ in their approach to making assumptions regarding different determinant factors for the aforementioned variable sets, which are in themselves uncertain. These include different development assumptions for parameters such as population growth; economic conditions; technology development; biodiversity and nature conservation requirements (that are also inherently difficult to assess); climate change; and indeed land use itself, which can strongly influence the biophysical capacity of land.[19] While they may differ widely in their findings for 'potential', the studies do show a general consensus regarding the parameters that can most markedly affect the overall supply potential (i.e. those variables that models are most sensitive to).

Retail and post consumer waste, primary residues from the agricultural and forestry sectors and the by-products of processing agriculture and forestry derived materials are judged to be of prime importance for near-term bioenergy supplies. This is facilitated by the fact that they can often be extracted for energy applications as part of existing waste management and agriculture and forestry operations. Importantly, these bioenergy feedstock sources can also

[19] Underlying most of these parameters and their starting assumptions (and future assumed changes in behaviour) is the 'human' assumptions (i.e., the reason for current activities and peoples capacity/reasons to adjust). For example, much economic study is based on the assumption of 'rational' markets and choices but this is being tested and questioned. Thsu human behaviour is important here.

make a significant contribution to bioenergy supplies in the longer term. This is especially so for a number of countries with large forest industries and significant per-capita forest biomass flows. Such jurisdictions have good prospects for making forest biomass an important part in the domestic energy supply. They may also export forest-derived biofuels to other countries.

Despite the importance of residues, there is clear consensus that dedicated production of bioenergy feedstock will be required if bioenergy is to be one of the major sources of energy in the future. At present, the total global industrial forest biomass flow is only roughly 1/20th of fossil fuel use. Agricultural biomass flows – although larger than the global forest biomass flow – are also rather limited compared to the incumbent energy system. As such, unlocking the global potential of bioenergy requires both realization of near term cost competitive biomass resources – notably residue, by-product, and waste flows – and promotion of growth and development of dedicated biomass production systems.

In most countries, the wood supply infrastructure has yet to develop in response to changing demand patterns, particularly as bioenergy becomes an increasingly important end use. This development concerns not only technology and economics of logistical systems, but also institutions, and regulatory/policy development. Regulations need to reflect the new demands being placed upon these 'environmental' resources and ensure that the increased forest or field biomass extraction rates respect ecological bounds – or so called 'sustainability constraints'. One example is the increased extraction and utilization of harvest residues in forests, including branches, tops and even stumps. There is consensus that such activities require oversight, regulation and compensatory measures to maintain nutrient balances. Moreover, increased forest wood demand in general can be expected to stimulate measures to intensify silvicultural activities – for example, by forest fertilization. Such intensification efforts need to be managed carefully and responsibly.[20]

Similarly, agricultural biomass extraction for energy uses has thus far mainly been based upon conventional food/feed crops that are used as feedstock for 1st generation biofuels, dung for biogas – and in some countries harvest residues (notably straw) that are used for heat and power. Lignocellulosic plants are only produced on significant scale for energy in a few countries so far. To date, most experience comes from the production of fibre plants for non-energy purposes (e.g. pulp wood).

An indicative overview of global biomass resource potential for land-based biomass supply is shown in Table 1-1 overleaf.

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[20] Some hold that IF the bioenergy industry was simply interested in production then 'sustainability' is focussed around continued sustained production (e.g., supply fertiliser to replace and balance nutrients). However if the industry is looking to develop markets that address market failures (as 'externalities') such as climate change then sustainability of production systems becomes much more complicated and onerous in ensuring. Similarly it is increasingly difficult to prove that biomass energy systems are operating in a sustainable way that is simply beyond sustained production.

Table 1-1 Overview of the global biomass resource potential of land-based biomass supply over the long term (indicative numbers: primary energy)

Biomass category	**Comment**	**Global biomass resource potential around mid century (EJ/yr)**
Energy crop production	Large potential requires global development towards very high-yielding agricultural production and full utilization of available areas that can support some form of energy crop production. Zero potential reflects that studies report that food sector development combined with various limitations can be such that no land will be available for energy crop production.	0 – >500
Agricultural residues	Bi-product streams associated with food production and processing, both primary (e.g. cereal straw from harvesting) and secondary residues (e.g. rice husks from rice milling). Sensitive to development of food/feed demand as well as to competition from alternative uses, including soil conservation.	20 – >50
Forest biomass	Bi-product streams associated with forest wood production and processing, both primary (e.g. branches and twigs from logging) and secondary residues (e.g. sawdust, shavings and bark from the wood processing industry). Availability for energy depends on competitiveness of this use compared to other non-energetic uses such as board production. Unexploited forest growth – forest growth on lands estimated as available for wood extraction that is not required for production of conventional forest products such as sawn timber and paper – represents an additional resource. Low-end potential indicates that studies report that demand from other sectors than the energy sector can become larger than the estimated forest supply capacity.	30 – 150
Dung & animal wastes	Generation and availability is highly dependent on the size and character of future livestock production systems. Shifts from grazing to indoor animal production systems can reduce dung generation rates per unit animal product but increase recoverability of the dung for energy.	5 – 50
Organic wastes	Biomass associated with materials use etc. (e.g. waste wood and municipal solid waste)	5 – >50

Note that higher end numbers in assessments often refers to theoretical model based estimates of what could become available given full exploitation of available productive capacity. In reality, many factors prevent this from happening. Sources include: Lysen & van Egmond (2008) Field et al. (2008) van Vuuren et al. (2008) IEA Bioenergy (2009) and Wirsenius et al. (2010).

Importantly in the context of this report is that while many factors are discussed – and underlined as areas of uncertainty in relation to future bioenergy potentials, these studies almost universally focus upon the WHAT – i.e. volumes and the socio-economic factors that affect land use intensity and can shift potential production volumes up and down.[21] For example, existing works commonly call for resolution of methodological and data issues in areas such as:

- the competition for water with other economic sectors;
- human diets and possible protein chains;
- crop yields, agronomic intensity, and different agricultural production systems;
- the demand for wood products and other biomaterials – and related competition;

[21] Note: Changing land use affects the supply of food, it influences the supply of raw materials for other applications, and it also affects climate change (LULUCF concerns).

- the impact of large-scale biomass production on land and food prices;
- impact on biodiversity objectives, and more.

However, we perceive a significant gap in the debate and discussion. There is much less attention upon HOW such volumes may be called for on the market, may be delivered to market, or actually enter the market; or WHERE it may be most feasible to mobilise supply chains in the short to medium term. Explorative modelling needs to be complemented with concrete examples of how things are actually developing in the market place, and recognition of other institutional factors that affect the arising of meaningful volumes of biomass for bioenergy in the short to medium term. An approach is required that focuses on the means to reach "goals" rather than just discussing the hypothetical feasibility of the goals.

1.2 Focus questions

Pursuant to the gap defined in the preceding discussion, this report aims to provide insights into the general question:

How can we mobilise global bioenergy supply chains?

In the first instance, this discussion will <u>not</u> seek to examine such issues of how, why or when revolutionary changes in land use may or may not eventuate. Rather, we focus on the potential mechanics for mobilisation of large volumes of biomass for bioenergy – we use the analogy of 'keys'. As such, the report has the objective to identify:

What are the keys to unlocking the potential of bioenergy?

This discussion seeks to introduce and discuss factors that may more rapidly mobilise large biomass volumes seeking to provide details of some 'key' parameters such as:

- how and where biomass supply chains are developing – and which forms they take;
- where are institutional weaknesses apparent, and how might bioenergy proponents seek to overcome them;
- how might a professional system serving the bioenergy sector arise and how could it serve global biomass supply chains;
- how policy positively and negatively affects bioenergy development – and where and how might policy be influenced by bioenergy proponents;
- which potential sources and forms of biomass (bioenergy carriers) appear most interesting or feasible for "acceleration".

Related to the above parameters, and also of great interest within this discussion, but beyond its scope, are queries such as:

- who are the actors that can deliver bioenergy to prospective markets, and who are the prospective users;
- how can actors and the biomass streams that have the capacity to deliver linked together;
- what are the potential time scales of biomass mobilisation and what pathways to exist to truncate such time scales.

For this report, there is a desire to do more than 'define strategies' for dealing with political intervention and the interference of other industries with the progress of the bioenergy trade. The prime role of this work is intended as a "thought provoker" and a basis for the formulation of more focused study. However, there is also a need to better understand how policies may work better. As such, there is a policy advice component in the remit for this report (not least as this work has been commissioned by the Swedish Energy Agency).

1.3 Target audience and Reference Group

In the first instance this report is intended for the Swedish Energy Agency (Energimyndigheten). It is to serve as a foundation for discussion among senior planners and strategists as they consider the manner in which Sweden and other countries (with which Sweden interacts) may seek to stimulate global bioenergy activities.

Moreover, the report should be directly relevant to practitioners and scientists working in areas similar to that of Task groups within IEA Bioenergy, an organisation within the International Energy Agency (IEA). Specifically, these include Task 40 (Sustainable International Bioenergy Trade - Securing Supply and Demand), Task 43 (Biomass Feedstocks for Energy Markets), and Task 30 (Short Rotation Crops for Bioenergy Systems). Task 40 and Task 43 groups were included in the Reference group for this project and the Draft version of this report was circulated to them for review. Moreover, initial outputs of this project were presented at the International Energy Agency Task group side event at World Bionergy 2008 in Jönköping Sweden. The two workshops IEA Bioenergy "T40: How to speed up the process to make it happen"; and "T30/32/40: Future European supplies – domestic short rotation crops or free trade?" had circa 30 attendees for the former, and the 50+ for the latter.

While this report has direct overlap with much of the work of Task 40 (Sustainable International Bioenergy Trade - Securing Supply and Demand), Task 43 (Biomass Feedstocks for Energy Markets), and that of Task 30 (Short Rotation Crops for Bioenergy Systems); it should also be of direct relevance to those involved in topics such as that addressed by Task 31 (Biomass Production for Energy from Sustainable Forestry).

The reference group[22] applied for this project consisted of a) all members of IEA Task 43 and members of IEA Task 40, Björn Telenius (affiliated with the Swedish Energy Agency) and Åsa Karlsson (Swedish Energy Agency).

As such, the primary end users for this work are policy-makers, researchers and bioenergy planners.

1.4 Scope and Limitations

As indicated, this work is exploratory. It has a role to provoke thought rather than just provide quantifications. While 'scenario quantifications' are included, they are neither definitive nor exhaustively developed. In the first instance, this discussion will not seek to examine such issues of how, why or when revolutionary changes in land use may or may not eventuate. Rather, the work focuses on identifying (or adding detail to) some of the parameters that are important for mobilisation of large volumes of biomass for bioenergy – we use the analogy of 'keys'.

[22] A requirement of the funding body – the Swedish Energy Agency.

Moreover, as so much of the work in this study involves delineation and consideration of institutional factors – a great deal of the content is theoretical and involves drawing parallels from disparate examples from other industries. A good deal of the argument posed would be difficult to verify empirically.

There also remain many areas that could have been included in the scope of this work, but have not been addressed within this study. Some examples, that we find of interest include:

- consideration of indicators of the investment climate in countries suitable for biomass production (e.g. comparative measures of political risk, investment performance, etc.);

- non-policy pathways for influencing large scale land use change (e.g. business models for land-leasing, contract formulation, portfolio management etc.);

- a thorough cataloguing, typology and capacity assessment of bioenergy actors and users;

- a broad suite of case studies drawn from major 'production potential countries'.

1.5 The structure of this report

Having introduced this work, this first chapter is concluded with a general outline of the report.

Chapter 2 describes the point of departure for this work with background to work in professional circles and observations from the field. In the first part, detail is provided to show that the field is immature and that many challenges exist within this condition. Two foundational items are then delineated to underpin the rest of the report. First, theoretical considerations for emerging industrial sectors are drawn from management literature, and then a qualitative policy framework analysis is introduced.

Chapter 3 elaborates on examples from the field and presents a series of challenging areas for biomass/biofuels production and trade and for the bioenergy industry. Five main topics are addressed within two sub-sections: firstly challenges related to diversity are outlined (i.e. the geographical, socio-economic and energy carrier related diversity of biofuels and their supply chains); secondly, key institutional parameters for the industry are outlined. This second section divides issues into; the role of collective action; the need to 'standardise' the 'bioenergy offering' for external stakeholders; the importance of building a profession, and of professionalism for managing difficulties (and opportunities); and the implications of interplay with other industries – and with certain stakeholder groups.

In Chapter 4, we present a number of observations regarding political interventions in markets; then seek to highlight the phenomena discussed with a series of relevant four case studies.

Chapter 5 presents several quantifications for a number of biomass resources that are judged as potentially available in the near to medium term. These include both residue flows in agriculture and forestry and new dedicated feedstock supply systems.

The report is concluded in Chapter 6. This summarises the diverse content of the report and presents key considerations for ways forward.

2 Observations from the field and theoretical considerations

In order to provide context to the reader, (and as a starting point for this discussion), this section presents a number of observations and inferences that we have recorded and developed in our professional work with bioenergy and bioenergy trade over the past decade or so. These points will be revisited, re-examined and tested in different parts of this document.

2.1 Observations from the field

The biomass trade has a number of characteristics. As will be shown later in this introduction, it shares such characteristics with other industries that grow, or have grown.

Based upon our observations, upon extensive participation in the academic and industrial debate, and upon feedback from professional stakeholders upon many of the ideas presented in this chapter,[23] we propose that international production and trade in biomass:

- is a formational branch with poorly developed norms and institutions;
- has many different parts, links, chains and sub-chains that have not yet developed sufficiently so as to function together;
- has developing chains that do not yet function internally (e.g. technology, finance, socio-economic status and performance, etc.);
- has developing chains that do not yet function externally (e.g. information and resource exchange with stakeholders/society; collective action/industry organisations, outreach etc.; legitimacy outreach to garner support, acceptance, provide good citizen role, etc.; mature interaction with policy-sphere, etc.);[24]
- is regionally and trans-nationally heterogeneous with significant differences in laws, business/operational culture, morals, ethics and norms, pedo-climatic conditions, calculation models, etc.;
- exhibits widely varying degrees of knowledge and capacity (or lack of knowledge/capacity) and often takes the form of a relatively narrow group of industry specialists interacting largely with one another, a challenge that amplifies when knowledge or understanding is required of other links in international biomass trade chains – and when communication is required with the outside world;
- is characterised by significant degrees of uncertainty regarding goals for trade, possibilities available for trade, and the relevance of varying physical or market factors to such goals and possibilities.

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[23] As an example: co-authors of this report have presented variants of this material in a number of IEA fora – and to a number of international bioenergy conferences.

[24] An example of one issue that affects both intra-industry financial issues, and inter-industry issues is the very manner in which different bioenergy 'components' assess the viability of investments. In the forestry sector for example, there are different accounting models for a) capital investments in machines etc. and b) for long term forests – these models are difficult to explain to new types of 'renewable energy financiers' – for example. Moreover, each tradition-bound industry has its own language leading to inherent communication difficulties.

Bioenergy development also face difficulties connected to that strategic investment decisions have to take place in a context of many uncertainties related to:

- market risks, not the least in relation to new technologies that are not yet proven in commercial applications
- political uncertainties, impacting both the investment climate in many countries having good biophysical bioenergy potential, and national/international policy regimes influencing the competitiveness of bioenergy on energy markets
- political capture and market power held by incumbent industries

Pursuant to the above proposed challenges, we commence this analysis with a number of postulations that shall be examined within the study:

- separate components or links in international biomass/bioenergy supply chains have not yet emerged organically or simultaneously, nor have they grown in forms that are suitable for joining together in an effective or efficient manner;
- for effective links between stakeholders and geographical areas to grow in international biomass/biofuel trade chains, actors with ownership or accountability over several links must be involved;
- policy as well as market based instruments are required to set rules and regulations that address such cross-chain coverage and accountability in order for international biomass/biofuel trade chains to develop and grow in response to policies induced market demands

2.2 Theoretical considerations for emerging industrial sectors

Factors considered to pose barriers to the uptake of a new field of industrial activity include perceptions of technical, market and economic risk (Robison & Barry, 1987; Sharpe, 1964; Tversky & Kahneman, 1974); lack of technical and intellectual capacity (Barney, 1991; D.J. Teece, 2000, 1996; David J. Teece, Pisano, & Shuen, 1997); weakness of stimulating and supporting actor networks; inadequate supply chain coordination; and limited customer understanding (both industrial and retail) of technical possibilities (Aldrich and Fiol 1994). The bioenergy industry and the supply chains that support it constitute such a new field of industrial activity.[25]

An area of management discourse that can contribute to a clearer strategy for the promotion of international bioenergy production and trade is improved understanding of the so called *institutional environment* that enfolds such trade. This work is strongly influenced and guided by so called 'new institutionalism', which holds that institutions operate in an environment consisting of other institutions. Every institution is influenced by the broader environment (or in simpler terms by types of institutional peer pressure). A major guiding principle for the school is that the main goal of organizations is to survive. In order to do so, they need to do more than succeed economically; they need to establish legitimacy within the world of institutions.

[25] Albeit, it can be argued that it is a cross-adaptation of existing non-related fields (e.g., forest residue; waste utilisation; cereal crop residues; adapted species such as sugar cane and so forth).

In the context of bioenergy, we consider discussions of 'legitimacy' to be particularly important because concessions will continually be required of the industry – in many instances these may lead to less than optimal solutions. An important point for institutionalism and bioenergy is that the world of organizations is heavily influenced by 'institutional isomorphism': organizations adopt business practices not (just) because they are efficient, but because they furnish legitimacy in the eyes of outside stakeholders. In many examples from theory stakeholders such as lenders, government regulators, and shareholders are mentioned. These are equally valid for bioenergy, but we also see other stakeholders for this industry that already have a very significant 'legitimacy-constraining' stake for the bioenergy sector – environmental NGOs and similar interest groups. Among other things, this can mean that the need to make operational or industry-development[26] concessions to maintain the confidence of outside parties (particularly when they are not well informed, or may have a belief based opposition to the industry) can force (or influence) organizations in such a way that they are <u>less creative and innovative</u> in their practices. We should be prepared to note this limitation in the context of bioenergy and expect that technically sub-optimal solutions may be forced upon the industry by the need to maintain legitimacy (DiMaggio & Powell, 1983).

In the light of observations presented in Section 2.1, and in recognition of themes deemed important with institutional analysis, this work will examine a number of aspects of emerging industrial systems associated with bioenergy and with global bioenergy supply chains. As such a number of areas institutional interest includes:

- **convergence** of supply chains to (more) standardised forms;
- **convergence** of product portfolio's, contracts and market dynamics to (more) standardised forms;
- **market** understanding and acceptance;
- **relationship** to incumbent industries;
- **professionalization** of the field (e.g. including items such as the development of professional corps, associations, and formal educational programmes);
- **political** understanding and acceptance (e.g. evidence of tangible support from politicians and political structures that indicate acceptance and approval of the sector);
- **public**/stakeholder understanding and acceptance (e.g. evidence of activities becoming 'trusted' or 'taken for granted' by stakeholders in the general public and in markets)

The next section of this report will provide a summary overview of underlying theoretical considerations that provide justification for the choice of such parameters, and also provide insights into likely phenomena that are influencing the establishment and stabilisation of global production and trade in bioenergy (e.g. supply chains).

Following that, and related to each of the above, certain aspects of risks and the role of risk related costs in the emergence of international bioenergy chains will be considered, in the light of the above aspects.

[26] I.e. in the way the industry is developed, where investments are placed, etc.

2.2.1 Legitimacy and the 'liability of newness'

For this study guidance and structure is drawn from sociological and management fields. A pathway chosen to support the analysis is an exploration of a phenomenon labelled the *'liability of newness'* that encompasses concepts termed *cognitive* and *socio-political legitimacy*. As much as possible, this discussion will seek to use more widely used terms such as 'acceptance' and 'understanding'.

The way these concepts are used in this analysis follows from the logic that if important stakeholders – particularly those controlling fiscal resources,[27] rule-making,[28] or both – accept and place value on a technological endeavour, then it consequently should have a higher probability of prospering and becoming established in society. Moreover, studies that use *cognitive* and *socio-political legitimacy* concepts often relate to how 'mature' or 'embedded in society' an industry is – other terms used can be 'commonplace', 'taken-for-granted'[29] or 'readily identified'. A mature industry may be more self-determining or able to influence its external environment but bioenergy is a relative newcomer – and has limited ability to do so in many contexts. In this discussion, we begin with the relevance of *the liability of newness* for the bioenergy sector.

Literature on technology lifecycles and industrial change identifies three main phases of evolution: a formative phase, an intermediate development phase and a mature industry phase (Williamson 1975). The formative phase is considered to be characterised by uncertainty regarding the design and potential of a new product or technological system, and more rapid entry and exit of firms. By contrast, the intermediate phase can be identified by a refinement of manufacturing techniques and a sharpening of market definitions (Van de Ven and Gerud 1989; Jacobsson and Bergek 2004).

This analysis works from a point of departure that few, if any, parts of the technological and institutional system[30] for the global trade in bioenergy are mature. Rather, it is held that the technological systems related to some biofuels are formative at this juncture (e.g. lignocellulosic ethanol, hydrogenated biodiesels, some new forms of pellets from agricultural waste, and so forth) while some bioenergy carriers are in the intermediate phase (e.g. wood pellets, woodchips, Brazilian/U.S. bioethanol, rape methyl ester, Malaysian palm-oil for biodiesel or direct firing, etc.). In general, it appears reasonable to judge that supply chains that have reached 'intermediate' status are essentially limited to wood fuels from established forestry industries. Despite their widespread nature in agriculture, the production systems used for 1st generation liquid biofuels would not be deemed intermediate by many stakeholders as their entire ecological performance is currently under question. For second generation biofuel systems this work assumes that they are generally located within what Bergek et al. (2008, p581) have termed "the earliest stage of the formative phase". Here the technologies have not yet passed from research and demonstration to product commercialisation; actors in this early

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27 e.g. here key groups could be financiers or research funders

28 e.g. a key group is policy-makers but as will be explained, a broad suite of stakeholders can influence this.

29 For example: behavior that follows this pattern is described so that instead of acting under rules or based on obligation, individuals act because of conceptions. 'Compliance occurs in many circumstances because other types of behavior are inconceivable; routines are followed because they are taken for granted as 'the way we do these things' (Scott 2001, p. 57). In a bioenergy context, this might mean that a decision to fire a large scale industrial boiler with biomass is simply made on a cost basis comparison against other fuel sources – all perception related risk barriers having dissipated as the technology becomes *'entirely main-stream'*; alternatively, that a bioenergy solution is looked for as a first option – *"because one simply 'goes renewable' when one can as that is the 'thing to do'"*; and so forth.

30 This term is used inclusively; this can address technologies, the technological system that surrounds the fuels, the processes required for their trade and the required infrastructure to support the trade, and so forth.

stage strive to gain legitimacy by getting the technology accepted as a "desirable and realistic alternative to incumbent substitutes", such as the relevant offerings of the oil and gas industries, or actors involved with 1st generation biofuels.

In this context, it is noted that establishment of 1st generation biofuels is held by many to have paved the way for 2nd generation biofuels by contributing to the development of technical infrastructure, rules and standards, but has also created significant challenges for actors involved with 2nd generation biofuels. The developers of the 2nd generation biofuel industry now need to convince industry, policymakers and the public at large that 2nd generation biofuels can meet transport sector demands while avoiding the negative effects that – deserved or not – have been attributed to the rapid growth of 1st generations biofuels. Areas of immediate challenge are taken up in the 'food versus fuel' debate[31] (e.g. food price impacts), and a wide debate of various negative environmental effects (e.g. deforestation, biodiversity threat, water demand, and more).

While this discussion does touch upon biofuels and technologies in the formative phase, the key focus of this analysis remains upon the rapid mobilisation of large scale bioenergy supply chains. As such, this discussion is more related to those biofuels that can be produced, traded and used in the short to medium term. As such, the focus is generally on parts of the industry in the intermediate phase or moving from the formative to the intermediate.

Also relevant to the context of this discussion is that 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 several decades and Geels reports that the first major commercial market for steam ships took almost 50 years to be realised (Geels, 2002). These authors relate that time frames of this length are not unusual and often the investment required during the formative period can be substantial, accruing little or no return. Already at this point, readers in regular contact with bioenergy and bioenergy trade issues should recognise the content of a number of the debates and discussions that recur in bioenergy, biomaterial and biofuels circles. Aldrich and Fiol (1994) propose that some portion of this formative period reflects the struggles of new business ventures to develop cognitive and socio-political legitimacy. In the field of technological innovation systems (TIS) research, legitimation is seen as a prerequisite for the emergence of new industries and innovation systems; variously influencing the research directions of other firms, creating markets and shaping political institutions (Anna Bergek, Staffan Jacobsson, & Sandén, 2008, p. 581 & 588)

Taking a related but slightly different line, analysts examining the ecological theory of organisational evolution (Baum & Jitendra V. Singh, 1994; Hannan & Carrol, 1992; Reuf & Aldrich, 2006), argue that during the formative period, new industrial sectors or concepts often lack 'legitimacy'. Legitimacy is conferred by stakeholders that are in agreement that the activity is 'desirable, proper or appropriate' – something that is often discussed as 'social taken-for-granted-ness'. In simple terms for this discussion, an example of this might be that increasing food commodity prices – within limits – may need to be accepted as an unavoidable effect of increasing energy demand within the new food-climate-energy paradigm (n.b. this is a view that is not yet widely accepted!).

The absence of, or a low degree of legitimacy, implies that the task of establishing the new business venture may be rather difficult; providers of capital can be suspicious; suppliers and

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[31] A paper from DEFRA - http://www.defra.gov.uk/foodfarm/food/pdf/ag-price-annex%205.pdf also addresses this question in a useful fashion.

customers may well need education to simply understand the technological development and unsympathetic government regulations might require transformation (S. Jacobsson & A. Bergek, 2004). A general theme is that the enhancement of legitimacy early in the evolution of an innovative business concept can reduce the duration and difficulties of this formative phase. For this discussion, this in turn implies that deliberate strategies to enhance legitimacy of various biofuel and bioenergy trade regimes can, or should be pursued.

Analysts in this area also hold that new business areas have a higher propensity to fail because of this 'liability of newness'. Therefore a greater risk of mortality experienced by businesses in a new industry such as bioenergy (innovative entrepreneurs) is held to be related to a relative lack of cognitive and socio-political legitimacy in the formative period (Aldrich & Fiol, 1994; J. V. Singh, Tucker, & House, 1986).

There have clearly been cases of 'mortality' in the bioenergy sector. A recent example is Swedish-based SEKAB International AB (SEKAB). Apart from financial difficulties, the company also was subject to strong critique (from both stakeholders and shareholders) of its sugarcane ethanol activities in Africa. As part of the fall-out of this, SEKAB and EcoDevelopment in Europe AB (EcoDevelopment) entered into an agreement in October 2009, whereby EcoDevelopment took over 100% of shares in SEKAB's two subsidiaries SEKAB Bioenergy Tanzania Ltd and Ecoenergia Moçambique. The transfer of ownership was granted at a nominal price (practically at no cost - SEK 400).

Some other companies have managed to stay in the business despite strong critique, one example being Neste Oil. Neste was widely criticized for the selection of palm oil as a key source of vegetable oil for its NExBTL plants.[32] Neste is a member of the Roundtable for Sustainable Palm Oil (RSPO) that gathered palm oil producers, users and critical environmental NGOs to develop sustainability criteria and certification. Despite the strong public debate about the often negative socio-economic and environmental consequences of the production chains for palm oil and other related 1st generation biofuels, little of the certified palm oil that has been produced so far has been sold. Low demand from buyers – in the case of palm oil also including supermarkets, food and cosmetic manufacturers – indicates either that users do not consider the certification systems in their present state as sufficient to guarantee legitimacy, or that they expect to gain legitimacy based on other means.

Also an inability to progress fast enough to deliver on items such as political goals rapidly enough to satisfy some stakeholder expectations could be indicative of 'failure' to some. The 10% share of biofuels in the vehicle fuel mix agreed within the European energy policy of 2007 (EC, 2007a) is an example of a high level target that is highly dependent upon the successful growth of this sector – also an example of one that has caused much controversy for other legitimacy related reasons (e.g. related to evidence that it has stimulated a range of environmental problems such as new forest clearing in order to meet market demand for oil seed crops, etc.) This may be a target that is not met, in part at least due to slow bioenergy and bioenergy trade implementation.

[32] NExBTL is a renewable diesel production process commercialized by the Finnish oil and refining company Neste Oil. Unlike transesterified biodiesels, NExBTL is able to supplement or partially replace diesel fuel and unblended NExBTL meets the requirements set by the international standard DIN EN 590. The diesel is produced in a patented vegetable oil refining process that entails direct catalytic hydrogenation of plant oil, which is triglyceride, into the corresponding alkane. The glycerol chain of the triglyceride is hydrogenated to the corresponding C3 alkane, propane without the generation of a glycerol side-stream.The diesel is not an oxygenate like traditional transesterised biodiesel as the process removes oxygen from the oil. Unlike the yellow transesterified biodiesel, the product is clear and colourless paraffin, with a good cetane number (85 to 99) and better properties than even petroleum oil derived diesel. As it is chemically identical to ideal conventional diesel, it requires no modification or special precautions for the engine.

The motivation for using a framework linking cognitive and socio-political legitimacy to the creation of new industries is the desire within this work to propose pathways that can be taken to positively impact the building of global bioenergy supply chains (i.e. as an important part of the bioenergy sector). Analysts that have applied such approaches seek to suggest strategies by which innovative entrepreneurs can enhance inter and intra-industry linkages in order to help overcome legitimacy obstacles and enhance chances of success [refer also to (Deeds, Mang, & Frandsen, 2004; Katila, 2009; Shepherd & Zacharakis, 2003).

2.2.2 Important differences between acceptance and understanding

As was noted at the start of the previous section, to relate these concepts to the topic of this report (albeit in simplified form) for this discussion we shall represent them with the notions of *acceptance* and *understanding*.

Acceptance – *Socio-political* legitimacy[33] may evidence itself via phenomena such as the public acceptance of an industry, government subsidies to the industry, or the public prestige of its leaders (Aldrich and Fiol 1994) – a number of these topics were touched upon in our introduction in relation to the bioenergy industry and also regarding biofuels trade. In the context of policy-sphere actors (some of whom may be involved in creation of policies important to bioenergy industry) it seems logical that public approval for an industry that has been championed and supported by government (as it has in Sweden for example) also has the potential to transfer prestige on the political leaders. Thus a theme within this discussion is that the acceptance of bioenergy and large scale bioenergy trade activities by the public, and by public opinion-formers, constitutes a driver for policy-sphere activity.

Understanding – while also paramount to the survival of new areas of business, *cognitive legitimacy*[34] is related more to *knowledge* and *understanding* as a prerequisite for the acceptance described above. Without widespread knowledge of their activities and long-term consequences of their industry, proponents of new technologies or businesses may face difficulties obtaining the approval of cautious government agencies, of financiers, or customers (Aldrich & Fiol, 1994; DiMaggio & Powell, 1983). In simpler terms, important market stakeholders are more likely to support offerings that they perceive that they understand and for which they can readily find trustworthy information.

Table 2-1 below provides a conceptual framework that organises a larger suite of components for *cognitive* and *socio-political* legitimacy into strategies held (for this analysis) to be relevant to the context of in the business area of bioenergy and biofuels trade (after (Aldrich & Fiol, 1994). It indicates different modes in which proponents of a new industry may seek to: enhance cognitive and socio-political legitimacy at different levels (organisational, intra and inter-industry, and institutional). These items are examined in much more detail in later sections of this report (i.e. Sections 3.2 and 3.3).

[33] For this discussion, this can generally be approximated to 'social and political acceptance and approval'

[34] For this discussion, this can generally be approximated to 'understanding related to understanding and comfort'.

Table 2-1 Potential proponent strategies to promote new industry development via enhancement of legitimacy [after (Aldrich and Fiol 1994)]

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

Table 2-2 below has been populated with phenomena that are held to contribute to the achievement of legitimacy (if and when achieved) in column 1; and examples of how these may evidence themselves in the field of practice. These indicators derive from the wider body of scientific work surrounding new business ventures and organisations and their social or political legitimacy as defined above.

Table 2-2 Evidence of efforts to influence and enhance the legitimacy of new industries

Phenomenon of interest	*Examples of evidence for progress or problems in practice*
Commitment of high level politicians	.. political spheres driving intervention and providing commitments that support advanced bioenergy and biomaterial systems (Rosenau 1999).
Third party evidence of reliability	.. how processes for providing external evidence of reliability (e.g. from objective 3rd parties) might be emerging or be seen as being needed (Hawthorn, 1988)
Alignment of 'bioenergy' with established and understood systems	.. whether or how issues are communicated in simplified and/or inclusive forms, and whether (and how) well established systems (e.g. petrochemical refineries) are used as analogies (Aldrich & Fiol, 1994; Hawthorn, 1988)
Concealment of complexity and contradictions in communication	.. indications that proponents of the new system seek to explain their complex ideas without having to refer to explicit external criteria, and thus enable effective communication to the wider public (Fisher, 1985)
Establishment and convergence of standards and designs	.. competing design concepts, conflicting standards and so forth – or of emerging convergence[35] as an attempt to prevent recurring failures (Aldrich & Fiol, 1994; DiMaggio & Powell, 1983)
Synergistic or antagonistic inter-industry relationships with established actors	.. the nature of inter-industry relations and how they affect the potential for progress for a new system (Aldrich & Fiol, 1994; M. B. Meznar & D. Nigh, 1995; Stinchcombe, 1968)
Intra-industry relationships and trade association development	.. the nature of intra-industry relations, and the development of trade associations etc., and how these affect the potential for progress for innovative systems (Aldrich & Fiol, 1994; Van de Ven & Gerud, 1989)
Institutionalisation of information dissemination	.. engagement in educational activities and other institutionalised forms of information dissemination and capacity building (Aldrich & Fiol, 1994; Hannan & Freeman, 1984)

As such, eight potential phenomena are listed where factors that influence and enhance the legitimacy of innovative business concepts might be pursued. These underpin the content of

[35] For example, harmonization of definitions and standards to facilitate international biomass/biofuel trade.

this report.

We anticipate (and as we report in coming sections we observe) that these phenomena are currently occurring within the bioenergy and bioenergy trade field and all have the potential to affect to some degree on understanding, acceptance and support for the bioenergy and bioenergy trade. Thus by extension, this work will seek to contribute to development of strategies to achieve more rapid mobilisation of large volumes of biomass/biofuel by identification of areas where work is required in such areas.

2.3 Theoretical considerations for sound policy interventions

Important to this discussion is that all of the factors listed thus far are affected by, or underlain in some way by the policy framework that enfolds the industry. Inadequate or unstable policy frameworks can contribute to the relative seriousness of such barriers to the progress of bioenergy (Aldrich & Fiol, 1994). Indeed, they may also encourage reticence or even resistance among those targeted by policy interventions (Oliver, 1991). Similarly, negative market experiences, including those that are the result of unwise investment or flawed strategies on the part of industrial actors, can serve to increase the doubts of those assessing the industry as an investment target.

In most discussions one factor of importance, the economic situation, is repeatedly held to be paramount (e.g. the profitability of an investment). It is our experience that sustained higher oil prices and transitional policy support for the bioenergy sector have often been heralded as sufficient stimulus for investment. In recent years, the high price of oil and the policy measures that have been enacted in some countries in Europe do appear to have created economic conditions that should be sufficient for a significant increase in bioenergy use.

However, industrialists and investors expected to be at the centre of growth in the sector apparently perceive the situation less optimistically. National policies that aim to expand bioenergy (and thus help underwrite industry investment in bioenergy) are frequently described as uncertain.

Moreover, on a number of occasions, inexperienced industry and/or finance sector actors have invested unwisely within reigning economic and policy support regimes. In addition to the damage to their own ventures, such negative experiences also can apparently lead to both damaged industry reputation and heightened risk related barriers to investment. As such, it appears that risk-averse behaviour from the side of industry and/or the financial sector can be reinforced by a range of factors. Both policy-makers and bioenergy actors may be contributing to negative feedback loops.

This section investigates examples of policy interventions where unintended outcomes (both positive and negative), apparent mismatches and miscommunication have arisen from the interplay between national policy interventions, industrial bioenergy activities, and biomass supply chains. Prior to introduction of cases however, we provide a framework for qualitative analysis of policy interventions to support argumentation and to facilitate cross-case comparison.

2.3.1 A policy framework analysis

There is a relatively broad portfolio of policy instruments that seek to drive technical and behavioural change towards increased biomass production and utilisation in areas such as energy and green chemistry (EC, 2007b). As such, when evaluating the effectiveness and/or appropriateness of a policy it is important to have a set of policy evaluation criteria – if for no other reason than to maintain consistency. Here we seek to rationalise some difficulties experienced in bioenergy sector as it is related to the effect of policy interventions.

A number of frameworks exist for comparing the relative merits and performance of different policy interventions (Kahneman & Sugden, 2005; Mickwitz, 2003; OECD, 1997). However, in recognition of the strong environmental undertones of much of the debate surrounding biofuels and bioenergy trade, the implications of large scale biomass harvesting, and related implications of global biomass trade, this discussion applies an environmental policy intervention viewpoint. Here we have sought to apply one of these assessment frameworks (Mickwitz 2003) with minor modification to better suit the context of biofuel, bioenergy and bioenergy supply-chain interventions. General criteria included in this framework are included in Table 1-3. They include 11 assessment parameters grouped across three categories (general, economic, and democracy related).

Table 2-3 Criteria for the evaluation of policy instruments (after Mickwitz 2003)

	Criteria	**Related questions for assessment**
General criteria	Environmental & goal effectiveness	To what degree do the achieved outcomes correspond to the intended goals of the policy instrument?
	Enforceability	Can the policy be enforced with the available human and financial resources of the governmental regulator and/or other enforcement agents?
	Appropriateness	Do the implementing businesses or operations have the human, knowledge-based and financial resources to respond to the intervention in the manner anticipated?
	Persistence	Are the effects persistent in such a way that they have a lasting effect on the state of the environment (or market)? Does the policy provide incentives for long-run improvements and technological change?
	Flexibility	Can the policy instrument cope with changing conditions?
	Predictability	Is it possible to foresee the administration, outputs and outcomes of the policy instrument? Is it thus possible for those regulated, as well as others, to prepare and take into account the policy instrument and its implications?
Economic criteria	Economic efficiency	Are the benefits worth the costs? Both benefits and costs are valued in monetary terms.
	Cost-effectiveness	Do the results justify the resources used? Could the same results have been achieved with fewer resources or could the same resources be used more effectively to achieve a better result?
Democracy related criteria	Legitimacy	To what degree do individuals and organizations, such as non-governmental organizations (NGOs), interest organizations and firms accept the socioeconomically and environmentally related policy interventions?
	Transparency	To what degree are the outputs, outcomes of the socioeconomic/environmental policy instrument, as well as the processes used in the implementation observable for outsiders?
	Equity	How are the outcomes and costs of the socioeconomic/environmental policy instrument distributed? Do all participants have equal opportunities to take part in and influence the processes used by the administration?

A practical definition of the task of evaluating environmental policies is given in the EU 6th Environmental Action Program (European Parliament and the Council of the European Union (2002) 2002). Here, the objectives are formulated as "improvement of the process of policy making through:

ex ante evaluations of the possible impacts, in particular the environmental impacts, of new policies including the alternative of no action and the proposal for legislation and publication of the results;

ex post evaluation of the effectiveness of existing measures in meeting their environmental objectives."

Mickwitz (Mickwitz 2003) holds that no evaluation can resolve all these uncertainties and unambiguously determine to what degree the observed development is due to the evaluated policy instruments. Rather, this work will seek to advance the discussion by bringing forward new aspects and explanations of observed outcomes in the area of global bioenergy supply chains.

3 Challenging areas for the Bioenergy Sector

Examination of the formative period of new areas of business 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" (Aldrich & Fiol 1994).

Lack of institutional support for the dissemination of information about a new business concept may also handicap the efforts of the proponents of new business areas in securing socio-political approval (Aldrich & Fiol, 1994; Carrol & Delacroix, 1982). Such analysts 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. Developments can even reach the point of government agencies displaying considerable resistance to the new activity.

Relating this to a bioenergy context, Jacobsson and Bergek (2004)argue that in Germany 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 lead to a Parliamentary Resolution calling for more R&D in the area of renewable energy technologies. In contrast their work also provides an example of how at the same time the so-called Swedish 'nuclear power trauma' highlighted the failure of the renewable energy sector to achieve trust and hence socio-political legitimacy. It was not perceived by the broader public as being a viable substitute for nuclear power. They argue that this led to a poor market development in the 1980s.

However, the renewable energy market – led by the bioenergy industry – has now been widely and strongly established within Sweden (Erik, 2006). By 2005, the share of renewable energy in primary energy consumption in Sweden was approximately 30% (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 and the vital importance of biofuels "… in which we have freed ourselves from the dependence of oil" (World Bioenergy, 2006). Further on this theme, this bioenergy conference in Sweden enjoys royal patronage and it is now customary that the Swedish King and top level politicians (e.g. the Prime Minister or his deputy) open these events.

However, the respected and accepted standing of the Swedish bioenergy sector is not common to the bioenergy industry around the globe. As following discussion will outline, it is young, volatile, and in a number of areas insecure, in many parts of the world. As such, it has not yet become legitimate. The development of such institutional aspects is central to the topic of this report – the mobilisation of global bioenergy supply chains.

As has been alluded to above, an important part of institutionalism in Sweden has been the involvement of government, and government agencies in the building of industry. As an example in this vein, Shan et al. (1991) demonstrated how this type of legitimacy was important to speeding the slow development of the US 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 Federal Drug Agency

(FDA), the Environmental Protection Agency, and other government institutions, resulting in the first FDA approved diagnostic kit for an important biotech product. Shan et al. (1991) argue that these moves significantly raised the founding rate of biotech firms in the years that followed. Van de Ven and Gerud (1989) also emphasise 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 difficulties related to such, innovative entrepreneurs must transact and form alliances with government agencies (Aldrich & Fiol, 1994; DiMaggio & Powell, 1983). As shall be presented later in this report, some parts of the bioenergy sector are extremely complex (e.g. some in their technological complexity, some in the complexity of their interaction with society or the environment, or both).

This chapter provides detail and content in areas related to building the legitimacy of the industry as a key pathway towards unlocking the potential of bioenergy. In section 3.1 the theme of heterogeneity in biomass supply chains is introduced as a challenge for the industry. In section 3.2, four specific areas where the heterogeneity problem (and a range of related issues) is being dealt with in some way are discussed. These include the role of collective action, moves towards a 'meta-standardisation' of the bioenergy concept, the building of professional resources for the industry, and the manner in which synergistic or antagonistic relationships with incumbent industries are being addressed.

3.1 Challenges of diversity – International bioenergy systems and supply chains

One of the key strengths of bioenergy when it is considered as an important component of the future global energy mix is its diversity. Diversity expresses itself in a number of ways: there is the widespread global availability of biomass; the relative interchangeability of many biomass types as fuels sources (e.g. pellets from a multitude of sourced materials); bioenergy carriers are available as solid, liquid and gaseous fuels; there are functional fuels delivered by relatively simple and traditional processes (e.g. 1st generation liquid biofuels), and there are highly technical and advanced systems emerging to produce fuels (e.g. 2nd generation fuels) that match the performance of existing fossil-based systems; there are fuels for local use, and there are fuels that can provide for large-scale export industries.[36]

Further, and has been described earlier in this report, bioenergy systems also fit within a diverse group of other anthropogenic and natural production systems: they can be based upon waste and by-product streams (e.g. agriculture, forestry, municipal waste, industrial waste, etc.), or they can be specifically produced as a main product from agricultural or forestry systems. Supply chains take many forms and can also deliver diverse ancillary benefits. These can include environmental services such as carbon sequestration, biodiversity enhancement, water filtration, and more. They can also deliver social benefits such as employment opportunities, economic diversification, and rural development. Contrasting these positive points; bioenergy supply and utilisation systems can also result in environmental and social problems – thus in simple terms one might state that there are 'good bioenergies', 'okay bioenergies', and even 'bad bioenergies'[37] – all dependent upon the specific context of their

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[36] This diversity continues in cultivation forms, supply structures, processes for value adding, differing technologies and plant morphologies, varied logistical infrastructure, (boats, trains, harbours, etc.), varying contract forms and end user markets, different combustion technologies, differing quality standards, and so forth ad so on.

[37] ENDS Europe reported that the "UNEP sustainability panel highlights dirty biofuels" – Indicating that the production and use of biodiesel from palm oil on deforested peatlands in tropical regions can generate up to 2000% more greenhouse gas emissions than fossil fuels, according to a study published by a UN sustainability expert panel on Friday.

production. Many of these bioenergy carriers have partial or substantial overlap in markets and may compete with each other – as do the sectors, or industries that produce them. Moreover, unlike many other types of renewable energy types, many bioenergy carriers offer flexibility in time and space as they can be transported and stored.

Somewhat counter-intuitively perhaps, the very diversity and flexibility associated with 'bioenergy' also presents a significant challenge to the emergent industry. In the simplest of terms, one can pose the query – *What really is bioenergy?* That bioenergy is available nearly everywhere and has many forms and levels of complexity introduces considerable confusion in the eyes, minds and debates of society.

The following sub-sections present a number of different bioenergy supply chains – along with key components and a number of inconsistencies. These shall also underpin later discussion focused upon the importance of a clear 'picture or recognition of what bioenergy is or may be'; the emergence of a strong base for collective action, and what the role of industry associations may be; the role of professional corps in the bioenergy sector and the role that they have to play in mobilising global supply chains.

3.1.1 Ethanol

- Cultivation has different forms: sugarcane, maize, cassava, grapes, etc.
- Structure and scale varies widely: small-holder farmers, agricultural estates, industrial scale agriculture/collectives, lease farming, etc.
- Comprises an important component of local/regional or national agricultural sector.
- An industrial process that is well established, (generally) large scale, professional. Often integrated with the production of other foodstuffs.
- Technologies, techniques and infrastructure for distribution, storage, shipping, etc. are (generally) established.
- Typical contract forms are between sellers in the form of cooperatives, and buyers in the form of agents or distributors.[38]
- End-users within the fuel sector. In this sector there are many large multinationals/alternatively mega-corporations with (so far) minimal expressed interest in upstream integration other than engagement with the establishment of monitoring/verification procedures for meeting standards/sustainability certification requirements.

3.1.2 Value-added solid wood fuels (e.g. 'pellets' and briquettes)

- Cultivation expressly for pellets/briquettes manufacture is limited.
- Raw material has traditionally been sourced from cheap excess or waste streams such as by-products from sawmills. In the future, it shall be more commonly derived directly from lignocellulosic plants, and in increasing quantities from other sources such as agricultural by-products (e.g. straw from cereal or oilseed crops).
- Production often integrated with sawmills – but these have largely varying capacities. Large scale producers are of most interest for international trade.

[38] N.b. there are also contracts between feedstock producers and ethanol

- Pellets producers are typically small or medium sized independent companies.
- Raw material costs are a significant portion of the total production cost. Investment in excess production capacity has (often) led to escalation in raw material prices.
- Scale economies are attractive for logistics, storage and shipping.
- End use is in two distinctly separate markets segments:
  - Large-scale combustion
    - Heating plants and/or combined heat and power plants in a growing number of industries.
    - Coal based power plants employing biomass co-firing with coal.
    - Large well established public sector companies, e.g., owners of district heating systems.
    - In this sector, the market is characterised by –
      - Fuel switching that has a number of drivers: economic factors, quotas, social contracts, etc.
      - Direct contract formulation between the consumer and the fuel producer is common. Large plants also purchase from pellets distributors/agents.
  - Medium – and small scale combustion –
    - Single-family dwellings, small domestic apartment blocks, schools, small public buildings etc.
    - In this sector the market is characterised by –
      - Direct cost related competition with other fuels and heating systems.
      - Contracts with distributors.
      - Distributors often purchase directly from the fuel producer.
      - Demand is highly weather dependent (variations of +/- 30% on a yearly basis).

3.1.3 Agricultural by-products

- Require processing prior to medium-long distance transport (compare to pellets above).
- Can be technically challenging to fire/combust.
- Buyers usually found among large scale users.
- Small scale users are increasingly common and often include farms using e.g., own straw for meeting their own or nearby heating needs.

3.1.4 Woodchips

- The majority of woodchip trade is local/local.
- Logistics face a series of challenges – such as storage problems, material loss, health risks (e.g. related to moulds and fungi), and fire risks (e.g. spontaneous combustion).
- International trade exists with chips from storm felled trees (USA, Southern Europe) and salvaged dry timber.

- Distribution structures vary and many are *ad hoc*, include agents and direct contacts.
- Environmental and sustainable cultivation questions are important.
- Fired in specially designed chip boilers, etc. and in larger coal fired plants using fluidized bed boilers, pulverized coal fired or grate-fired boilers.
- Large well established public utilities in the purchaser chain (n.b. these are often owned by private companies but traditionally have strong links to the public sector as customers for heat, or heat and power).
- There is doubt if system economics will move towards chips as a fuel choice for long distance international trade. New pre-treatment options such as torrefaction may provide alternative solid biofuel options.

3.1.5 Roundwood (logs)

- International trade already takes place at relatively large scale within the pulp and sawn-timber (milling) industries.
- Immediate potential for application within bioenergy.
- Well developed, if somewhat impractical technological systems for logistics including shipping.
- Can be expected to be based upon energy plantations in the first instance.
- Political, social and land use questions related to biomass/biofuel options based on plantations will influence such trade and need to be addressed.
- Plantations should (probably) be designed so that they support roundwood trade, cost effective silviculture, high timber density, straight logs, and low contents of ash and chemical residues.
- Buyers within the large-scale sector, large well established (public) companies, potentially methanol and ethanol producers and possibly established within the forest industry based on restructuring pulp plants.

3.1.6 Foodstuffs industry - by-products

- International trade is “easy and simple” as the fuel – both from organisation and spatial perspectives is present in the entire trade system.
- Many of these fuels are difficult to fire/combust as they generate problems with both emissions and slagging.
- Availability is limited indicating a risk of price competition.
- Buyers grouped among large scale users.
- Sellers generally large scale foodstuff chains.
- Majority is sold via direct contracts, however agents do exist. Generally speaking the trade chain functions similarly to trade in foodstuffs.

3.1.7 Methanol, DME, FT-diesel, methane and other biofuels produced via biomass gasification routes

- Studies propose that economies of scale favour production in large biofuel plants, similar in scale or larger than pulp plants.
- Favoured by possibility to sell surplus heat/power.
- High capital cost requires uninterrupted operation leading to high short-period willingness-to-pay to ensure fuel supply.
- Some plant configurations allow for co-processing of coal and biomass as combined feedstocks allow for adjustment to temporary high biomass prices (same as for co-firing options).
- Energy plantations to support production may be of interest with time.
- Location close to receiving terminals for long distance shipping – or own terminals at the biofuel plant – can reduce the need for raw material production site adjacency to ensure cost competiveness.
- Large (deep-pocket) capital actors are required for the establishment of processes (plant requirements).

3.1.8 Diversity themes relevant to this study

The material presented in sub-sections 3.1.1 to 3.1.7 indicates clearly that there is extreme variation in structure, underlying logic, and nature of logistics and markets for the large number of different biofuels. It is intended that the brief 'summaries' for different biofuels (or biofuel supply chains) provide an insight into the wide span of the field. For the rest of this report, it is anticipated that the reader will keep in mind a range of the factors presented, such as:

- while some areas of bioenergy are well established, many others are very new or developmental;
- there are a wide range of cultivation forms, pedo-climatic contexts, and production scales;
- logistics systems for some energy carriers are 'standard' or well developed, other are only emerging;
- end-user markets vary from large scale utilities and international corporations all the way down to domestic-dwelling scale;
- energy carriers sources can be waste streams or dedicated crops – or a combination;
- for some biomass forms, bioenergy utilisation constitutes a new form of competition for material or land, or both – for others, markets are new and relatively competition free;
- a number of bioenergy carriers are subject to significant environmental concerns or sensitivities while others remain (at least for now) largely free of controversy.

3.2 Key factors for progress of the new industry

This discussion builds upon the Section 3.1, where the bioenergy sector was portrayed as young and heterogeneous. Here an examination of how the sector – and emergence of large scale supply chains – are also challenged in other areas is provided. While these overlap and interconnect, they are presented here in four key categories.

- **Collective action** – theory and practice provide evidence that the sector will be (and is) facing difficulties posed by incoherent diffusion of knowledge about its new activities, or incoherent trust-building and reliability-enhancing strategies within their emerging industry. Moreover, while this varies from country to country, in many cases it has not yet established a reliable reputation vis-a-vis other industries. As a result, early actors in the industry may be working alone in their reputation-building activities. Pursuant to this, Section 3.2.1 examines implications of the emergence of vehicles for collective action such as industry councils, cooperative alliances and trade association.

- **Standardisation of the "bioenergy" concept** – again evidence from theory and from the field indicate that a lack of 'standard designs' block the diffusion of knowledge and understanding (Aldrich & Fiol, 1994; DiMaggio & Powell, 1983; S. Jacobsson & A. Bergek, 2004). Section 3.1 has already shown how diverse the industry is when one examines energy carriers and supply chain forms; however, this is also complicated by the differences between 'good bioenergies', 'okay bioenergies', and even 'bad bioenergies' – all dependent upon the actual mode of their production – a topic also alluded to in Section 3.1. While an exhaustive examination of the topic is far beyond the scope of this report, the discussion in Section 3.2.2 introduces this topic and also the theme that progress in this area seems to be gravitating towards clearer definition of "environmentally and socially acceptable bioenergy carriers".

- **Building professional corps** – while very closely related to the discussion of collective action in the form of trade associations and the like, the lack of a well defined and strong professional community and tradition, also encompass formal institutional processes such as education. Particularly valid in the context of this report is the importance of the building of the profession through education, creation of clear linkages with established educational curricula, and development of a 'language' for the industry that is easier for the media and other opinion-formers to utilise positively. This topic is taken up in Section 3.2.3

- **Synergistic or antagonistic relationships with incumbent industries** – also important is how the bioenergy sector can be influenced by bordering and overlapping industries. As has been mentioned, these include well established and influential sectors such as forestry, oil, power and agriculture. As has also been alluded to, it is inevitable that the overlap of the agricultural sector in particular will also increasingly overlap with time. Observations from the field indicate that bioenergy is already perceived by some industry elites to disrupt accepted institutions (including spoken and unspoken rule systems) and industry ethics. This may be particularly so in the forestry and power sectors. This is taken up in Section 3.2.4

3.2.1 Collective action in the bioenergy sector

Arguments presented at the outset of this chapter set the scene for this examination of how industry founders can purse public or official support.

Institutional conditions can place constraints upon the rate at which a new industry grows by affecting the diffusion of knowledge about its new activities and thus also the extent to which it is publicly or officially tolerated. If founders have pursued effective trust-building and reliability-enhancing strategies within their emerging industry, and have established a reputation vis-a-vis other industries, the groundwork has been laid for attaining legitimacy at the institutional level). If such situations have been achieved at this level, the early actors in the industry are no longer working alone. Rather, it can be anticipated that industry councils, *cooperative alliances, trade associations, and other vehicles for collective action are in place to achieve institutional legitimacy* (Aldrich & Fiol, 1994, p659).

The quote above picks up a number of important themes for this discussion regarding the role of alliances such as trade associations – and how their interrelations have in moving the bioenergy sector forward. Among other examples that could be taken, attention is immediately drawn to: (i) the manner in which the industry communicates for public acceptance; (ii) the trust that domestic and industrial consumers have in the 'systemic performance'[39] of the fuels they purchase; and (iii) the relative *'good reputation'* of the industry (or otherwise) relative to that held by other energy carriers or energy service providers.

In such a diverse industry, views exist that clear communication of *pros* and *cons* of bioenergy carriers is important (Peck, Bennett, Bissett-Amess, Lenhart, & Mozaffarian, 2009). The same holds for availability of energy service offerings that are both well defined and thoroughly understood by stakeholders – if the industry is to ameliorate confusion, or promote acceptance and support, or all of these. While in some countries the bioenergy sector can be argued to be increasingly mainstream and broadly accepted (Sweden being a prime example) this situation is simply not common when one looks around the globe – or even around Europe. Widespread and trusted knowledge and mainstream utilisation of supply chains and production systems for the multitude of bioenergy carriers are not common. Further, it can be argued that few if any analysts or practitioners can be found that would claim insight into the long-term prospects for, or consequences of the industry.

A prime role of engaging in collective action in this context is to unite in building a reputation of reality, of something that "naturally should be taken for granted by others" (Aldrich and Fiol, 1994). Among other things, this requires the creation of new vocabularies, labels and beliefs by linking the underlying beliefs and values of the industry (its culture) with the behaviours of its members (and what stakeholders may perceive as their identities). Analysts indicate that a more influential image can emerge when entrepreneurs work through bodies such as trade associations. As an example, these can assist new industries 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)" (Aldrich and Fiol, 1994).

Moreover, as indicated in the introduction of this chapter, a key role for such bodies is also to be active in political spheres. Here they have a key role to represent the interests of the new business concept to government agencies.

Shifting from analysts' views of what <u>should</u> be happening, to events on the ground, it is clear that this process is well underway in the bioenergy sector. As an example, Table 3-1 indicates a wide range of organisations in Sweden that are active promoting the interests of the sector. While this grouping may be mirrored in other countries, it is highly likely that the Sweden has come further in this regard than most, if not all jurisdictions.[40]

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[39] A deliberately broad meaning is implied here – this could encompass a range of contexts all the way from the functional quality of a biodiesel in an engine, or a pellet in a furnace, to the life-cycle impacts of a biofuel as assessed by detail life cycle assessment.

[40] This shall remain a postulation without empirical back-up in this report. However, it is the observation of the authors that there is a very strong case for this. Sweden has one of the most developed biofuels markets in the world, and in recent years the industry has enjoyed a very high degree of support from the National government and the National energy agency. While it is in no way claimed that all the industry associations shown in the table 'pull together', there is a high degree of interaction and collaboration between them. Moreover, with Sweden being a relatively small country, most if not

Table 3-1 A selection of Swedish bioenergy related federations and associations

Solid fuels	Liquid & gaseous fuels	Umbrella organisations & 'other'
Pelletsindustrins Riksförbund (PIR) [National pellet industry federation] Svenska Torvproducentföreningen (STPF) [Swedish peat producers' association]; Svenska Trädbränsleföreningen [Swedish wood fuels association];	BioAlcoholFuelFoundation (BAFF); Svenska Biogasföreningen (SBGF) [Swedish biogas association]	SVEBIO [Swedish Bioenergy Association] Lantmännen [Farmers association]; Renhållningsverksföreningen (RVF) [Association of waste management facilities] Gröna Bilister [Green Motorists] Lantbrukarnas Riksförbund (LRF) [National farmers association] Miljöfordon i Sverige [Environmental vehicles in Sweden] Svensk Fjärrvärme [Swedish district heat]

In other countries of Europe, there are also a wide range of federations and associations (roughly equivalent in remit to SVEBIO shown in the table above). Table 3-2 shows a selection of national bioenergy associations. Note that many of these countries also have sub-groups as shown for the Swedish sector that are not indicated in this tabulation. Note also, that other countries outside Europe also have, or are in the process of forming (e.g. Ukraine established such an organisation during 2009) such organisations.

Table 3-2 A sample of European bioenergy federations and associations

Organisation	**Jurisdiction**
EBIOM - Association Europeenne Pour La Biomasse	EU Umbrella
ITABIA - Italian Biomass Association;	Italy
Austrian Biomass Association;	Austria
ITEBE - Institut des Bioenergies,;	France
BBE - Bundesverband BioEnergie,	Germany
NOBIO - Norsk Bioenergiforening –;	Norway
CARMEN - Centrales Agrar Rohstaff Marketing und Entwicklungs Netzwerk,	Germany
REA - Renewable Energy Association,	UK
Czech Biomass Association;	Czech Republic
Valorisation de la Biomasse,;	Belgium
DANBIO - Dansk Biomasse Forening	Denmark
FINBIO - Bioenergy in Finland.	Finland

all of these actors are well known to the others. As an example, the World Bioenergy conference held yearly in the city of Jönköping in central southern Sweden is one of the largest bioenergy events in Europe – all of the Swedish organizations mentioned above participate in this event.

While these two tabulations of industry/sectoral organisations make it quite clear that collective action is both well established and emerging (throughout Europe at least) this does not imply that all organisations are collaborating, 'sending the same signals', or even cooperating. While they do have a remit to promote the industry and lobby for support – they do not present a common view.

Importantly, in the context of this discussion, each and every organisation can be expected to be serving the interests of its direct members – and will be active with lobby work and information dissemination in differing ways. The interests of each individual group may or may not overlap with those of others – often they will be at odds. Even where interests align, there is no guarantee that the forms and content of the messages sent out by such groups will be consistent. This is a topic that is taken up in some details within analysis of new business emergence who argue that the immediate environment of organizations 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 (Aldrich & Fiol, 1994; DiMaggio & Powell, 1983; S. Jacobsson & A. Bergek, 2004).

Such analysts claim that here are two important factors common to new business areas that hinder the collective action required to gain socio-political legitimacy:

1. 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.

The emergence of competing product designs is a clear issue within the bioenergy sector. This can encompass conversion system designs (e.g. 1st versus 2nd generation fuels, sugarcane versus maize ethanol, rape biodiesel versus canola versus palm biodiesel, etc.); fuel types (e.g. biodiesel versus ethanol versus biogas); or production system designs (e.g. certified biodiesel versus uncertified; biofuels planted on former grazing land versus biofuels planted on newly cleared land); and so forth.

In this light, it appears that subgroups have formed, that there are forms of conflict (e.g. our fuel is better than theirs) among the subgroups and that this has led to increasing levels of confusion and disarray – both within an industry and among external stakeholders. It is argued here that such developments are indeed very likely to constrain the efforts of industry proponents to act together and promote the industry as a whole.

However, these 'conflicts', 'potential points of discord' or 'competitive issues' can be addressed and to some extent overcome. The existence and continual evolution of the industry associations mentioned above is clear evidence of this. As analysts indicate, once innovative entrepreneurs establish an intra-organizational level of trust, they can then begin to establish stable interactions with government institutions and begin to build socio-political legitimacy. The following sections discuss areas that must be focused upon in more detail.

3.2.2 The standardisation of bioenergy supply chains and products

This issue of conflicts', 'potential points of discord' or 'competitive issues' presented above is related to what shall be referred to as the 'standardisation' of bioenergy supply chains and products. This argument is grounded in expert claims that competitive individual strategies hinder a united collective front by an industry and that 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 (Aldrich & Fiol, 1994; DiMaggio & Powell, 1983).

Here it is held that issues such as 'food versus fuel' and "rainforests versus biofuels" and "more CO_2 than fossil fuels" are argued to constitute examples of 'mistakes' made to date.

Aldrich and Fiol (1994) go further in this light and argue that under these conditions, the establishment of new organizations will also be repressed and failures will also be recurrent. They indicate that a lack of agreement on a dominant design hinders the legitimacy of new areas of business or industrial activity (e.g. such as bioenergy) by increasing the confusion of institutions about what standards should be set, and of other entrepreneurs about what standards should be followed.

Arguments are posed that reaching some 'implicit agreement on a dominant design and common standards' is important to moving forward. An example at a lower level of complexity may be the development of quality and performance standards for solid biofuel pellets (n.b. this does not imply however that the process towards achievement of standards has been simple). A more difficult but apparently 'feasible' issue now being dealt with is the 'carbon intensity' of different liquid biofuels, and moves towards minimum GHG savings requirement for biofuels. A more contentious and even more difficult example may be 'total impact acceptable from the supply chain system', or alternatively, 'the total social and environmental benefit of a fuel in comparison to the fossil alternative'. This is an issue that is in part addressed by efforts towards so-called 'sustainability certification' of biofuels. The latter example in particular is very much related to public acceptance, and achievement of a 'social licence to operate' for the industry.

Pursuant to the above discussion, this analysis is also interested in factors within the supply chains themselves that may realistically be expected to evolve into more 'standardised forms'. Rather than 'regulatory or performance standards' *per se*, here interest is more focused on the actual shape and function of supply chains. Two examples in this category with great importance to the mobilising large scale trade in bioenergy include: a) the convergence of supply chains to (more) standardised forms; and b) the convergence of product portfolio's, contracts and market dynamics to (more) standardised forms.[41]

To take up the theme of 'social licence to operate' as a key topic, a recent study on the understanding and acceptance of advanced bioenergy and bioproduct systems (Peck et al., 2009) indicated that 'by and large', the political support for the pursuit of advanced bioenergy in Europe is strong. Importantly, results also showed that a good proportion of the senior policy-makers questioned largely share the views of the bioenergy related scientific community with regards to the promise of good environmental and social performance of advanced technologies (e.g. 2nd generation biofuel production systems and biorefineries). This was markedly so regarding important sustainability contributions that the pursuit of advanced bioenergy applications can deliver (e.g. such as climate change mitigation, rural development, and reduced feedstock competition).

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[41] Other areas where this type of action may be important for biomass and bioenergy trade is within the description of the major concepts and technologies, within the regulatory framework (e.g. forestry and agriculture – which includes field and forest energy crop production), overview of biofuels (which includes descriptions of 1st and 2nd generation biomass conversion technologies), standards for biofuels , and so forth.

However, while policy support appears relatively strong, visible, audible and critical public questioning of biofuels is common. One can observe growing uncertainty in society and the broader scientific community regarding the sustainability of modern (industrialised) agriculture practices and the relative environmental benefits of products that can be produced by bioenergy/bioproduct facilities. Biofuels have a very high profile in this debate. There is clearly growing doubt regarding the relative environmental or social benefits that can be obtained from the utilisation of biomass to replace fossil fuels in areas such as transportation fuel production. We have now entered a world where a UN special rapporteur on the right to food has openly labelled biofuels *'a crime against humanity'* (Erlanger, 2008). Examination of a few mainstream media sources such as the Guardian, the BBC, and the Financial Times reveal headlines including: *'UN chief calls for review of biofuels policy'* ; *'Biofuel demand makes food expensive'* (Blythe, 2008), and *'UN agency calls for rethink on biofuels'* (Blas, 2008). Key public opinion-formers such as Greenpeace herald *'Biofuels under (belated) scrutiny'* (Greenpeace, 2008) and, importantly in the context of the stimulation of large developments in 2nd generation biofuels, *'EU biofuels target must go ...... blind faith in so-called second generation biofuels that are years away and could even cause environmental damage should not justify setting strict EU targets today'* (Greenpeace, 2008).

While these examples of critique are predominantly related to biofuels from oil seed crops or grain alcohol – the bioenergy (and bioproducts) industries must face up to the potential seriousness of their impact. It is likely that few stakeholders presently have the capacity to judge the reliability of claims regarding the perhaps nuanced advantages of more advanced bioenergy systems (particularly those also involving bioproducts or biomaterials and so forth). This is especially so where such involve social or environmental tradeoffs elsewhere in the value-chain. If the complexity of more advanced bioenergy system concepts (and the multitude of technological pathways these entail) are confusing to scientists working in the field (and it is our observation that this is often the case) then there may be public opinion and political backlashes waiting; stakeholders could increasingly become confused or disturbed by the aims and activities of bioenergy sector. Both the strengths of variability and flexibility within bioenergy <u>and</u> the tradeoffs constitute a communication challenge.

The existence of potential confusion or doubt; be it well-founded or unfounded, also bears with it the potential to negatively affect vital components of an emerging sector. Such components include factors such as political support, industrial engagement and investment, and venture capital or finance-sector funding. The very considerable costs and scales of the engineering and supply chain endeavours required to realise any advanced bioenergy concept underlines the point that support from among a wide range of stakeholder groups is vital. Policy makers and politicians constitute one such group and it is held here that few in bioenergy circles would disagree that the support of the political community is of pivotal importance. Among other things, very significant investment support is likely to be required from regional, national and supra-national governments (e.g. the EU) to underpin private sector initiatives to test and build facilities for the production of (e.g.) second generation biofuels (VTT Technical Research Centre of Finland, 2006).

Above it was indicated that present European political support for the bioenergy sector appears relatively strong. Such support is however, significantly linked to public acceptance. A key issue for improving public acceptance of large scale bioenergy supply systems will be related to the belief (or otherwise) in the 'sustainability' of bioenergy systems. This is directly related to achieving a legitimate standard for bioenergy system performance. A detail example examining moves towards some form of "system performance certification" is provided here in order to provide context for discussion of the implications of stakeholder and market "confidence" and the roles that "standardisation" may have to play in the market.

Sustainability certification schemes for biofuels

Over the past 2 or 3 years, concerns have grown around the world regarding threats to sustainability posed by biomass production and conversion chains. While the rapid growth in bioenergy demand has stimulated international and regional supply chains and provided significant opportunities for biomass-rich regions to prosper, there are a growing number of cases where serious negative social and environmental negative side effects have occurred. While high profile biomass/biofuel production examples such as such as palm oil development in Indonesia or Malaysia, and soy cultivation in Argentina or Brazil often dominate in the debate, there are many more concerns. Indeed, some examples of the first phases of commodity market trading in both liquid and solid biofuels have likened 'wild west' scenarios. Adding to concerns is that good governance in many promising biomass producing regions is weak or even absent – the likelihood that such jurisdictions will unilaterally adopt production systems that protect their natural resource base and benefit their societies at times appears doubtful.

In response to concerns regarding the way 'biomass/biofuel producers' have moved to meet massively increased demand, (mostly Western) societies have protested the behaviour of their own energy sectors and are increasingly demanding that markets only supply products that are indeed contributing to sustainable development. At the very least, there is a broad desire that one should limit over-exploitation and damage, and stimulate positive factors such as social and economic development. Yet, it is remarkably difficult for a consumer – even a large scale industrial purchaser to determine the environmental or social implications of a biofuel purchasing decision.

As a first step in both reducing uncertainty, and forming a better foundation for a sustainable bioenergy sector, a number of countries have commenced the process of developing biomass certification systems, principles and criteria. These are explicitly developed to facilitate (more) sustainable biomass trade from and between their jurisdiction and other countries (often producer countries).

The application of biomass certification schemes is a young 'science' and experience is limited regarding how some criteria can be specified, monitored and enforced in practice. Similarly, efforts to standardise and harmonise emerging biomass certification schemes are only beginning.

A number of developments towards sustainable biomass certification have taken place in recent years. Leading examples of such analysis works are those conducted under the auspices of IEA Task group 40 on sustainable bioenergy trade (c.f. van Dam et al, (2008) for a précis of efforts in this regard) and those that have been commissioned by bodies such as the European Commission (e.g. refer to Vis et al, (2008) for a detail example of work commissioned by DG-TREN). Other significant efforts have also been conducted at the behest of NGOs such as the WWF (e.g. Dehue et al, (2007) and Fritsche et al (2006)).[42]

There are a number of emerging certification systems and practice, learning and change continues on the ground with such systems. Here systems from agriculture (e.g.

[42] The Roundtable for Sustainable Biofuels (http://cgse.epfl.ch/page65660.html) is particularly relevant to a case study presented later in this aper. For example, this is the current sustainability system employed (via regulations) through the Biofuels Act 2007 in NSW Australia.

EUREPGAP, SAN/RA, IFOAM)[43] from forestry (e.g. FSC, PEFC, FFCS)[44], from the power sector (e.g. EUGENE, Milieukeur, *ok*-power) are deemed relevant. Input can also be taken from private sector initiatives that lead their field (e.g. Electrabel and Essent Green Gold labels).

At national levels, a few governmental bodies that have taken their promotion of the use of biomass and the production of biofuels and renewable energy in their countries a step further. A number of jurisdictions have commenced the process of developing biomass certification systems, principles, and criteria that are intended to facilitate (more) sustainable biomass trade from and between their jurisdiction and other countries (often producer countries). In this light, leading practice is represented by the UK, the Netherlands, and Belgium. Other schemes of a more limited remit have been instigated by countries such as Canada, the US, Germany and Brazil. In addition, and central to future progress, are the efforts of the European Commission at a supra-national level to develop thorough sustainability criteria and a European biomass certification system. Indeed, it is likely that activities such as research and pilot implementations that are stimulated by the EC will increasingly define leading practice.

Initiatives are also being led international bodies and partnerships. Notable among these are: the FAO initiated International Bioenergy Platform (IBEP) that has focused upon knowledge management and transfer to governments and private operators to formulate bioenergy policies and strategies; the United Nations Biofuels Initiative (UNBI), set in motion by UNCTAD with the aims to establish/promote sustainable production and use of biofuels in developing countries in ways that can be attractive for both domestic and foreign investment; and the IEA Bioenergy Task 40 on sustainable international bioenergy trade, which (as mentioned earlier) convenes workshops and studies on biomass criteria and certification options. Also relevant to this category, but more bounded by vested industry interests are the "round tables" on sustainable palm oil (RSPO) and soy (RTRS). These are both multi-stakeholder groups focussed upon on the specific aspects (and interests/limitations) of their own product.

While significant progress is noted among the many examples above, large gaps/shortcomings in both content and praxis still remain. One aspect that may cause difficulties for the broader acceptance of certification scheme is their initial point of departure in a (sometimes) limited set of ecologically grounded and science based parameters. Even category-rich criteria emerging such as the Dutch scheme (with a strong content of ecological sustainability, ecosystem services protection, and social parameters) may be open to criticism by influential stakeholders for a lack of rigour in the choice and justification of categories for inclusion and the manner in which they are posed within guides.

If, on the other hand, the detailed Dutch scheme with its six main sustainability themes (greenhouse, competition with food and other applications, biodiversity, environment, prosperity and social well-being) and its nine basic principles for biomass sustainability (with minimum requirements and indicators)[45] is taken as a benchmark, then

[43] EUREPGAP, EuroRetailerProduceWorkingGroup for Good Agricultural Practice SAN = Sustainable Agricultura Network, IFOAM= International Federation of Organic Agriculture Movements

[44] FSC=Forest Stewardship Council, PEFC= Programme for the Endorsement of Forest Certification, FFCS= Finnish Forest Certification System.

[45] Related to GHGs, carbon sinks, food supply and local biomass use, biodiversity, soil and soil quality, ground and surface water quality, air quality, local prosperity contributions, well being of employees and local populations.

shortcomings among the various other standards (either existing or under development) such as FSC, SAN/RA, RSPO, RTRS, IFOAM[46] etc can be immediately perceived. While these standards address parts of the Dutch criteria for biodiversity, environment and social well-being, important aspects such as greenhouse gas emissions and the food versus fuel versus material debate are not addressed at all.

Successful certification schemes will need to match the specific requirements of a region, take into account land use dynamics, and adapt to rapidly growing and fluxing markets. They also need to be in place soon enough to help secure the sustainability of biomass within the short term. If sustainable solutions are to be realistic, it will be necessary to coordinate worldwide on-going activities in this sector – thus harmonised standards are needed. This will also require that end-users can influence the production and trading chain of biomass and also seek to eliminate negative impacts in their supply chains. Activities such as research and pilot implementations that are stimulated by the EC will increasingly define leading practice. Moreover, the clear communication of the aim of certification schemes and the mode of their function is required for the ongoing process of setting up good practice codes and integrating sustainability safeguards in global business models[47] (i.e. outside certification processes).

The true implications of moves towards certification are of course, yet to be seen. It can however be expected that this will impact the industry to some extent – at the very least, such moves will add considerably to the effort required to source, validate and bring a product to market. It is relatively clear that a resource intensive additional task is to be imposed upon the industry by the need to maintain legitimacy.

As a final note in closing this section, these trends provide grounds to believe that there will be winners and losers if and when the industry and the market establish clear (and demanding) standards. It is typical that some organizations may gain more than others as an industry's legitimacy is strengthened. One example of such is described by Rao (1993) in his study of the early years of the American automobile industry. As the auto industry struggled for acceptance, firms that won victories in reliability and speed competitions organized by third parties were more likely to survive than those that did not win. Parallels to this appear to be emerging in the bioenergy sector. The first winners in a category may be the first generation biofuels that do deliver high performance in GHG emissions and overall system efficiency (e.g. Brazilian sugar-cane with high yields and low carbon footprints, and certain European ethanol production systems where heat recovery/utilisation infrastructure and links to animal feed demand provide for high performance). Should they be able to enter the market at a competitive production cost then second generation biofuels may be a second group. This sector of the bioenergy market already markets explicitly the relative superiority of 2nd generation fuels over 1st generation in key areas such as GHG emissions, and fuel productivity per hectare – competition in the first instance being that to win support from policy-makers (e.g. for subsidies etc.).

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46 Roundtable of Sustainable Biofuels, "RSPO" - Roundtable on Sustainable Palm Oil, "SAN" – Sustainable Agricultural Network, „EurepGAP" –)

47 The broader Corporate Social Responsibility agenda is valid in this regard. The emerging content and concepts of biomass certification appear well aligned with much of this agenda.

3.2.3 Building professional corps

The significant activities – and the large number of personnel involved – in the industry associations and collectives described in Section 3.2.1 are evidence that a 'bioenergy profession' exists, and that it is growing.

However, if one considers the bioenergy sector in comparison to other industries – the petroleum industry, or forestry, or agricultural, for example – then very clear differences in the extent, maturity, and relative degrees of influence can be seen. Theorists indicate that whilst established industries have the benefit of the institutionalised dissemination of information about their activities, new business concepts often lack the critical mass (e.g. of information from established and legitimate institutions) required to increase their level of cognitive legitimacy (Hannan and Freeman, 1984; Aldrich and Fiol, 1994). 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 the innovators who are early movers in new business areas, as educational institutions in particular can create information regarding the competencies of the new business concept and assist in its dissemination, which is a primary requirement for gaining legitimacy. Such factors also directly affect external opinion builders; the mass media for example is not familiar with the language for describing the activity, and their interpretation/representation may be inaccurate and misleading (Phillips, 1960).

Progress in this area is being made – even if at a modest scale in comparison to the aforementioned examples. A recent study (Bioenergy NoE, 2007) demonstrated that Masters and PhD courses in bioenergy have increased dramatically over the recent years. A first study conducted during 2006 found some 60 MSc. level courses related to bioenergy in Europe, with 55 of these being commenced between 2000 and 2005. A diverse range of specialisations are offered, including all aspects of biomass utilisation technologies, optimisation of energy crop production, socio-economic analysis of bioenergy systems, and so forth. An update of this study conducted during 2009 indicates that the number of courses had increased to around 86 MSc. courses.[48]

These trends (in Europe at least) can be expected to increase – if for no other reasons that progress towards the goals of the Biomass Action Plan (Council Directive 2003/30/EC) are expected to stimulate the creation of up to 300 000 jobs in the sector. It appears assured that a demand for experts in the bioenergy field will continue – and that this should provide motivation to formal institutions to deliver in this area. In varying degrees, similar developments can be observed around the world.

Nor is the building of the profession limited to formal education or industry associations – by no means! As the sector grows rapidly (as it is) there is a concomitant increase of skills and knowledge in the field. Practitioners, regardless of their educational or vocational background, are 'learning by doing' on a daily basis. Other areas of considerable growth and activity that clearly contribute to the theme addressed within this subsection include:

- the research community – the number of research project, research staff, bioenergy related research networks, experimental facilities, research grants, etc. has grown rapidly in recent years; similar to field practitioners, while many of these professionals

[48] Bioenergy NoE report: Advanced Education and Training in Bioenergy in Europe available at http://www.bioenergy-noe.com/Resources/user/docs/Advanced%20Education%20and%20Trainining%20in%20Bioenergy%20in%20Europe%202009%20-%20final.pdf

have 'moved in' from other scientific fields, an increasing number are building their careers firmly within the bioenergy sector;

- academic and professional journals – publication pressure has grown rapidly in established journals (e.g. biomass and bioenergy) and new journals have appeared (e.g. the new journals BioFPR and Bioenergy Research), this trend can be expected to continue;

- International Energy Agency (IEA) bioenergy activities are both broad-ranging and an important stimulus to the industry – as well as an important source of information and guidance for both internal and external stakeholders; 21 countries plus the European Commission participate in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, European Commission, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland, United Kingdom, USA; within IEA activities there is a broad and comprehensive suite of activities, these include:
    - Task 29 : Socio-Economic Drivers in Implementing Bioenergy Projects
    - Task 30 : Short Rotation Crops for Bioenergy Systems
    - Task 31 : Biomass Production for Energy from Sustainable Forestry
    - Task 32 : Biomass Combustion and Co-firing
    - Task 33 : Thermal Gasification of Biomass
    - Task 34 : Pyrolysis of Biomass
    - Task 36 : Integrating Energy Recovery into Solid Waste Management
    - Task 37 : Energy from Biogas and Landfill Gas
    - Task 38 : Greenhouse Gas Balances of Biomass and Bioenergy Systems
    - Task 39 : Commercialising 1st and 2nd Generation Liquid Biofuels from Biomass
    - Task 40 : Sustainable International Bioenergy Trade - Securing Supply and Demand
    - Task 41 : Bioenergy Systems Analysis
    - Task 42 : Biorefineries: Co-production of Fuels, Chemicals, Power and Materials;
    - Task 43 : Biomass Feedstocks for Energy Markets

- and so forth

While only a snapshot of developments that contribute to the professionalization of the field, it is held that these developments (and the potential for their further stimulation) must be considered in any intervention strategy aiming to mobilise global bioenergy supply chains.

3.2.4 Relationship to incumbent industries

Management of the relationship with other industries is a vital role for growing the "bioenergy profession and professional networks. As has been highlighted throughout this discussion, the bioenergy sector, its production system, and supply chains, overlap and interact with other sectors. Issues of potential synergies or conflicts with different industries clearly exist. In some cases direct competition for important resources or markets are involved, but not necessarily so. As has been alluded to, there are issues related to land and land use with parts of the agricultural industry; over wood with some wood-based industries; related to fibre with the pulp industries; pertaining to overlapping markets with solid, liquid, and gaseous fuels, and so on. Moreover, other stakeholders that can be considered as parallels to 'incumbent industries' include environmentally and socially oriented NGOs, and UN bodies such as the FAO, UNEP, etc. It is held here that such actors have a 'stake' in the utilisation of resources such as land and water – and other parameters such as 'social cohesion', biodiversity, and so forth.

Inter-industry relations, whether hostile or collaborative, whether competing or cooperating, affect the availability of resources and the conditions on which they are available to any particular industry (Aldrich & Fiol, 1994; Martin B. Meznar & Douglas Nigh, 1995; Stinchcombe, 1968). If an established industry feels threatened by a new area of business activity, they have the potential to question the value of the new industry, its relative efficacy, or its level of conformity to the existing norms, values or and laws (and often considerable resources at hand to do so). The progress of a new business activity towards acceptance and legitimacy (e.g. such as the bioenergy sector and its supply chains) can be negatively affected by rumours, information suppression or inaccurate dissemination. Even after a new industry develops into a recognized entity, other industries may withhold recognition or acceptance (Aldrich and Fiol, 1994). Incumbent industries (or stakeholder groups) have many pathways with which to seek to maintain their ability to control the conditions on which the resources are available to them. New business areas are vulnerable to such inter-industry processes. Indeed, the situation may even go so far as the opposing industry using the resources they have at hand to induce, or promote 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.

The discussion in Section 3.2.1 is directly related to the building of a 'critical mass' of bioenergy proponents that can unite to build the reputation of their new industry as a visible and taken-for-granted entrant into the larger community – and as a counterbalance for potential negative signals or attacks sent by other industries or stakeholder groups.

Naj (1991)) demonstrates an 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. Another example of new sector repression has also been established by Peck (2003). In a study of the aluminium industry in the early 20th century, he documents how the formative phase of the "secondary" recycled aluminium industry was suppressed by the established "primary" aluminium sector.

Examples can also be found in the bioenergy sector. One early case is related to the European particle board industry. This sector was one of the first areas affected by the new industry – demand for pellets created direct competition for shavings and sawdust from sawmills and wood processing plants. A 'waste' material suddenly had a competitive market and the (previously very cheap) raw material upon which the board industry had built its business model was threatened. Significant lobby work was observed from the industry in the first half of this decade protesting the 'threat to jobs' and the like, and calling for limits and controls upon the bioenergy sector (TØI and KEMA Consulting, 2005).[49]

Another vocal industry that viewed the bioenergy sector as a potential competitor in terms of competition for biomass resources, is (or was)[50] the pulp and paper industry. For example a 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) – a carefully constructed example of a competing industry attempting to block the legitimacy of the bioenergy sector.

The process of calling bioenergy supply chains into doubt is not limited to actions by those affected by competition for biomass. In the agricultural sector, there are significant protests from farming associations in Australia against the large scale conversion of grazing lands to plantation forestry. The plantation forestry industry (of which bioenergy is an emerging part) is blamed for disruption of local economies and ways of life (this topic is examined in more detail in the plantation forestry case in Section 4.1). As far as NGOs etc. are concerned, the calls for biomass sustainability certification detailed in Section 3.2.2 are very much driven by such stakeholders. A factor within this that highlights the importance that 'being established' as an industry can make is the observation that it is the bioenergy sector that is largely being required to meet such guidelines. The pressure on the agricultural sector (where all of the issues are equally relevant) is muted in comparison.

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 in addition to the formation of trade associations or industry councils as discussed in earlier. On a positive note for the bioenergy sector, such relationship-building can clearly be seen.

For example, much work is being performed (e.g. in Europe and the US in particular) towards the co-production of 2nd generation biofuels, and paper pulp in retrofitted pulp and paper mills; there is great interest in extending operations at sugar mills to include the production of lingo-cellulosic ethanol, and so on.

There are also burgeoning relationships between the petrochemical industry and the bioenergy sector (e.g. the Neste Oil biofuels example raised in Section 2.2.1, and also the extensive work by Shell, including their involvement in the Choren plant in Germany). Such collaboration may increasingly give the bioenergy sector access to the vast resources for refining, shipping, bulk liquid storage, distribution, etc. controlled by the fossil sector. For instance, progression of 2nd generation conversion technologies appears to benefit all groups, and representatives of the petrochemical industry have been members of a number of research consortiums for the progression of bio-based products.

3.3 Institutional implications for the mobilisation of global bioenergy supply chains

The insights into institutional factors affecting the bioenergy sector – and thus the mobilisation of its supply chains – that have been presented, also provide guidance for the

[49] See also Kåberger (2005).

[50] This situation is highly dynamic and the authors have observed marked changes in the views of pulp plant owners in recent years. The acceptance of bioenergy as a potential contributor to their overall economic viability (as opposed to being a threat) is growing. Contributing to this is recognition that many pulp plants will face closure as they become uncompetitive against plants run on plantation timbers produced at much lower costs.

formulation of strategies towards the generation and sustenance of trust, reliability, reputation and finally, institutional legitimacy. Gaining the trust of stakeholders within and around the sector can provide a basis from which to build a knowledge base both in the industry and society. Moreover, it can provide for cooperative and/or collaborative exchange with other similar organizations. Such interactions in turn make it easier for the sector to organize itself collectively and to build a sound reputation for their industry.

However, as examples included in the previous section have highlighted, evidence of good function within one context (e.g. one type of biofuel or one biomass production system) does not automatically serve as evidence of trustworthiness within a broader context. The following discussion will seek to summarise the findings of this chapter briefly, and delineate a number of areas where strategies for overcoming inherent institutional challenges need to be pursued.

Section 3.1 presented a dilemma that in some cases the very diversity and flexibility associated with 'bioenergy' can also present a significant institutional challenge to the emergent industry. That bioenergy is available nearly everywhere and has many forms and levels of complexity introduces considerable confusion in the eyes, minds and debates of society.

Section 3.2 then followed up with examples from other industries (and the academic literature that has examined them) in four areas. For each, related strategic considerations were introduced. The first addressed was the role of collective action in the form of industry councils, cooperative alliances, trade associations, and the like, in pursuit of effective trust-building and reliability-enhancement. Among other things, the discussion touched upon how such representatives of the industry must communicate: for public trust and acceptance; to ensure that domestic and industrial consumers trust the 'systemic performance'[51] of the energy carriers they purchase; and to build and maintain a *'good reputation'* for the industry relative to other industries – particularly in environmental and social spheres. Moreover, the point was made that while intra-industry competition over product/service designs and standards is inevitable (e.g. in light of the field's diversity) it must be recognised that discord within the industry may well add to the existing confusion and uncertainty among external stakeholders. There is very clearly a role for collective action in reducing such institutional barriers; in a Swedish context, where the bioenergy sector appears to be very soundly grounded, a large group of bioenergy interest groups do appear to be pursuing such strategies. In the context of this report however – with a global supply chain focus – it is proposed that there is much more that can be done.

The second theme addressed, builds upon both of the preceding topics. Here the need for some 'implicit agreement on a dominant design and common standards' was presented as important for the sector. It was stressed that while examples at a lower level of complexity, such as quality and performance standards for solid biofuel pellets, or even evolution of supply chains and contract forms into standard forms, may be relatively straightforward, a key issue is much more likely to be about establishing standards for 'the total social and environmental benefit of a fuel in comparison to the fossil alternative' (in practice more likely to be the 'total impact acceptable from the supply chain system'). This is an issue that closely related to efforts towards so-called 'sustainability certification' of biofuels. A broad industry resolution and management of this area is potentially pivotal for the potential of bioenergy being leveraged.

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[51] A deliberately broad meaning is implied here – this could encompass a range of contexts all the way from the functional quality of a biodiesel in an engine, or a pellet in a furnace, to the life-cycle impacts of a biofuel as assessed by detail life cycle assessment.

A third area required to support the industry was presented as building of the professionalism of the Sector. Evidence was put forward that in addition to skilled professionals and vocational workers, the industry needs to create information regarding the competencies of the new business area and assist in its dissemination. Links to formal education programmes was presented as an important component in defining the language, concepts etc. that other external opinion builders such as the mass media use in their interpretation/representation of the sector.

Finally, the management of relationships with other industries was presented as a manner in the sector can help maintain the availability of resources and the conditions on which they are available. It was argued that bioenergy production systems and supply chains overlap and interact with other sectors and there are a wide range of potential synergies or conflicts with different industries. Moreover, the case was presented that while this sometimes involves direct competition for important resources or markets, in other cases the 'conflict' may be more obscure. An example developed in this context was the apparently antagonistic stance of some environmentally and socially oriented NGOs. While challenging, experience from other fields suggests that the sector must create reliable relationships with other established groups in order to overcome challenges associated with other actors controlling resources critical to the bioenergy sector.

4 Observations regarding political interventions in markets

Four bioenergy/policy cases are presented in this section. These present situations in which policy regimes or interventions have contributed to greater demand, production, or trade in bioenergy – or alternatively, how they have disrupted such developments. The foci for each case are instances where the activities, plans or strategies of industrial actors deemed important to the progress of bioenergy have been affected by the approaches taken by policy-makers or the interventions put in place by them – almost always in a manner different to that intended.

As noted in the presentation of the analytical framework in Section 2.3.1 on page 17, here we are seeking to apply a form of *ex post* evaluation to policy interventions in order to assess the reasons for (limited) success or failure of measures and seek pathways for improvement.

The first case is provided in far greater detail than the latter three as it is a direct example of the rapid mobilisation of a large scale bioenergy supply chain. The events that have been assessed demonstrate how a policy intervention to stimulate forestry investment has underpinned the emergence of a multi-million tonne per year biofuels export industry based on plantation forest harvest waste. The case also describes a number of unintended outcomes – some of them also undesired.

The second case, drawn from Sweden examines a situation where a range of government (mostly tax) incentives for renewable energy transport fuels combined with low tariffs on imported ethanol (also EtOH) stimulated a major trade regime, but then how confidence and trade were disrupted by a number of factors. These are related to both internal industry discord and pressure from external EU actors.

The third case addresses a marked policy shift in Germany in 2007, when the newly elected Government significantly altered the tax exemption regimes for liquid biofuels that had constituted the principal driver for the growth of transportation biofuels in Germany. The policy shift, although strongly grounded in economic efficiency arguments, sparked a heated debate within the biofuels community that largely focused on its detrimental impact on the industry (particularly in Germany).

The fourth case examines some aspects of the UK's Renewables Obligation (RO) scheme introduced in 2002 to promote renewable energy in the UK. This scheme entered force in an atmosphere of great pressure on the British Government from industry to minimise costs involved in reducing greenhouse gas emissions. Instead of a price-based support, such as the feed-in tariffs in Germany, the UK opted for a quantity-based scheme with 'green' certificates. While the RO scheme was intended to stimulate competition between companies and technologies, and meet targets at the least-cost, several policy flaws were experienced. A series of adjustments to the scheme introduced (among other things) considerable uncertainty to the market.

4.1 Australian plantation forestry and bioenergy pellets

This first case examines drivers for the establishment of more than 700 000 hectares of

Australian hardwood plantations in the period since 1997.[52] It demonstrates how a policy intervention to stimulate forestry investment has underpinned the emergence of a multi-million tonne per year biofuels industry based on plantation forest harvest waste; delineates potential production volumes, and a number of key parameters of socio-economic performance; and examines social, economic and environmental successes and failures of the intervention within a structured analytical framework.

Projections generated in this work indicate that the Australian wood pellet biofuels industry can grow from a 2009-startup at 200-400ktpa scale, to as much as 2 Mtpa by 2012, with the majority of output initially being exported to Europe. The analysis indicates that forest-waste beneficiation should also spread to both conifer plantations and native forests where active forestry is undertaken. This would increase the current forestry waste available for biofuel pellet production up to some 4Mtpa – and to over 6Mtpa within a decade.

Overall, this study finds that the Australian wood-fuel pellets industry can expand rapidly and deliver a number of important economic, social and environmental benefits. The conclusions provide policy advice directed towards policy makers wishing to pursue strategies for the establishment of large scale biomass plantings for biofuels and/or roundwood. This includes guidance for both the stimulation of plantings, the avoidance of a key pitfalls, and ideas for further increasing the accrual of ancillary benefits.

4.1.1 Introduction

In the period since 1997, more than 700 000 hectares of hardwood plantations have been established in Australia – with the majority of these being planted on land previously used for livestock grazing. The prime stimulus for plantation establishment has been a tax management scheme known as the "Managed Investment Scheme" (MIS). It is a commercial retail-funded industry that has been unique to Australia (DANA Review, 2009).[53] These plantations are now coming on line for their first commercial harvests of pulpwood and have also provided the foundation for the creation of a wood-biofuel pellet export industry. The biofuel industry appears likely to grow from a minor domestic industry to well in excess of a million tonnes per year production within the space of a few years.

One of the key reasons behind the establishment of these schemes by the Federal Government was a desire to reduce a national annual sawn-timber deficit of circa AUD 2 billion (circa Euro 1.14 billion). The country has both recognised and sought to address this challenge since at least the 1960s – a process that had mixed success. In general, Australia has had great difficulty in attracting investment in forestry activities that can take decades to deliver a financial return. Over a 20 year period from the mid-1960s state governments[54] supported the establishment of (predominantly radiata pine) plantations on Crown[55] land sites made available at no financial cost seeking to achieve a national goal of 1.2 million hectares of softwood by the year 2000 (Poynter, 2007). While these schemes did result in a softwood plantation estate of slightly more than 1million ha (Australian Government, 2009) those now

[52] Other sources suggest >1 Mha since 1997, predominantly hardwoods. See: Gavran, M. & Parsons, M. (2010).Australia's plantations 2010 inventory update, national forest inventory. Canberra: Department of Agriculture, Fisheries & Forestry.

[53] This is described in te Plantations 2020 Vision program - http://www.plantations2020.com.au/ . It is important to note especially the strategic partnership between government and industry. Plantations for Australia: The 2020 Vision is a strategic partnership between the Commonwealth, State and Territory Governments and the plantation timber growing and processing industry. (see http://www.plantations2020.com.au/vision/index.html).

[54] Australia is a federation of 6 states and two territories.

[55] Government owned lands.

supplies more than 70 % of the country's sawn timber needs, it involved the clearing of public native forests and infuriated environmentalists. Campaigns against these practices led to cessation by the late 1980s (Poynter, 2007).

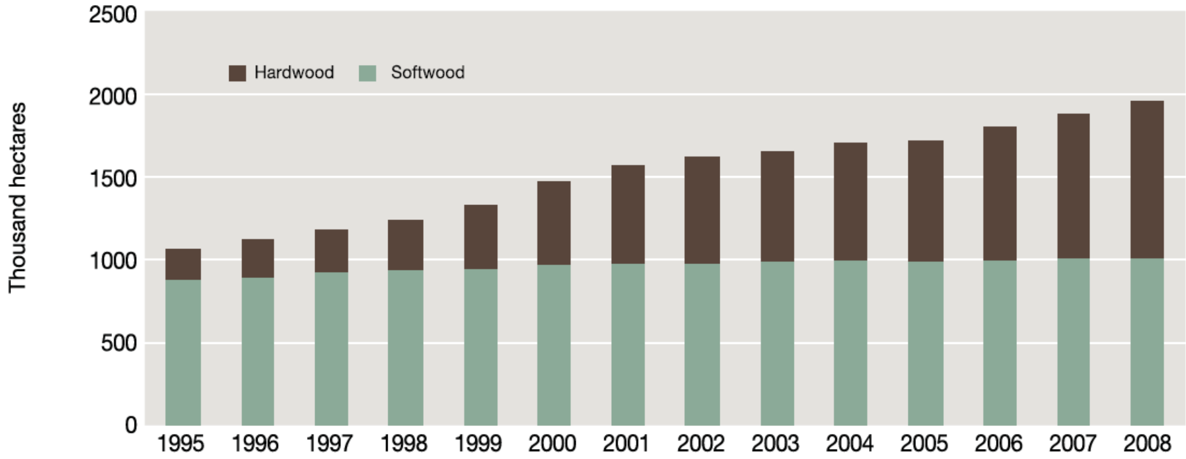

Figure 4-1 Total plantation area by type, Australia, 1995–2008 (Australian Government, 2009).

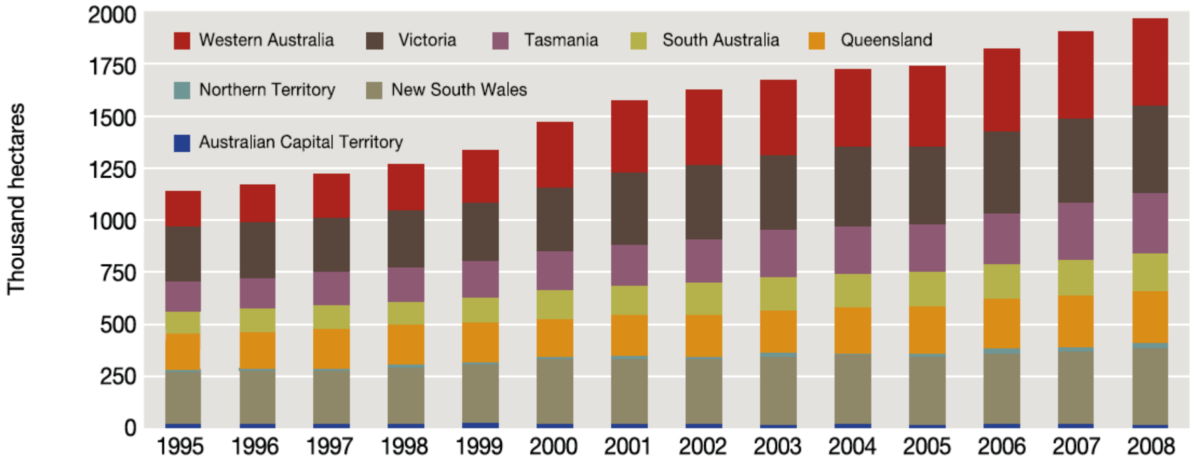

Figure 4-2 Total plantation area by state and territory, 1995–2008 (Australian Government, 2009).

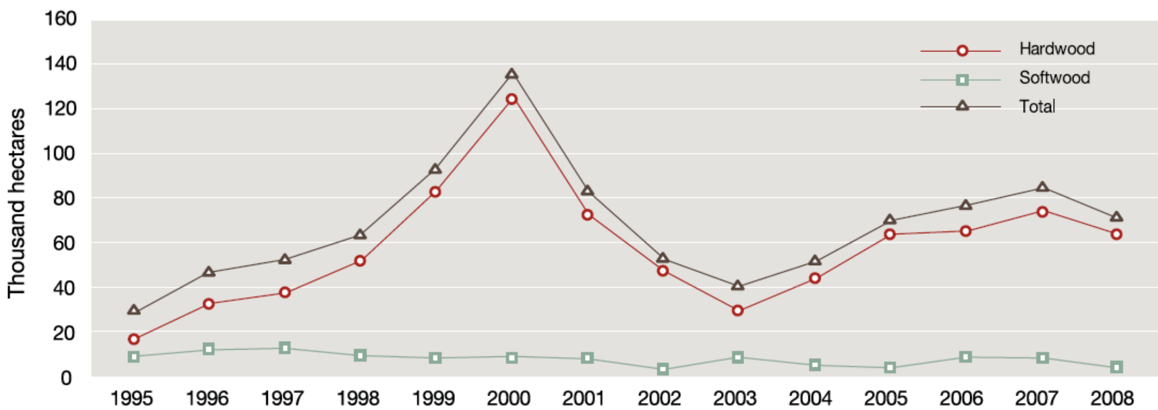

Figure 4-3 New Areas Planted: 1995 to 2008(Australian Government, 2009).

In parallel, a range of financial inducements to encourage on-farm planting have been available to landowners for many years. A major advantage perceived for farm forestry is that it overcomes the land acquisition problem, however relatively few farmers proved willing to plant good land at any great scale. As such, farm forestry efforts led to only small gains to the planted area. Moreover, plantings were largely on low to moderate quality sites and were subject to variable standards of management (Poynter, 2007).[56]

4.1.2 Australian MIS Plantations

In 1997, federal and state governments announced a plan to treble the nation's area of commercial tree crops by 2020. As this would not be achievable through traditional farm forestry plantings, the MIS investment model evolved as a means of attracting the private investment required to facilitate rapid plantation expansion (Poynter, 2007). The prime mechanisms driving private investment were significant 'up front' tax deductions (100%) for expenditures incurred by investors for plantation establishment and management. (i.e., the investor received a tax deduction in the year of investment - the forest company then had a period of time to plant and establish the trees).[57]

MIS funds have financed and driven tree-planting on more than 700 000 hectares of land. While the upfront tax benefit of MIS has overcome much of the difficulty in attracting forestry investment, a large proportion of funds have gone into plantations growing a single product — hardwood pulp-woodchips for export. The dominant species has been Tasmanian Blue Gum[58] scheduled for harvest on a 10-15-year rotation. While these plantations are important to meeting future regional demand for paper, they contribute only marginally to the local shortfall in sawn hardwood timber. MIS investors have not prioritised investment over the time frames (30-35 years) required to grow hardwood plantations for such products (Poynter, 2007). In addition to short rotation forestry for pulp, there have also been commercial-scale domestic and exotic sawlog/veneer, fragrance oil, and biomass and carbon plantations (DANA Review, 2009). As this analysis is focused upon biomass for bioenergy – largely derived from commercial pulp and saw log harvest waste – this discussion will focus upon such forestry plantations.

While the scheme has been very successful in stimulating the planting of hardwoods and was also perceived as a commercial success for the first decade or so of its existence, in 2007/8 there were severe financial set-backs and a number of large companies failed (DANA Review, 2009). Failures are largely attributed to extravagant and unrealistic claims regarding potential plantation revenues and up-front profit taking by the 'prospectus' companies selling the investments (Ajani, 2008).[59] In the period 2008-2009, a fall out and stabilisation of the schemes appears to be taking place – however, Government incentives are still in place. As of late 2009, there are plans to remove immediate tax breaks for non-forestry schemes as well as increase the powers of the Governmental corporate watchdog, the Australian Securities and Investment Commission regarding such schemes (Sherry, 2009). Overall, in the period 2008 to

[56] Note however that Nuberg et al., 2009 estimate that of the 1.8 Mha of plantations established on farms by 2006 <10% would be considered as agroforestry (i.e., they are not commercial scale operations).

[57] Cf. http://www.plantations2020.com.au/assets/acrobat/Plantations%20and%20Tax%20Fact%20Sheet.pdf

[58] Eucalyptus globulus, a prime pulp timber that also produces good saw logs if rotation is longer 30 years. The pulp rotation can be 10 to 15 years.

[59] Ajani J. (2008) 'Australia's transition from native forests to plantations: the implications for woodchips, pulpmills, tax breaks and climate change', *Agenda: A Journal of Policy Analysis and Reform*, 15(3), 2008.

2010 there was significant industry consolidation and upheaval leading to reduced plantings. Most significant issues facing the MIS companies relate to their specific debt structures as well as concerns regarding cash flow from reduced investment in their products associated with investors generally reducing investment doe to the so-called Global Financial Crisis. During 2010 the Australian Government committed to retaining the MIS structure to facilitate long-term investment.

4.1.3 MIS promotions versus realistic expectations

The financial case advertised for some plantation forestry projects appears to have been generally inflated and misleading. This analysis indicates that actual financial returns (and thus plantation values based upon them) are roughly half to two thirds of those projected by investment prospectii. As such, more realistic internal rates of return appear to fall in the range of 5 to 7% (Eco Resource Development, 2002a, 2002b).[60] In the absence of the substantial tax incentives for investors, these returns would probably be insufficient to drive the shifts in land-use that have been achieved by the schemes to date. (cf. Paton (2005)).

Advertising for investment in forestry schemes commonly indicated expected yields (a.k.a. mean annual increment or MAI) in the range of 20m^3/hectare/year (m^{3}ha^{-1}yr^{-1}) to some 30m^{3}ha^{-1}yr^{-1} with stumpage[61] rates of some AUD$40/m^3 (circa €23/m^3). Much of the land targeted for planting lies within rainfall zones of 700mm/yr – under such conditions MAIs range widely but in general appear to be significantly lower than such estimates. Yields are more generally held to fall in the range 12 to 20m^{3}ha^{-1}yr^{-1} and it might be reasonable to expect growth rates of approximately 15m^{3}ha^{-1}yr^{-1} (Paton, 2005). As rainfall reduces, so does productivity – with figures of some 5m^{3}ha^{-1}yr^{-1} indicated for lower (e.g. 400-600mm) rainfall areas (Eco Resource Development, 2002a, 2002b). Lang (2009a) indicates that competition for land driven by MISs has led to plantings in lower rainfall zones.

As such, more realistic revenues should be expected in the order of some AUD$600-800ha^{-1}yr^{-1} (circa €340-450ha^{-1}yr^{-1}). This must be balanced against the all-up actual cost of purchasing land, planting it with trees and managing it over the rotation – a figure held to be around AUD$4500/ha (circa €2600/ha) by Ajani (2007, p. 255) – and most importantly, the high investment costs passed on to MIS investors – according to Lonsec Agribusiness Research (Lonsdale Securities, 2001), these averaged $9300/ha (circa €5300/ha) in 2001 (n.b. this also reflects the degree of pre-harvest profit-taking by the prospectus companies).[62] Paton (2005) states that the major operatives were paying grossly inflated sums for land in high-

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[60] Note that some care is required dealing with projections and cost bases founded in 2002 figures.

[61] A detailed assessment generated in 2009 (Advisor Edge Investment Research, 2009) indicates the following breakdowns of prices for woodchips from Blue Gum plantations; the analysis works back from reigning market prices (Free on Board FOB) for the first half of the year of 2009 – with an agreed international FOB price of 207.40 per bone dry metric tonne (bdmt) indicated. They indicate that the FOB price of $207.40 (circa €118)per bone dry metric tonne (bdmt) translates to a commercial mill-door price of AUD$78 per green metric tonne (circa €45)when adjusted for relevant conversion factors, plus the costs of processing, transport to port, and loading. Mill-door price represents the price the investors will receive for their logs when delivered to a chipping/ processing facility). This in turn translates to an approximate stumpage price of $49.00/m^3 (€28/m^3). The stumpage price represents the log price that is received by growers once all harvesting and transportation costs have been factored in. It is determined from the mill-door price by subtracting all of the harvesting and transportation costs, and by incorporating any conversion factors (i.e. volume-to-weight, green-to-dry, etc) that may be required. In the same order of magnitude, but reflecting lower stumpage, prices indicated by Paton (2005).
for products from foresty were around $AUD37/ m^3 stumpage, $AUD82 per green metric tonne of woodchip or a net price of $AUD 39 per metric tonne (gross price of $81.75 per green metric tonne of woodchip or a net price of $38.75 per metric tonne, or $36.68 /m^3.

[62] In simple calculations performed within this analysis, a positive NPV is achieved at a 7% hurdle rate if investment costs are limited to around AUD$6300/ha for establishment and management (pre-tax IRR7% at 12 years) – this calculation assumed an annual yield of 15m^3 and $40/m^3 stumpage (with maintenance costs of $AUD500/ha mid-rotation).

rainfall zones – well above the productive value for any other purpose mid-decade.[63] He provides an example from the area of Western Victoria known as the 'Green Triangle', where land prices reached $AUD5000 to $6000/ha. With a site establishment cost of $AUD1500 in year one, the raw cost per hectare of the greenfield development is some AUD$5500 for land purchase and $1500/ha for set-up cost, which translates to an establishment costs of $AUD6500 to $7500/ha. Paton goes on to[64] express doubt that plantation forestry projects would withstand scrutiny on a pre-tax basis at a discount rate meaningfully above[65] that delivered by grazing activities (broadly held to be around 5%) – or demanded by commercial plantation-sector investment (over 10%) (Paton, 2005).[66] Supporting these estimates of modest returns, internal rates of return of 5-7% are indicated by a regional forestry investment group in New South Wales (Eco Resource Development, 2002a).[67]

4.1.4 Ancillary Costs and Benefits

Despite the considerable achievement of annual plantings of some 70 000hayr^{-1} for more than a decade, the discussion thus far has presented a mixed economic case for plantation forestry via MIS schemes in Australia – that discussion focused on the economics and did not address deeper socio-economic issues. There has also been a volume of criticism of MIS schemes and associated negative effects in this realm.

Relevant to flow on social issues in some areas where there has been large plantings is the inflationary effect that they have had on land prices (Poynter, 2007). Increases in land prices have been as much as 25% in some areas (Lang, 2009a). Lang (2009b) goes on to point out that is also related to the poor growth rates achieved by MIS schemes relative to prospectus promises. A 'flood' of investment money for land purchase exceeded the availability of land in suitable pedo-climatic areas (note that land availability is a dynamic that is not simply determined by price, but also by retirement rates, land sale rates, and more). This in turn required that investment schemes purchase property further and further out towards the edge of the nominal economic 150km radius from ports.[68] This also involved a move into lower rainfall zones (e.g. sub-700 mm sites like north of Hamilton and west of Beaufort in Victoria) – and also coincided with an extended period of drought (or significantly below average rainfall). With the long dry period several plantation areas became sub-650 and effectively sub 600mm, with increasingly reduced subsurface moisture.

A second flow on effect of the abnormally high land purchase rates was that large tracts of this 'marginal' land (for E. globulus plantations) are categorised as fair grazing land.

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[63] Another side of this coin is that most agricultural land has increased in Australia over the last 15+ years and this has little to do with forestry. There is clear evidence that MIS forestry has lead to some increase in prices in specific parts of the country but given that plantation forestry accounts for approx 2 M ha and agriculture some 30 M ha care needs to be used applying such figures to the sector in general – see Elders (2005). Australian rural property index. 18: Elders.

[64] In 1999, the Australian Bureau of Agricultural and Resource Economics (ABARE) released a document entitled *Forest Plantations on Cleared Agricultural Land in Australia — a Regional Economic Analysis*. Paton (2005) reports that the ABARE estimates applied a discount rate of 7 %. However, he claims that no plantation forestry project would withstand any scrutiny on a pre-tax basis at a discount rate of 7%. Further, he reports of questionable advertising, with one 2001 prospectus advertising equivalent pre-tax returns of even more than 15%.

[65] The ABARE report indicated that forestry projects delivering a 2% premium above underlying grazing returns (e.g. in Western Victoria in SE Australia) would induce land-holders to convert from grazing to forestry (Paton, 2005).

[66] Paton indicates that for plantation-sector investment undertaken by bona fide owner-occupiers not operating under MIS protocols, for example, in long-rotation pine forestry, the secondary market acquires assets mid-rotation on returns rarely less than 10.5% real and closer to 12% real for onshore corporations who face a 30 % company tax impost.

[67] For comparison: Brazilian plantation investments are being advertised at purchase costs of circa €3100/ha to achieved returns of 8% to 14% per annum on 5 to 8 year plantation rotations (Greenwood Management, 2009). ABRAF (2008) indicate average eucalyptus plantation productivity of some 38 m^3/yr.

[68] Such as the Ports of Geelong and Portland in Victoria, Albany in Western Australia, Millicent in South Australia.

Communities were intact and significant local employment and cash flows to businesses and municipalities existed. Lang holds that the large-scale conversion to blue gum across catchments in response to higher land prices has had a detrimental effect upon rural jobs and school enrolments. This in turn flowing on into reductions in commercial services (bus runs, mail deliveries, etc.) and volunteer services such as fire brigades and school canteens. He goes on to state that communities have been significantly and negatively affected – and that as it now becomes evident that the new industry is not viable at real production and price levels, there has been a high cost/benefit ratio. Moreover, he stresses that the imbalance in timber products is relatively unchanged as Australia is still exporting unprocessed wood chips and buying in a similar series of value added product sawn timbers. Adding to this litany of problems for some plantation areas, Poynter (2007) reports that there are claims that plantations have reduced water availability. In recognition of the high water demands of growing plantation forests ((Nambiar & Ferguson (Eds.), 2005; Rumley & Ong, 2006) – including Eucalypts – this appears to be an issue that is logical and that could be foreseeable.[69]

On the other hand, MIS plantations do have supporters in regional communities where investor funds have established new areas for economic activity and employment.[70] The plantation industry has fostered the development of large scale nurseries, new supply chains, planting and establishment contractors etc. Moreover, it has stimulated work to develop new plant hybrids and has provided sufficient hardwood volumes to motivate feasibility assessments for new pulp mills. Importantly from an environmental point of view, new plantations established on grazing land constitute a land-use change that immediately benefits climate, with significant soil carbon capture associated such forestry (Giardina & Ryan, 2002; Poynter, 2007). The beneficiaries also include landowners who have been able to retire on the sales of marginal farms bought to expand plantations.

As has also been indicated, and central to this discussion, it is has also stimulated the founding of a new biofuels export industry in Australia based on woodfuel pellets (Lang, 2009a). The industry appears likely to grow from insignificant in 2008 to a scale of as much as 1.5 to 2 Mtpa by 2012.

4.1.5 Australia's new biofuel pellets industry

In the first half of 2009 Australia's first significant pellets plant dedicated to forestry plantation waste was opened near Albany in the South-West of Western Australia. The company 'Plantation Energy' commissioned a biomass pellet factory adjacent to the area's woodchip facility. The first 12 month's production target is 150kt with an eventual target capacity of 250ktpa. While the project was commenced by Plantation energy more than a year before, an Australian company, financial security was added to the venture in October 2008, when an American private equity firm, Denham Capital[71] made a US$80 million equity investment in the company and took majority ownership (Plantation Energy/Denham Capital Management, 2008).

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[69] There is good evidence of available of impact, but this is generally at specific and small scales across the larger catchments. Studies of impact of plantations can be examined at: http://adl.brs.gov.au/brsShop/html/brs_prod_90000003717.html

[70] Industry informants indicate that this particularly relevant in relation to introduction of processing industry (e.g. small locations such as Tumut in NSW).

[71] According to their website, with approximately $4.3 billion of invested and committed capital, Denham makes direct investments in all segments of the energy and commodities value chain, including oil and gas, mining, timber, power, carbon assets and energy-related infrastructure and services. The firm invests globally, with investments currently in the US, Canada, South America, Europe, Russia/CIS, Asia and Australia, and across all parts of the capital structure and all stages of the corporate and asset lifecycle, from development projects to mature, operating businesses. Denham typically targets investments in the $50 million to $250 million range (c.f. www.denhamcapital.com).

By December 2008, the company had also announced the construction of two more AUD$25m (circa €14million) wood pellet mills (each being 125ktpa modules) on the outskirts of Mount Gambier (near the border of South Australia and Victoria) and at Heywood, in the same region but further east into Victoria (Oldfield, 2008). According to Lang (2009a), Plantation Energy has plans for as many as 13 of the 125ktpa modules to be constructed at 6 to 8 sites around Australia by 2012 with goals of converting 2Mtpa of harvest waste to 1.6Mtpa of pellets.[72]

The commissioning of the plant in April/May 2009 was immediately followed by the signing of a three year AUD$70 million (circa €40million) supply agreement with Belgium-based Electrabel NV, a subsidiary of GdF-Suez, Europe's largest power company. The agreement between Plantation Energy and Electrabel is the first of its kind in Australia (TradeWesternAustralia.com, 2009). Barely two weeks after the signing of the first supply agreement, a three-year AUD 60 million (circa €34million) supply agreement with Essent Trading, an international asset-backed merchant energy trading company based in Switzerland was finalised (Plantation Energy, 2009).[73]

[72] He indicated knowledge of locations for at least 9 modules: Western Australia (Albany) 250ktpa; Tasmania 125 to 250ktpa; Victoria 125 ktpa; Mount Gambier (SA/Vic) 125ktpa; North East Victoria 250Ktpa to service existing pine plantations – and possible 250ktpa north of Brisbane in subtropical timber areas.

[73] The project proponents indicate that demand for pellets in Europe exceeded 8 million tonnes in 2008 and is expected to top 16 million tonnes by 2014.

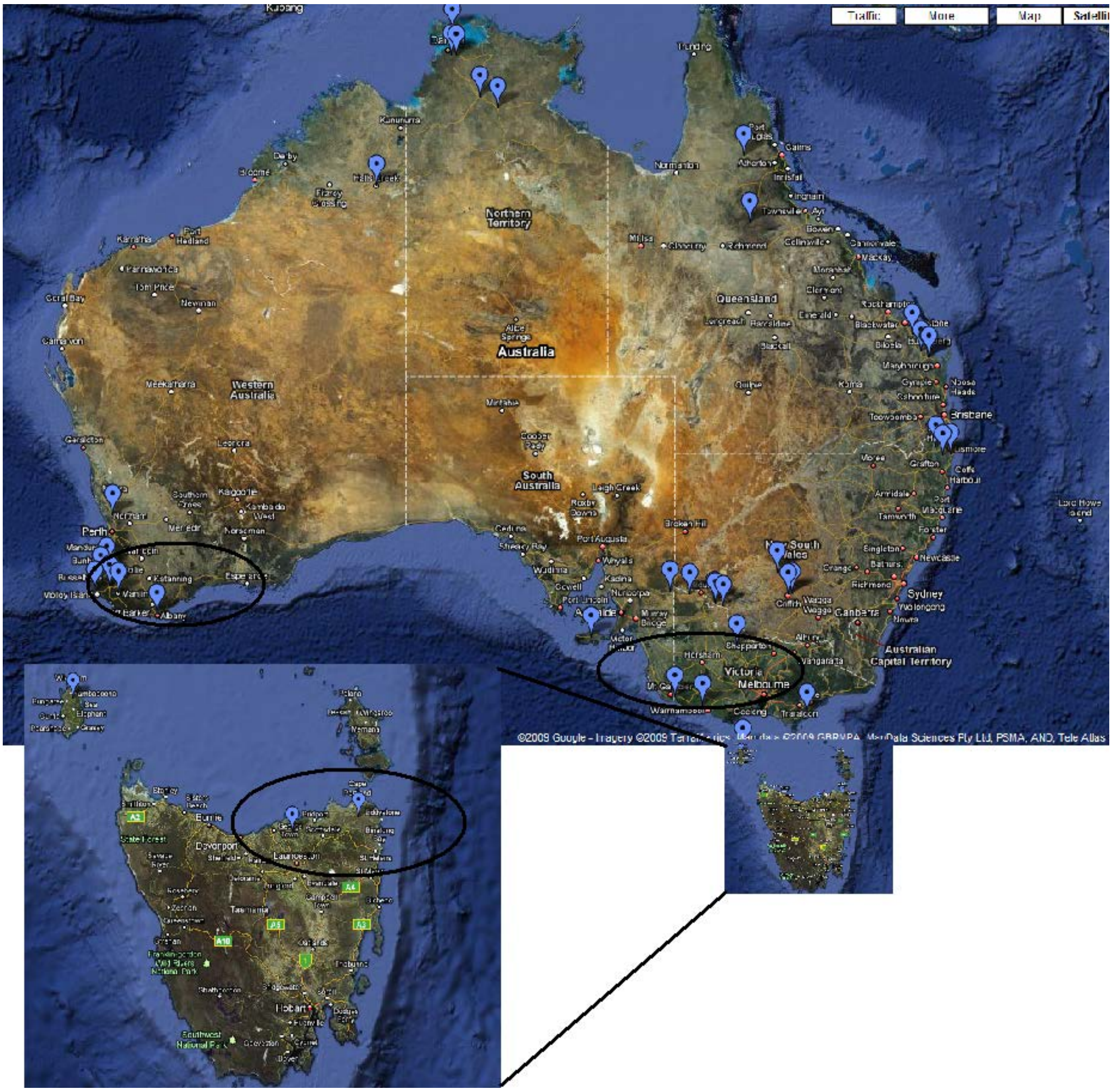

Figure 4-4 Locations of MIS schemes discussed in this paper marked with ellipses (maps from Google Earth).

4.1.6 Volumes of harvest waste available for export

In order to test the potential viability of a multi-million tonne per annum wood pellet industry in Australia, a simplified compilation of relevant forestry statistics and 'potential-biofuel' estimates has been generated in Table 1 below. A number of assumptions were required to generate estimates of forest harvest waste available for biofuels at the present time and into the future.

- Assumption 1: harvest waste available for biofuels circa 30% of harvested roundwood volumes excluding stumps;
- Assumption 2: forest productivity for broadleaf hardwood plantations $15 m^3 ha^{-1} yr^{-1}$ and for conifer softwood plantations $17.5 m^3 ha^{-1} yr^{-1}$.

- Assumption 3: Future productivity for newly planted hardwood (broadleaf) plantation forests will be essentially equivalent to plantations that are already mature and being logged – while more productive hybrids can be anticipated, it is assumed that new plantations will be affected by shortages of prime land.

Table 4-1 Forest harvest waste biofuel potential in Australia

Forest type	1997-98 '000 m^3 logs	2007-08 '000 m^3 logs	Increase %	Forest area 2007-08 ('000 ha)	Current est. biofuel from waste potential[74] (ktpa)	Est. biofuel from waste potential (circa 2015)[75] (ktpa)
Native broadleaved	9 937	8 940	-10%	596[76]	1 341	1 341
Plantation broadleaved	206	4 607[77]	2134%	950	691	2 138
Plantation Coniferous	11 016	14 913	35%	1 014	2 237	2 662[78]
Total	**21 159**	**28 460**	**35%**	**1 973**	**4 269**	**6 141**

Figures derived from ABARE (2009) with assumptions as listed.

The details of plantation advances, the breakdown of (projected)[79] financial performance, issues with speculative investment, and the inventory based analysis summarized in Table 1 provide for a number of observations.

- The MIS schemes have supported a rapid and fundamental change in the forest resource base in Australia – particularly plantation hardwoods.
- Hardwood plantations represent a non-traditional production form and have now introduced a side business in the form of pellet production.
- It appears that pellet production facilities will now spread to other plantation forestry areas – including conifer plantations.

[74] Based on 30% of roundwood volumes removed as harvest waste for bioenergy (Biosouth, 2007). This figure also allows for circa 30% of forest residues to be left lying. It does not include stump removal, which could potentially increase biomass available for energy by circa 50%. A specific density of 500kg/m^3 has been used to convert m^3 roundwood equivalent to metric tonnes.

[75] Based on 30% of roundwood volumes calculated from expected forest productivity when all plantations have reached harvest age (in this instance $15m^3ha^{-1}yr^{-1}$). N.b. roundwood harvest figures in column 2 do not reflect the production of new plantations.

[76] The area of native forest harvested in this period, back-calculated from native forest roundwood production assuming $15m^3ha^{-1}yr^{-1}$.

[77] The majority of these hardwood (broadleaf) plantation forests were established in the last decade and have not yet reached harvest age. As the plantation areas are already of a similar scale as the established coniferous plantations, it indicates that the productive capacity once online will be double to treble the volume indicated here (as can be seen from conifer production volumes).

[78] A conservative estimate of 17.5 $m^3ha^{-1}yr^{-1}$ has been applied for Radiata MAIs. This corresponds to medium productivity (Private Forests Tasmania, 2005).

[79] N.b. Plantations established within the MIS are only just now coming into commercial production.

- The existing base for biofuel pellet production based on all forestry forms could be in the order of 4Mtpa – growing to over 6Mtpa within a decade. Over 4.5Mtpa of this anticipated capacity will be provided by plantations.

4.1.7 Ongoing system improvement

Consideration of system dynamics and ongoing system improvement is important when assessing the outcomes of this case. There are a number of areas where ongoing developments are – or are likely to – contribute to improved economic performance of plantation forestry systems in Australia.

The establishment of a wood-fuel pellets industry that promises to expand rapidly is one such development. This in itself provides additional economic activity that has several components.

- Employment – the figures included in press releases covering plant openings indicate that some 12 direct employment places are generated per 100ktpa of pellets with claims of a multiplier effect of 4 (e.g. additional 36 jobs/100ktpa).
- Capital investment – each pellets plant implemented thus far (and with 11 more in planning) was reported to cost around AUD$25 million (circa €14million) per 125ktpa plant module (AUD$20 million /100ktpa) (Matts, 2009; Oldfield, 2008).
- Export earnings before costs of AUD$17 million (circa €10 million) per 100ktpa. The contract sums reported in the press (Plantation Energy, 2009; TradeWesternAustralia.com, 2009) indicate an approximate contract price of AUD$173 (circa €102/t).[80] 13 modules will have the capacity to produce some 1.625Mtpa. If all pellets are initially exported, this in turn indicates exports valuing some AUD$280million/year (€160million/year).

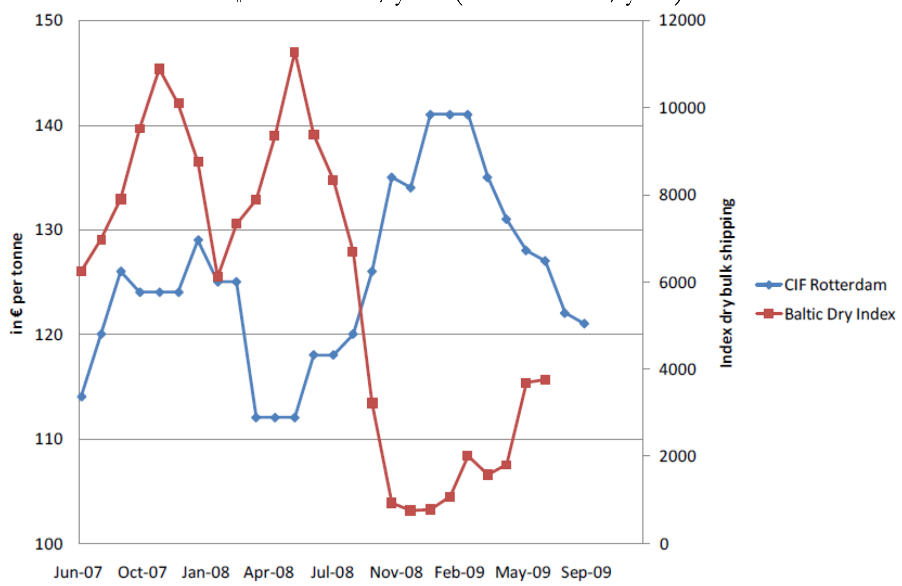

Figure 4-5 Prices of bulk pellets for large scale power production (CIF ARA, excluding VAT) and for comparison the Baltic dry Index (dry bulk shipping).

[80] While EU pellet prices vary, these figures can be compared to Dutch market prices, which spanned the range of 128 to 141€/tonne during the first half of 2009 (Sikkema, Steiner, Junginger, & Hiegl, 2009). Again an exchange rate of AUD1.75/€ has been assumed.

Shifting focus from immediate financial terms to silvicultural performance, there are also a number of parameters that are affected by the combination by plantation forestry, biofuels production from such forestry, or a combination of both.

- As has been experienced in Scandinavian forestry ((Furness-Lindén, Nordén, & Thor, 2008) recovery of harvest waste from the forest as an economic activity in itself can increase the economic returns of thinning operations in forests grown for saw logs. At present, in Australia, first thinnings in saw log forests are generally classified as 'non commercial' – thus indicating an investment that does not pay back until later harvest (when the accrued benefits of stimulated plantation growth are received).[81] The emergence of pelletizing plants now offers the potential for financial returns on thinning taken at all stages of plantation life.
- Increases in thinning activities both in plantations and in native forest also offer the promise of increased saw log yields. Wardlaw et al (2004) indicate that a range of studies have demonstrated significantly improved growth for a range of eucalypt species following thinning with one study predicting a near doubling of sawlog yields at age 65 (compared with unthinned forests) following pre-commercial thinning to 500 stems/ha at about age 15 years and commercial thinning to 250 stems/ha at about age 30 years. As such, the existence of a biofuels industry may now also offer possibilities for combined pellet-pulp-saw log strategies to be pursued profitably in plantations.
- Plantations have also provided an important stimulus for selective tree breeding.[82] Lang (2009a) reports that early plantations (early 1990s) utilised wild seed, but that since that time there have been significant selective breed generation activities, and hence the quality and productivity of trees planted has increased markedly.

4.1.8 Case analysis and discussion

This text has presented the creation of a significant biofuels industry as a side-effect of a policy intervention targeting a different area. Fortunately, biofuels production appears to have eventuated as a synergistic spin-off.

In order to support the analysis with structure, a relatively straightforward modification of an assessment framework for environmental policy interventions developed by Mickwitz (2003) is utilised. In the first instance we have not sought to focus this analysis upon biofuels and bioenergy – this in recognition of the fact that the MIS policy interventions were not focused upon biofuels. However, application of this framework can be found, and discussed, in other bioenergy work (e.g. Peck (2008) – and where case summaries are also provided in the earlier chapters of this report). General criteria included in this framework for assessment are included in the text of Tables 4-3 and 4-4 (overleaf).

Despite the fact that the taxation scheme addressed by this case was put in place with the primary aim to attract investment to plantation forestry and thus reduce a large national sawn-timber import/export deficit – thus constituting an economically based intervention – many

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[81] In eucalyptus forests grown for saw-timber Wardlaw et al (2004) indicate pre-commercial thinning to 500 stems/ha at about age 15 years and commercial thinning to 250 stems/ha at about age 30 years.

[82] This is not restricted to Australia. In Brazil for example, Ball of the FAO (2002) reports that have been several tree breeding programmes with *Eucalyptus*, which have given impressive results. They have included the clonal plantations of Aracruz (Brazil) and Pointe Noire (Congo). At Aracruz yields of 28 m^3/ha/year were obtained from the first plantations, mainly of *Eucalyptus grandis*, which were started in 1967 with seed from local sources. Further, he reports that a tree improvement programme, which identified suitable provenances and spontaneous hybrids for fast growth and resistance to pests and diseases was started in 1971; this has increased the increment to 45 $m^3ha^{-1}year^{-1}$and also increased the pulp yield. Hybrids of *E. grandis* with *E. urophylla* have, on certain sites, attained growth rates of 70 $m^3ha^{-1}year^{-1}$.

of the underlying drivers are environmental. As indicated, this analysis uses an environmental policy intervention viewpoint. An environmental viewpoint is valid in this context, not least as plantation forestry is inherently linked to *land use, land use change, and forestry* (LULUCF) – a central area of importance in the current climate debate. Indeed, the intervention explicitly targeted afforestation of farm lands cleared long ago. Other important environmental undertones include the broad needs to reduce economic pressures for exploitation of native forests for timber, the negative experiences from earlier plantation stimuli packages that involved the clearing of native forests on crown lands, and the growing demands (and activism) among NGOs and the broader public for native forests to be protected (often as national parks and reserves).

Also important to note within this analysis (although separated somewhat more from environmental themes) is that while farmers and graziers own and thus control the utilisation of land, their willingness to engage in 'land-use change' via afforestation has been shown to be low.[83] Over 30 years of experience has shown that farmers are reluctant to change their practices at the indicative rates of return promised by forestry. While indications are that the returns supplied by agro-forestry can be superior to those delivered by grazing (for example), the anticipated margin over-and-above traditional land-use has been insufficient to overcome tradition related reluctance, or risk-perception related hurdle rates. An indication of tradition related barriers has long been observed in the reluctance of farmers to plant trees as dual timber production and wind breaks/shelter belts. Despite evidence that significant portions of a property (e.g. up to 10%) can be planted with trees (e.g. as shelter belts) resulting in improved productivity for other farm activities such as grazing, hay production and cereals production (Department of Primary Industries (Victoria), 2009; Stewart & Reid, 2006), engagement levels have been low.

As such, the major stimulation provided by a tax break focused on non-traditional actors. The 'growers' that have invested in MIS schemes are generally people that have had little or nothing to do with either farming or forestry. They are largely 'small investors' who have responded to tax advantaged investment schemes that just happened to be 'green' and promised to be profitable on a time horizon of ten years or so. Within the promotion of MIS schemes, the key central actors can be supposed to be speculative investment companies and the multitude of independent (or perhaps not so independent) investment advisors around the country.

[83] For example see Nuberg, I., Reid, R. &George, B. H. (2009).Agroforestry as integrated natural resource management. In Agroforestry for natural resource management, 1-20 (Eds I. Nuberg, B. H. George and R. Reid). Collingwood, Australia: CSIRO Publishing. Table 1.3 indicating that <10% of forestry was established on farms across Australia and the remainder in dedicated plantations.

Table 4-2 Criteria for the evaluation of environmental policy instruments (part I) [after Mickwitz (2003)]

	Criteria	Related questions for assessment
General criteria	Environmental & goal effectiveness	***To what degree do the achieved outcomes correspond to the intended goals of the policy instrument?*** *Goals* – The 1997 goal of the policy intervention was to treble Australia's area of commercial tree crops by 2020 – and to contribute to self-sufficiency in sawn timber needs. This was to be achieved by attracting investors to the forestry plantation industry (including actors from outside farming or forestry). Forest plantations were to be established on previously cleared lands. The intervention had subsidiary goals to reduce the pressure to harvest native forests. *Outcomes*[84] – The intervention has resulted in a near doubling of plantation area by 2010 – on previously cleared land largely used for grazing. They are however, essentially growing a single product – hardwood pulp woodchips for export in plantations with a 10-15-year harvest cycle. While this is important for meeting future regional demand for paper pulp, it does not contribute directly to the goal of reducing national shortfall in hardwood sawn timber. Hardwood sawn timber production under the MIS model is currently limited to one Tasmanian company and some small areas of introduced Asian and African species grown intensively under irrigation in northern Australia. According to Lang (2009), most states governments and the Federal government have still been unable to set up a system that will stimulate long term investment in sawlog woodlots on farmland. WA and Tasmania are the exceptions and in WA spotted gum (Corymbia.maculata) and some other species also are shown to provide pulp quality thinnings.[85] Secondary positive outcomes of significance have also eventuated; the issues that surround them have grown greatly in importance since 1997, or they were essentially unknown at that time. Included in this category are: the contributions of the forests as a carbon sink contributing to climate change mitigation; the opportunities for a significant biofuels industry based on plantation waste, and the potential for harvest waste utilisation to underpin saw-log forest thinning operations.
	Enforceability	***Can the policy be enforced with the available human and financial resources of the governmental regulator and/or other enforcement agents?*** The policy has proved to be 'enactable' via the existing regulatory and taxation management processes. However, while the governmental taxation department apparently has the capacity to manage the financial parameters of establishment, technical and economic assessments of plantation performance indicate that many components of the system have a market value significantly below the investments made in them (cf. Paton, 2005; Poynter, 2007). This indicates that the manner in which MIS has been allowed to be applied has been flawed. A proportion of taxation-based funds have been misused, mis-managed or misappropriated.
	Appropriateness	***Do the implementing businesses or operations have the human, knowledge-based and financial resources to respond to the intervention in the manner anticipated?*** The scale of response across the country indicates that industry could respond with plantings at the scale aimed for. However, the financial difficulties of companies managing some 30% of the plantations established, demonstrates that the implementing businesses did not have the required capacity to manage the government incentives as planned. Today, the book value of such plantations may be only half to two-thirds of the sums paid by investors. Whether such financial performance was directly due to lack of capacity, due to speculative behaviour, or even due dishonest business practices has not been established by this analysis. There is however, evidence of all these components. Naivety, speculative behaviour, or inexperience has also reportedly stimulated investment in forestry in drier areas, or on more marginal land – in such instances, it is probable that risks will be higher, and yields will be lower – yet these plantation investments may have been advertised under the same 'offering' as for superior land. Supply chains were inadequately developed at the outset of the scheme and have developed into a strong industrial resource that can support further implementation (e.g. nurseries, seed banks, establishment contractors, etc.).
	Persistence	***Are the effects persistent in such a way that they have a lasting effect on the state of the environment (or market)? Does the policy provide incentives for long-run improvements and technological change?*** The plantations covering more than 750 000ha represent a standing and 'growing' national resource. Despite the financial difficulties noted above, the new plantations and the markets they have created will have both a lasting effect on the market and the environment. New markets (e.g. biofuels) have been created and sufficient hardwood volumes to motivate feasibility assessments for new pulp mills have been generated. Importantly from an environmental point of view, new plantations established on grazing land constitute a land-use change that immediately benefits climate, with significant soil carbon capture associated such forestry. Long run improvements have been achieved in many areas (tree breeding, supply chains, experience, waste valorisation, scale economies, etc.). It seems reasonable to assume that the economic viability of the schemes will continue to improve as these parameters continue to develop (albeit subject to land availability in suitable rainfall areas).
	Flexibility	***Can the policy instrument cope with changing conditions?*** The policy appears to have functioned for over a decade – and throughout the financial crisis of 2007-2009. The policy is being revised to account for a number of areas where it has performed poorly.

[84] The Government view of what the strategy has achieved is available at http://www.plantations2020.com.au/assets/acrobat/2020vision.pdf

[85] He goes on to add that another (thus far) ignored species suitable for sites down to 600mm rainfall is the relativley drought-tolerant Victorian blue gum E.Bicostata. This tree grows far better in the marginal areas of Victoria and apparently it is being planted in Libya on the coastal ranges, and in China.

	Predictability	*Is it possible to foresee the administration, outputs and outcomes of the policy instrument? Is it thus possible for those regulated, as well as others, to prepare and take into account the policy instrument and its implications?* This criterion is intended to be assessed ex ante. Examining the situation after some 10 years of implementation, it appears that by-and-large the policy has delivered along the lines that were expected – one major area apparently missed has been investor disinterest in longer-term investment schemes required for saw-log forestry.

Table 4-3 Criteria for the evaluation of environmental policy instruments (part II) [after Mickwitz (2003)]

	Criteria	Related questions for assessment
Economic criteria	Economic efficiency	***Are the benefits worth the costs? Both benefits and costs are valued in monetary terms.*** There has been scathing criticism of the cost versus benefit ratio for the taxation revenues foregone by the state in order to finance the scheme (cf. Paton (2005)). Moreover, the market value of many plantations appears to be only 50-75% of the price that investors paid and the scheme has failed to deliver forests for sawn timber. As such, the efficiency of the schemes is clearly in doubt. Despite this, the majority of income is yet to be realised for the first harvest rotation and new markets (e.g. fuel pellets) are emerging. Other flow-on effects to the nation can also be assessed in monetary terms – not least increased land values driven by increased competition for agricultural land.
	Cost-effectiveness	***Do the results justify the resources used? Could the same results have been achieved with fewer resources or could the same resources be used more effectively to achieve a better result?*** The comments listed above (economic efficiency) indicate that improved oversight of the scheme would have improved cost-effectiveness – perhaps markedly.
Democracy related criteria	Legitimacy	***To what degree do individuals and organizations, such as non-governmental organizations (NGOs), interest organizations and firms accept the environmentally related policy intervention?*** Until financial difficulties of 2008, the schemes appear to have been widely accepted. However, in the light of financial failures, Green politicians have been critical of the financial aspects. Moreover, two separate parliamentary inquiries planned to investigate MIS indicate a growing discomfort regarding the intervention (Rural Reporters, 2009). While some criticism has been levied in environmental areas such as 'mono-cultures', land-price inflation, and water availability (Poynter, 2007). They appear balanced by positive opinions in areas related to job-creation (Oldfield, 2008; Rural Reporters, 2009), increases in land prices in marginal farming areas (Lang, 2009a, Poynter, 2007) and soil carbon capture (Giardina & Ryan, 2002; Poynter, 2007).
	Transparency	***To what degree are the outputs, outcomes of the environmental policy instrument, as well as the processes used in the implementation observable for outsiders?*** This analysis indicates that the intent and mode of implementation for the intervention are largely transparent and visible. However, the processes by which the organisations managing investment funds have behaved (e.g. land purchasing strategies and practice, marketing activities, valuations, payment of dividends etc.) appear difficult to assess (i.e. non-transparent).
	Equity	***How are the outcomes and costs of the environmental policy instrument distributed? Do all participants have equal opportunities to take part in and influence the processes used by the administration?*** Assessment of the relative equity of the schemes is complex and unclear. There is a broad spread of costs and benefits. The costs of scheme establishment have been, and shall continue to be carried by the Australian tax-payer. The losses incurred for failed schemes have been borne by investors (albeit, losses appear commensurate in scale with the taxation benefit received). Short term financial benefits appear to have accrued to investment coordinating firms while long term benefits will be experienced by the country in a number of areas. These include: a balance of payment deficit should be reduced (timber exports/imports); environmental services such as carbon sequestration, rural job creation and improved taxation base. Other wind-fall benefits have accrued to land-owners in rural areas, particularly those who have benefited from increased land values at a time when they have sold their properties (e.g. in order to retire – or to shift their employment/livelihood).

4.1.9 Concluding remarks

This analysis has provided details of one pathway for a large-scale biofuels industry to be created.[86] If production is ramped up according to the plans of the investors behind the first pellet-production facilities, then the industry appears to have potential to grow from the 200-400ktpa scale of today to as much as 2 Mtpa by 2012. A remarkable facet of this case is that the emergence of this industry has been a side-effect of a forestry policy intervention.

The data collected also indicates that investment focused on the beneficiation of forest harvest waste will now spread to other plantation forestry areas – including conifer plantations. By extension it would also appear likely that harvest-waste from native forest exploitation could be added to this. It is likely however that that stakeholder sensitivity to more intense exploitation of biomass from native forests will be higher – moreover, there appears to be a consistent trend towards less harvesting of native forests as they are increasingly reserved for environmentally motivated reasons. Estimates based on forest data examined in this analysis indicates that the existing base for biofuel pellet production from all forestry forms could be in the order of 4Mtpa – growing to over 6Mtpa within a decade. Over 4.5Mtpa of this potential capacity would be provided by plantations. These figures assume that approximately 30% of harvest waste will be left on the ground for environmental reasons.

Shifting to a view of the future, it appears that the growth of forestry plantations will continue in Australia, although it also appears probable that there will be a slow down. Factors observed in this case that point towards a slowing of plantation expansion include the fall-out of financial failures among large plantation companies (and an associated drop in investor trust), and a dwindling supply of land (or land-sellers) in the geographical areas best-suited for plantation establishment. While investment in plantations for saw-logs has not been a success thus far, the production of saw logs from thinned pulp plantations is not precluded (e.g. for species such as E. Globulus). In the light of continuing shortfalls in national sawn timbers, this may be an interesting area for the future – or for future alteration of support schemes. It may also receive additional stimulus if (or when) international carbon markets become established. This not least as international experience indicates that carbon sequestration rate (per land area) of such species accelerates as trees become larger.

For the time being, the cofiring of pellets in Australian coal-fired power stations appears some way off. The high prices offered by European utilities, in the medium term at least, indicate that pellets will flow out of the country. The growth of domestic production of biofuels is however, a very important step towards the feasibility of this mode for carbon intensity reduction at some point in the future.

Moreover, this example highlights that there are large amounts of biomass in certain areas that can be mobilised in a short period of time. In the context of this report this can be seen in two ways: firstly, that given sufficiently attractive markets, pellets production can be stimulated rapidly from forest sectors that previously had little or no experience of the industry; secondly, that there are areas of the world where agricultural land can be converted for plantation biomass production in large quantities – and that if this happens, the biofuels can enter production within a decade or so.

[86] Albeit serendipitously.

4.2 Ethanol imports to Sweden

This second case examines a situation where a range of government (mostly tax) incentives for renewable energy transport fuels combined with low tariffs on imported ethanol (also EtOH) stimulated both a successful increase in biofuel utilisation (exceeding reference levels in the Biofuels Directive) and an exponential rise in ethanol imports from abroad. By 2005 these had risen to a level (290kt) dwarfing domestic production capacity by (Gulbrand, 2005). Incentives in the biofuels sector in Sweden are largely intended to enhance fuel security of supply and reduce climate change impacts of transportation. Concerning the market developments in the country, it appears that 'diversity' of supply and climate change gas reductions were emerging from the tariff regime.

Import of ethanol, mainly from Brazil, could take advantage of a special categorisation in import tariff rules allowing it to be imported as a low-tariff chemical product (circa 0.25€/hL) rather than agricultural product (circa 19.2€/hL tariff). This ethanol could also benefit from biofuels tax relief on the domestic fuel market (Lexmon, 2006). The favourable import regime for ethanol from outside the EU was apparently targeted for significant negative lobbying from European producers and from domestic actors. A political desire to protect the interests of Swedish grain farmers was (and is) present in the country; however, it exists in a situation of tension as a "free trade" ethos for items such as Brazilian ethanol also has strong constituency in political circles.

At the start of 2006 the Swedish government removed the reduced duty rate import option for ethanol destined for blending at 5% with petrol (E5), with an extremely short forewarning (Lexmon, 2006). The rise in imported fuel cost (circa €0.16/L to circa €0.48/L) effectively removed the price advantage over domestic (and other EU) production at the time (Lexmon, 2006).

This change had several apparent flow-on effects in the short term: firstly it redirected a deal of the sourcing of ethanol imports to other EU countries producing with higher carbon footprints than Brazil; secondly it (temporarily at least) removed a profitable import business involving both foreign and Swedish actors; third it further stimulated or supported investment in domestic grain-based ethanol production, and fourth it disrupted the expanding sugarcane ethanol activities of one of the largest bioenergy actors on the Swedish market (Talloil AB). Apart from their ethanol import activities, this company was entering markets for sugarcane-based alcohol production abroad and in the development of 2nd generation fuel production.

The tariff change was not however applied to ethanol destined for utilisation in the 85% alcohol blend (E85). As such, the highly visible 'biofuel' available from over 1000 service-stations in the country and utilised in a rapidly growing fleet of alcohol-ready vehicles was not significantly jeopardized.

Very large grain price rises shortly thereafter removed the newly achieved "cost competitiveness" for local ethanol producers resulting in postponement of the majority of planned production increases (Dahlbacka, 2007). Moreover, a shift in the public debate to the environmental footprint of 1st generation fuels, contributed to a marked increase in public concern regarding the carbon footprints and sustainability of biofuels – with grain based ethanol being one fuel subject to particular scrutiny. Indeed, it seems reasonable to say that the legitimacy of 1st generation biofuels of this kind had been falling rapidly in the period after circa 2006. This loss of legitimacy applies also to Swedish grain alcohol – despite that fact that examination of the life cycle (and green house gas) footprints for cereal based EtOH in Sweden indicates that they have relatively high performance.

4.2.1 Analysis - Ethanol tariff regime in Sweden

When viewing this case, it is important to recall that the prime motivation for incentives in the biofuels sector in Sweden are generally held to be to enhance fuel security of supply and to reduce the climate change impacts of transportation. Table 4-4 provides a summary of the main items considered valid within this case.

When viewing the industry/policy nexus, our aim is to understand roughly why industry had poor experiences. Two negatives of note will be briefly addressed here. First, a major Swedish company significantly damaged by the loss of a key business activity (Brazilian EtOH import) – damage that contributed to its downfall. Second, the domestic 1st generation EtOH sector that did not obtain the sorts of market security that were perhaps expected because of tariff protection. Prior to this however, important items will be summarised under the label of 'apparent' policy flaws.

Apparent policy flaws – as can be seen in Table 4-4, flaws are noted or proposed in a number of categories. However, the major weaknesses perceived in the intervention relate to a) the rapid implementation of a change without due warning, and b) the apparent failure of the change to contribute to key goals of biofuels policy in the jurisdiction. That is, the intervention did not seem to contribute to GHG reductions significantly. Moreover, the government in complying with the desires of national and EU vested 1st generation EtOH interests could actually have contributed to enhancing lock-in effects with inferior technology pathways. As it has turned out, it appears that the feedstock (cereals) price rises of 2007 have instigated serious industry reconsideration regarding such investments. Such developments – and increased EtOH price volatility due to food versus fuel competition for land have been deemed inevitable by agricultural market experts for quite some time (Schmidhuber, 2006).

Risk management by industry – as indicated, at least one significant domestic bioenergy business was negatively affected. Fortunately, the extremely rapid implementation of the change – for many a fundamental rule-making flaw – had been addressed by risk management within the company, and shiploads of ethanol could be turned around without liability for breach of contract. In this instance the industry actor had 'covered its bets', showing the importance of business intelligence gathering in key areas. Targets of such activity might have been events within the process of lobbying and the growing potential for political shifts. This example shows the important of preparing for business volatility in new areas – as it turned out, this market could simply be turned off by the stroke of a Governmental pen.

Table 4-4 Summary assessment of the Swedish Case

Environmental & goal effectiveness	The GHG performance of Brazilian EtOH is markedly superior to grain EtOH (albeit, the performance of Swedish grain alcohol is high). As such any removal of sugar-cane EtOH has likely increased national CO_2 emissions. Replacement with EU-sourced EtOH adds more uncertainty to this with wide variation in environmental footprint. Improved transportation fuel security of supply has not eventuated as cereal price increases have precluded marked increases in national EtOH production.
Appropriateness	Due to the cost vulnerability of indigenous cereal based ethanol, national actors and EU actors can only take advantage of the reduced competitiveness of imported ethanol to a reduced extent. Moreover, the appropriateness of trade barriers of this kind is widely questioned.
Persistence	No positive lasting effects on the environment are offered by the change. The higher floor price dictated by the tariff does in theory provide better cost competitiveness for 2nd generation EtOH, but its market implementation lies in the future. The technological improvement/availability of ethanol engines is unaffected by the changes as E85 availability is unaffected.
Flexibility	The intervention could not be readily adapted to account for impacts of fluctuations in cereal alcohol feedstock costs. This jeopardised cost competitiveness of E85 and E95 fuels.
Predictability	The lead time for the intervention was too short to allow import industry actors to compensate. Risk management by industry was required.
Economic efficiency	The intervention strategy was not economically efficient. Environmental benefits have not accrued. As imports largely stopped, nor has revenue eventuated and EU sourced fuels are more expensive.
Legitimacy	Legitimacy of intervention was presumably high among 1st gen. suppliers but in environmental terms apparently low among many stakeholders. Legitimacy decreased with time as the cost sensitivity of feedstocks for grain ethanol displayed the non-viability of that industry, and climate change considerations became more obvious. The new Swedish Government has successfully sought to reverse the tariff imposition.
Equity	It does not appear that outcomes benefited the environment or any domestic actors particularly, and the import industry was disrupted – as such support and legitimacy from stakeholder groups appears low. A state visit by Brazil included the tariff as a top agenda item (Karlberg, 2008) indicating a tangible impact on that country.

On the side of the incumbent domestic ethanol industry, a number of weaknesses are apparent. For a number of reasons, major investments in this industry appeared unwise and had been questioned in many fora prior to the 2007 grain price-hikes. Reasons for doubting the viability of 1st generation EtOH investments are held to include that the technology pathway is questioned seriously on:

a) the grounds of vulnerability to loss of (cheap) feedstock supply;

b) both production cost and life cycle analysis grounds due to (at times relatively) poor performance against existing alternatives;

c) the grounds of (relatively) poor performance against emerging alternatives as measured in life cycle analyses [LCA];

d) the basis of ethics related issues within the emerging food versus fuel debate.

Plans for the expansion of the domestic grain EtOH have been postponed or cancelled due to high feedstock costs. FAO sources (Schmidhuber 2006) indicate the likelihood of 'higher' cereal prices being maintained into the future.

4.3 Biofuels quota in Germany

This case explores a policy shift in Germany in 2007, when the newly elected Government significantly altered tax exemption regimes for liquid biofuels. The main driver for the growth of liquid biofuels in Germany had reportedly been the excise duty exemption brought in at the beginning in 1993 for B100. This exemption was then formally extended in 2004 to include low-level blends of biodiesel and bioethanol. This regime was removed in favour of The Biofuel Quota Act of January 2007. The main factors held to underpin political motivation for biofuels promotion in Germany are climate protection, fuel security of supply and development of rural areas (Bockey, 2007).

The new tax structure involves a dual concept system involving 1) a timetable for stepwise increased tax on biodiesel, biodiesel blends and plant oil over a 5 year period (other biofuels tax-free) and 2) a fixed quota for biodiesel with stepwise increasing quotas for bioethanol and the total sum of biofuels (cf. Bockey (2007); Reinhardt (2007)). In this light, an EU-wide shift to quotas took place involving at least 14 member states during the period 2006–8 (Erämetsä, 2008) and as such, quotas appear to be the emergent norm across the EU. Notably, the new regime exempts 2nd generation synthetic biofuels (biomass to liquid BtL); hemicellulose derived bioethanol (also 2nd gen.) and E85 from taxes until 2015.

The policy shift sparked a heated debate within the biodiesel community regarding its detrimental impact on the industry (particularly in Germany). The group most markedly affected is held to be small and medium-sized Fatty Acid Methyl Ester (FAME) biodiesel production. Moderate critics of the policy shift highlight damaging flow-on effects to fuel filling stations offering pure biodiesel, and negative economic impacts due to overcapacity in crushing, milling and conversion operations (Bockey, 2007; Reinhardt, 2007), while vehement (alarmist?) opponents complain of impacts such as: a shutdown of 3 to 4 Mt of medium-sized German biodiesel production capacity; 90% shutdown of small and medium sized biodiesel plants; shutdown of the majority of Germany's 2000 biodiesel refuelling operations; the loss of 20 000 jobs; relocation of national industry, and a 50% loss of domestically produced fodder protein supply (German Association of Biogenic- and Renewable Fuels e.V., 2008).

It appears that there are several angles to view this intervention from. First we take up a tax and macro-economic perspective recognising the theoretical superior cost effectiveness of obligations-based biofuel regimes, and the rapidly escalating cost to German society of the 2004 Mineral Oil Tax act. These costs have been estimated to have grown from circa €0.3 to €3 billion in the period 2000-2006 (in the form of lost fuel tax revenues) and indications are that the new tax regime could save the taxpayer some €2 billion per year by 2010) (Reinhardt, 2007). An important part of this situation includes flow-on effects of energy market 'subsidisation' of agricultural oil seed production (Schmidhuber J. (FAO), 2006) – this in turn unbalancing markets in areas such as stock feed where an oversupply of protein meal results (a co-product of vegetable oil).

Second, we recognise a technological perspective with emerging shifts from 1st generation to 2nd generation biofuels in mind. Here, actors in the existing FAME biodiesel industry (particularly smaller scale) appear less-likely to contribute to technology advances in the medium to long-term and may even constitute a barrier via both vested interest action and technology lock-in effects. Moreover, FAME fuel quality and performance concerns are relevant, particularly in the light of a lack of interest from the motor vehicle industry in supplying engines approved for biodiesel use and even 'shelf-life' considerations for the fuel itself (Erämetsä, 2008; Reinhardt, 2007). In contrast, 2nd generation BtL fuels being paraffinic in structure are immediately compatible (or at least very much more compatible) with all existing infrastructure and diesel engines – moreover, they produce extremely low tailpipe emissions.

Third, the issue of where replacement biodiesel comes from (if German production is reduced) must be addressed. Here, apparently questionable import markets for subsidised fuels from elsewhere, particularly where import via schemes such as the US "splash and dash" loophole exist(ed) raise concern. In that situation, 100 percent biodiesel imported to the US from countries such as Brazil or Malaysia, had a "splash" of fossil diesel added allowing the importer to qualify for US tax credits for biodiesel. Such fuel could then be shipped for sale in markets such as Germany (Swanson, 2007). There is also wide-spread concern regarding the production of Palm Oil in a number of countries.

While biodiesel tax exemptions have been granted for agriculture and forestry activities (Bockey, 2007) the new Biofuels Quota Act and new tax rates are held to favour large biodiesel producers and 2nd generation technologies. The change in legislation also effectively shifts focus from B100 to B5. The change in policy support for biofuels is leading to a complete re-assessment of opportunities and risks by participants in the biofuels market (ITEBE, 2007).

4.3.1 Analysis – Biofuels quota in Germany

Similar to the prime motivation for incentives in the Swedish biofuels sector, in Germany enhanced fuel security of supply and reduction of the climate change impacts of transportation were also listed as paramount. A third factor however, that of rural development, has been given a more explicit profile in German practice. Table 4-5 provides a summary of items considered valid within this case.

In this instance there is one prime focus when examining an apparent clash between policy and industry; that of the very significant negative impacts on stakeholders in the FAME fuel (biodiesel) sector. A very important contributing factor to this is certainly the construction and rapid expansion of an entire industry that had an apparent reliance upon permanent tax relief in order to achieve market viability.

Apparent policy flaws – as with the previous case, flaws are noted or proposed in several areas. As such, three areas of significant weaknesses are perceived in the policy regime that was replaced. The first of these is that it appears to have been inefficient economically (i.e. if based on a monetary cost benefit analysis) – or at least not nearly as cost effective as the regime that replaced it (e.g. degree of goal achievement per unit of investment). Secondly, it appears unlikely to have been contributing significantly to a key German environmental objective of reducing greenhouse gas emissions due the poor life cycle GHG emissions of rape seed derived FAME biodiesels. Thirdly, the burgeoning FAME industry supported by the tax relief system did not seem to offer either the fuel chemistry, or the technological development pathways that can contribute to policy longer term goals for biofuels. Among other challenges in this last category, FAME biodiesels have inherent technical challenges *vis a vis* technical specifications, possible blending proportions, tailpipe emissions, and suitability for standard engines.

In short they are outperformed by paraffinic diesels produced by hydro treating or Fischer Tropsch processes (Erämetsä, 2008). A fourth area of concern, but perhaps not a 'weakness' *per se* is that there are time issues related to the change of policy regime. Here it appears that the removal of tax exemptions appeared some 3 years earlier than was expected for the industry (in Feb. 2004, the EU Commission granted a German application to exempt biofuels from tax until the end of 2009

(Bockey, 2007)). It is reasonable to argue that this would have reduced to some degree the industry's ability to improve system processes and scale economies. Moreover, some questions remain as to whether the tax relief granted to 2nd generation fuels in the new tax set-up provide sufficient time for industrial scale production to be established. Finally, and on the other side of the coin, many biofuel proponents hold that the presence of 1st generation infrastructure is a prerequisite for 2nd generation to arise. In this instance, it appears that a deal of the 1st generation system will disappear.

Apparent weaknesses in industry approaches – even in the light of the above point regarding time concerns, a pattern of 'reckless' investment in a technologically sub-optimal (inferior) sphere is seen in the German oil seed diesel sector. The scale is large – and thus the potential fallout is also large. One additional aspect to be added to the points made regarding grain alcohol production pathways is that in this case the functionality of the oil seed derived FAME fuel appears to be inferior (or at least more 'problematical') as well. It is difficult to reconcile the commitment of so much investment to an industry so reliant upon permanent tax relief (or forms of subsidies) for its cost competitiveness.

Table 4-5 Summary assessment of the German Case

Environmental & goal effectiveness	1st generation FAME fuels systems supported by the previous regime exhibit poor environmental performance and marginal GHG savings in comparison to 2nd gen. Fuel security of supply gains and rural development gains were concrete but are achieved at high cost. Replacement by 1st gen. FAME fuels from abroad does not appear to contribute to policy goals. Stimulation of superior technology pathways (if stimulated by reform) could better achieve goals.
Appropriateness	The incumbent FAME sector (particularly SME portion) does not have technology or feedstock chain parameters that allow them to compete in the medium term (deliver fuel of high technical specification at competitive prices and in large volumes).
Persistence	Previous regime could not deliver persistent environmental gain or long run technological improvement. If the policy intervention opens for 2nd generation then persistent gains may be achieved both for climate, rural sector and local emissions. However a high degree of technical risk and development remains before such promise is revealed.
Flexibility	The tax rates in the new system may be adaptable. The incumbent system was apparently reliant upon total tax relief and many market actors will generally lack the ability to adapt
Predictability	A road map 9 years into the future provides predictability. Albeit, the previous system was removed 2 years prior to indicated dates (2009) hence uncertainty may remain for this intervention. It should be noted that taxes imposed on FAME fuels are to be ramped up from relatively low levels – economically viable producers are given time to adapt in this regard.
Economic efficiency	The previous system was very likely not economically efficient. Proponents of the previous taxation regime claim that economic spin-off benefits exceed the costs of the scheme and cite at least one study (IFO 2007) to support that view. Presumably government analysts disagreed.
Cost Effectiveness	Pursuant to comments on goal effectiveness, this analysis suggest that the levels of investment in the previous policy regime could have been placed more effectively in stimulation of more environmentally benign and technologically flexible fuel production systems that still offered benefits to the rural sector.
Legitimacy	The former biodiesel system appears to initially have had broad legitimacy with stakeholders – particularly from a "green symbolism" viewpoint. Revelations regarding the cost to society of the scheme and poor environmental performance of the fuels may have eroded such legitimacy. The tangible results of the new scheme will conceivably be much less visible than the old.
Equity	It is clear that the intervention leaves losers among the FAME fuel system. In recognition of one constituency, tax relief has been granted to rural actors in this regard (small producers).

4.4 Renewables Obligation in the UK

The Renewables Obligation (RO) scheme was introduced in 2002 to promote renewable energy in the UK. This scheme entered force in an atmosphere of great pressure on the British Government from industry to minimise costs involved in reducing greenhouse gas emissions (Toke, 2007). Instead of a price-based support, such as the feed-in tariffs in Germany, the UK has opted for a quantity-based scheme with 'green' certificates (Ringel, 2006).

The RO scheme is based on the idea of stimulating competition between companies and technologies, and meeting targets at the least-cost. However, the feed-in tariffs in Germany suggest that such a support mechanism is well-suited to promote the use of renewable electricity quickly. The debate between the benefits and drawbacks of feed-in tariffs and 'green' certificates continues across the EU (Falk, 2008; Lipp, 2007).

The RO requires licensed electricity suppliers to source a specific and annually increasing percentage of the electricity they supply from renewable sources. The current level is 7.9% for 2007/08 rising to 15.4% by 2015/16 (Office of Gas and Electricity Markets, 2005). Suppliers meet their obligations by presenting Renewables Obligation Certificates (ROCs). Where suppliers do not have sufficient ROCs to cover their obligation, they must make a payment into a buy-out fund. The underlying principle of the RO and ROCs is to utilise a market-based instrument to increase the penetration of renewable electricity in the UK, and to facilitate the integration of renewable technologies with conventional ones on competitive terms (Office of Gas and Electricity Markets, 2005).

Relevant to this analysis is that the legislation has been criticised on many fronts. Detractors have focused on themes such as the RO scheme's apparent capacity to only stimulate investments in the lowest cost-non-innovative technologies. Moreover, it has also been found to contribute to excessive risk exposure for renewable operators; perverse incentives that encourage investment to points below the renewables goals; structural weaknesses that lead to situations where the certificate buy-out prices are less than the value of the certificates, and disincentives to invest in innovative technology domains.

In terms of bioenergy, the RO scheme has always included co-firing of biomass as an eligible technology, but with certain limits. This situation was altered in 2004. Currently, a number of possible changes to the RO scheme are under discussion in the UK and are to be introduced at the earliest in April 2009. With these revisions, it is likely that the co-firing eligibility rules will likely change again (UK Department for Business Enterprise and Regulatory Reform, 2006). These changes are proposed for a number of reasons, including the fact that the potential for co-firing significantly exceeds the current caps – as does interest in co-firing.

It is worthwhile to consider that which was in place before the RO scheme was introduced in 2002, namely the Non Fossil Fuel Obligation (NFFO). In the 1990s in the UK contracts for supplying renewable electricity were auctioned off in several rounds of NFFO bidding. This appeared to produce low prices, but also very few schemes (Smith & Watson, 2002). In total, 3270 MW of renewable electricity was commissioned, but only 1000 MW had been installed by the end of 2003 (Lipp, 2007). Planning problems were identified as a major barrier, but also detailed analysis later showed that many of the bids were uneconomic (Toke, 2007). The NFFO also underwent a series of changes before it was replaced by the RO scheme (Lipp, 2007).

In the RO scheme, renewable operators produce electricity, which is sold on the power market to electricity suppliers at market prices. For each MWh of renewable electricity generated, the renewable generators are allotted ROCs. They can sell these certificates in the market to either electricity suppliers or traders. Through the sale of certificates, the renewable operators are expected to be compensated for the higher cost of renewable power generation (Wordsworth & Grubb, 2003). Thus, renewable operators have 2 main revenue streams – the sale of electricity and the sale of ROCs. The electricity suppliers are obliged to buy ROCs to meet their targets, which are defined by the regulator based on their total electricity sales. In this way, a market is created for renewable operators to sell their certificates (Office of Gas and Electricity Markets, 2005). Renewable electricity generation in the UK has been increasing since the 1990s. Most growth is observed in wind power and landfill gas based generation, mainly indicating lower cost of generation in these segments. The RO scheme has been criticised on a number of fronts, primarily because it has only been able to stimulate investments in the lowest cost technologies (Toke, 2007). For bioenergy, this means that co-firing of cheap biomass (mainly imported feedstocks, such as waste wood and food residues) in existing facilities has shown some growth. However, energy crops (which is seen as the key biomass feedstock for the UK) has not expanded as expected (Business Council for

Sustainable Energy, 2007) – in this light, the national biomass action plan calls for some 350 000 hectares of dedicated energy plantations, but thus far only a few thousand hectares have eventuated. Additionally, few investments have been made in dedicated bioenergy plants (UK Department of Trade and Industry, 2005).

A primary reason why energy crops have not expanded in the UK is linked to a lack of long-term contracts between farmers and electricity companies. Most coal-fired power plants have been very reluctant to sign any contracts with farmers, instead preferring to announce they would like to utilise energy crops for co-firing, but leaving the risks of growing such crops to the farmers (Bates, Howes, & O'Brien, 2006). This strategy does not appear to be working with few farmers investing in energy crops. Additionally, there is considerable interest from electricity companies (and their coal-fired power plants) to utilise greater amounts of waste for co-firing (Bates et al., 2006). This is a much cheaper feedstock than energy crops.

4.4.1 Analysis – UK Renewable Obligation

In the UK, the British Government has put climate change high on the political agenda. This will require greatly increasing renewable energy in the UK energy mix in order to reduce greenhouse gas emissions. However, the British Government has also made it clear that the least cost solutions are a priority, so a market-based instrument, called the RO, was introduced to stimulate the renewable energy industry. Table 4-6 highlights items considered the most relevant in this case regarding bioenergy. In this instance, there is a major focus on the changing governmental priorities for the RO based on the apparent 'failures' of the scheme and industry lobbying for greater co-firing opportunities.

Table 4-6 Summary assessment of the UK Case

Environmental & goal effectiveness	The current RO scheme generally promotes least cost technologies (for example co-firing of cheap and imported biomass), which in many instances may not constitute the long-term goals desired by policy.
Appropriateness	As suggested, the RO scheme promotes the least cost technologies currently available. However, in the bioenergy field this translates to only co-firing of (cheap and imported) biomass, and very little plantations of energy crops.
Persistence	The RO scheme can help the UK to meet initial targets for renewable energy, although it has struggled to do that so far. Its revamping is evidence that it was unlikely to deliver persistent environmental gains or long-term technological improvement.
Flexibility	The time frames and process required to revamp the RO scheme indicates that it is insufficiently flexible to cope with the dynamics of the renewable energy field.
Predictability	The prices for ROCs are unpredictable and inbuilt structural weaknesses appear to have left renewables operators without necessary incentives in a number of cases.
Economic efficiency & effectiveness	The underlying principle of the RO scheme is to utilise a market-based instrument to increase the penetration of renewable electricity in the UK, and to facilitate the integration of renewable technologies with conventional ones on competitive terms. Put simply, the least cost solutions. However, it is increasingly apparent that the RO scheme based on 'green' certificates is similar or more expensive than feed-in tariffs. The administrative burden of maintaining and enforcing the scheme is described as being rather high. There are indications that the suggested changes to the scheme will also complicate it further.
Legitimacy	Heavy stakeholder criticism combined with policy changes and discussion of further alterations is affecting the legitimacy of the RO scheme.
Equity	The scheme favours large renewable operators with 'parent' electricity utilities. In this way, they can sign long term contracts. Small and medium 'independent' renewable operators are disadvantaged since it is difficult to sign such contracts, and therefore gain access to capital from financial institutions. The RO scheme generally promotes least cost technologies and as such, has apparently disadvantaged innovative technologies that have potential to deliver longer term benefits.
Cost effectiveness	The RO scheme appears on the surface to be a relatively low cost policy for the British Government. The cost of increasing renewable electricity is passed onto electricity companies who then charge consumers. However, its effectiveness has been shown to be lacking in several areas, including meeting targets. Again, feed-in tariffs appear to be superior to 'green' certificates. Short term cost effectiveness in this case is being criticised as it does not appear to deliver benefits of structural change in the longer term.

Apparent policy flaws: The RO scheme has always included co-firing of biomass as an eligible technology, but with certain limits. Limits were altered in 2004. By 2008, a number of possible changes to the RO scheme were under discussion in the UK, and the co-firing eligibility rules were to change again. Among other things this has resulted in the introduction of 'banding' of ROCs and 'double ROCs' for some energy sources. As has been noted, in addition to the flaws of volatility, the overall RO scheme has been criticised on a number of fronts due the manner in which it addresses (or inadequately addresses) a number of issues. These include that:

- the risk exposure for renewable operators is high both in terms of price risks and volume risks;
- that there are perverse incentives in the market that encourage renewable operators to aim below targets;
- even if the British Government sets ambitious targets this could result in the prices for ROCs exceeding the buy-out price;

- electricity companies appear hesitant to sign long-term contracts with 'independent' renewable operators because of variations in the ROCs market; and
- the RO scheme has predominantly stimulated only least cost technologies;
- and that the process appears to have been captured by larger industrial actors.

Apparent weaknesses in industry approaches: The changes to the RO scheme have been proposed for (at least) 2 reasons. First, the RO scheme is not meeting the targets for renewable energy. In the bioenergy sector, energy crops (which are seen as a key part of the UK strategy on renewable energy) are not being planted as expected. Rather than a weakness in industry approaches, the incumbents appear to have acted generally rationally within the incentive frameworks provided. As such, industry has focused on the least cost solutions, which is co-firing (cheap and imported) biomass in existing facilities. Second, the potential for, and the industry interest in, co-firing appear to exceed the current caps. In this instance, industry is heavily lobbying the British Government for further changes to the RO rules to effectively allow unlimited co-firing. This is perceived by the renewables industry (and parts of the British Government) as a way to extend the role of coal in energy supply – based on the assumption that carbon capture and storage will become commercially viable in the future.

4.5 Common themes in case analyses

We believe that this analysis has highlighted three important common themes that are also substantially interwoven.

The first we shall call the 'quality' of the policy intervention in its role to support categories of bioenergy technology pathways. An inference being that if the policy has too many flaws then there is higher potential for industry/policy dysfunction. In these cases, contributory factors to negative effects included that the policy frames in place supported systems that: may be outdated or soon outdated by some emerging or potentially disruptive technology system; that had limited potential for improvement in comparison to alternatives; that did not offer demonstrable gains in (some) key policy areas (e.g. GHG emissions); or supported goals that themselves may not have long term stakeholder legitimacy (e.g. increased plantings of oil seed crops). The need to make policy that will be legitimate among stakeholders in the longer term is clearly an area that requires work in a number of the cases addressed.

The second point relates to the areas where put simply: investments from the side of industry seem to have gone wrong; not just because they were reliant upon the policy for economic viability, but also because, to varying degrees they failed to fulfil the categories of 'technology system quality' defined within the description of 'quality' policy interventions. The inference in this case being that if the technology system has too many flaws, then policy support may disappear. Industry must test its systems better in this regard.

The third area relates to the diligence of industrial and political sphere research and intelligence gathering as carried out by industry actors. While the 'wisdom of hindsight' of course makes it easier for analysts to see these things *ex post*, it does seem that industry should have seen some of these problems coming much earlier than they did. The inference in this third point is that the due diligence processes undertaken by actors in the bioenergy field were[87] insufficient in the areas of a) assessing the vulnerabilities of their technologies to varying market influences, and b) the vulnerabilities of their businesses to policy shifts.

[87] With the exception of the one example where the ethanol importer did have contingency arrangements in place for policy shifts.

5 Mobilizing biomass on the near to medium term – some quantifications

Complementary to the preceding discussions, this section provides quantifications of biomass resources judged as 'potentially' available in the short to medium term. These biomass resources includes residue and waste flows in agriculture and forestry and dedicated feedstock supply systems. It is assumed that in the near-term at least, that the latter will be based on plants that are already cultivated at significant scale.

5.1 Agricultural biomass

In recent years the development related to 1st generation biofuels (also described in some detail for selected cases in the previous chapter) have shown that as long as the biofuel feedstock consists of conventional plants that are already cultivated for food/feed/materials purposes then substantial biofuel feedstock quantities can be mobilized in the short term. This is based simply in the fact that farmers, plantation owners or other actors can and do invest in increased production in response to increased food commodity prices (or expected future increases).

Table 5-1 exemplifies this for the case of Brazilian ethanol, showing forecasts made by three institutions in Brazil – The Interdisciplinary Nucleus for Energy Planning (NIPE), The Union of Sugarcane Industries (Unica), and Ministry of Agriculture, Livestock and Supply (MAPA). Brazilian ethanol expansion is proposed to be achieved by increasing productivity in cane ethanol production and by converting extensive pasture to the more intensive production system of cane plantations. In recent years, expansion has in part been stimulated by inflow of resources from new investors, but it is also an example of a well established activity that has been expanding in response to increasing demand. The same can be said for oil palm, maize, rape seed and other conventional crops suitable as biofuel feedstock. These feedstock producers already have experience of supplying a biofuels industry – indeed it is common that a portion of feedstock producers in these categories have interests in biofuel plants. As a consequence, this expansion is less likely to be hindered by business culture mismatch or other constraining factors.

Table 5-1 Forecasts for the short and mid-term expansion of sugarcane

Source	Sugarcane				Ethanol		Year of Projection	Source
	Area		Quantity		Quantity			
	Total	Increase	Total	Increase	Volume	Increase		
	million hectares	*million ha per year*	*million tons*	*million tons per year*	*billion liters*	*billion liters per year*		
NIPE	20 to 30	1.12	n.a.	n.a.	205	10.8	2025	CGEE, 2006
Unica	8.5	0.83	601	58	29.7	2.6	2011	Jank, 2007
	11.4	0.68	829	50	46.9	3.1	2016	
	13,9	0.61	1,038	47	65.3	3.3	2021	
MAPA	9	0.43	650	32	25	0.4	2013	MAPA, 2006
					30	1.6	2015	

While the expectation of high or even increased prices is what usually drives increased production in traditional agriculture sectors that serve the biofuels industry, the events of 2007 and 2008 caused considerable concern.

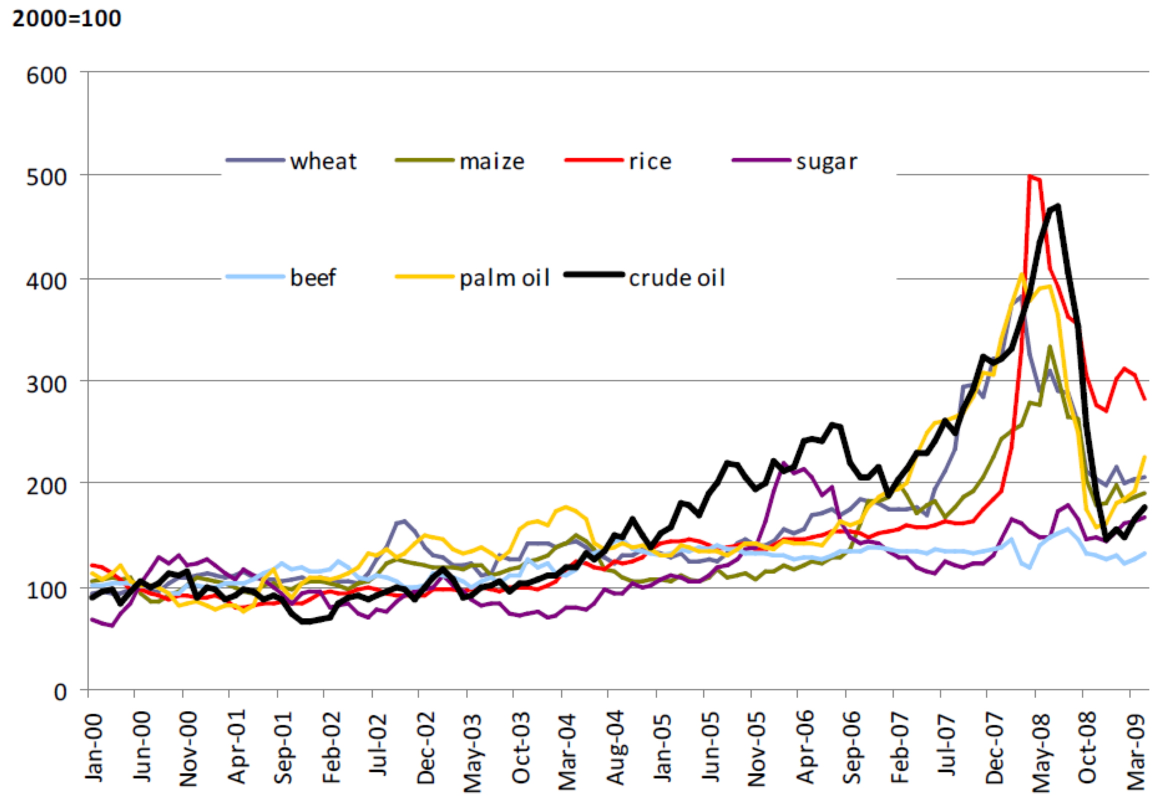

Figure 5-1 Index of world commodity prices, January 2000 – April 2009 (DEFRA, 2009)

The years of 2007–2008 saw dramatic increases in world food prices, creating a global crisis and causing political and economical instability, and social unrest in both poor and developed nations. As can be seen in *Figure 5-1* above, the commodity prices spikes impacted a range of important cereals and oilseeds. This affected a number of commodities that trade in both biofuel and food markets (as well as a number that do not such as rice). The increased food commodity prices (especially cereals) impacted poor segments of populations in particular. This was especially so in developing countries with limited institutional capacity to manage such negative effects.

Systemic causes for the worldwide increases in food prices continue to be the subject of debate. While bioenergy trade is widely accepted to be a contributing factor, there is broad consensus that it was by no means a critical driver. Initial causes of the late price spikes included droughts in grain-producing nations and rising oil prices. Oil price increases (also shown in the figure) also caused general escalations the costs of fertilizers, food transportation, and industrial agriculture. The increasing use of biofuels in developed countries has also been identified as a significant contributory cause - as was an increasing demand for a more varied diet across the expanding middle-class populations of Asia. Such factors, coupled with falling world-food stockpiles all contributed to the worldwide rise in food prices.

While this discussion shall not go into a detail dissection of different factors that can impact food availability and prices, it is important to note that the debate that has arisen after these events have lead to increased attention upon alternative bioenergy expansion options that do not *directly* compete with the food sector. This said, it is not yet widely appreciated that the expansion of non-food crops for biofuel feedstock also can and shall have impacts on food production and thus upon prices in many cases. Among other things, expansion of biomass-for-biofuel activities will result in competition for land, water and other production inputs. Countering this are the expectations and desires that crops adapted to climate/soil/slope conditions not suitable for conventional crops can be applied in many cases. Under ideal situations the bioenergy sector may expand without impacting the food sector. However, as a rule these crops yield better on good cropland soils and will not be cultivated on the more marginal land unless rising prices on good cropland soils (i.e. rising food commodity prices) make cultivation on marginal soils preferable.[88]

However, it can be anticipated that actors shall still expect to see attractive cost/price relations in the coming years even in the case of less dramatic food commodity price development than discussed above. It is foreseeable that steady increases in demand for such food commodities and for biofuels will occur. With such market opportunities, countries having potential and capacity to expand their production – for one, or both of these markets – will likely do so. With increased competition for land and other agricultural inputs, it is also foreseeable that steady increases in food staples can occur should this eventuate.

It also seems reasonable to propose that high food price volatility and price spikes can have a more negative impact on food security than slowly increasing food commodity prices. The latter allow more time and space for mitigation measures – not the least by stimulating development of agricultural productivity in developing countries. Further, experience has also shown that short term responses to very high prices often involve the extension of cultivation to new land. This bears with it the (significant) potential for negative effects such as biodiversity loss, GHG emissions related to vegetation clearing and so forth. Experience has also shown that periods of stability combined with good prospects for reasonable agriculture returns contribute more to productivity growth via yield increases.

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[88] This is a complex topic that is related to farm level optimization and risk reduction via diversification and shall not be developed further in this discussion. It is stressed however, that there are a number of drivers that may lead to the planting of bioenergy crops on marginal rather than prime lands.

Table 5-2 below shows results indicated by modelling of global land suitability for rain fed cultivation of a selection of important biofuel crops. These include first generation biofuel feedstocks (sugarcane, maize, oil palm, soybean, and rapeseed) and lignocellulosic crops (miscanthus, switchgrass, reed canary grass, poplar, willow, eucalyptus). In addition to factors such as soil, climate and topography, land suitability depends on which agronomic system that is assumed to be in use (e.g. the degree of mechanization, levels of fertilisation, and measures taken for pest, disease and weed control). These assumptions also influence the biomass yield levels considered feasible on the lands assessed as available for bioenergy plantations. As stated, Table 5-2 shows the potential for rain fed cultivation – if the potential for irrigation was also taken into account, it would influence both spatial extent and attainable yield levels.

Information regarding the present global land cover – agricultural land, cities, roads and other human infrastructure, and distribution of forests and other natural or semi-natural ecosystems (including protected areas) – was overlaid in order to quantify how much suitable land there is based upon different land cover types. For instance, about 680 Mha of currently unprotected grass- and woodlands is assessed suitable for soybean, 580 Mha are assessed suitable for maize and less than 50 Mha are assessed suitable for oil palm (note however that these land areas may not be added as areas assessed as 'suitable' for the different crops overlap). If one considers unprotected forest land instead, an area of land roughly ten times larger (almost 500 Mha) is deemed suitable for oil palm. However, converting large areas of forests with high carbon content into oil palm plantations would negatively impact biodiversity and also lead to large CO_2 emissions that can dramatically reduce the climate benefit of substituting fossil diesel with biodiesel from the palm oil produced.

Table 5-2 Suitability of land for production of selected bioenergy crops (Mha).

	Cultivated land												
		Potentially suitable[1]											
	Total	Sugarcane		Maize		Oil palm		Soybean		Rapeseed		Ligno-cellulosic	
		A	B	A	B	A	B	A	B	A	B	A	B
N America	230	8	7	103	28	0	0	103	24	132	49	104	43
Eur & Rus	305	0	0	49	84	0	0	17	37	160	81	4	123
Oceania	53	1	0	2	3	1	0	2	5	10	10	9	10
Asia	559	41	56	156	125	37	8	149	145	45	122	210	132
Africa	244	29	28	113	54	10	9	122	48	39	19	125	50
C America	43	10	6	13	13	3	3	17	11	5	3	32	5
S America	129	46	32	42	38	4	9	87	23	45	15	109	12
World	**1563**	**135**	**130**	**478**	**345**	**55**	**28**	**498**	**294**	**436**	**299**	**592**	**374**
	Unprotected grassland and woodland												
		Potentially suitable[1]											
	Total	Sugarcane		Maize		Oil palm		Soybean		Rapeseed		Ligno-cellulosic	
		A	B	A	B	A	B	A	B	A	B	A	B
N America	452	1	1	2	5	0	0	4	13	7	25	11	19
Eur & Rus	459	0	0	5	8	0	0	1	3	24	21	0	17
Oceania	496	1	1	27	23	1	0	9	29	4	8	34	46
Asia	511	2	5	4	14	3	1	5	14	7	31	18	15
Africa	878	26	44	211	115	3	9	194	152	50	42	238	118
C America	71	2	2	3	7	1	1	4	6	3	4	9	8
S America	541	54	87	78	76	6	18	131	117	63	40	241	85
World	**3408**	**87**	**141**	**330**	**247**	**14**	**30**	**348**	**334**	**158**	**170**	**551**	**308**
	Unprotected forests												
		Potentially suitable[1]											
	Total	Sugarcane		Maize		Oil palm		Soybean		Rapeseed		Ligno-cellulosic	
		A	B	A	B	A	B	A	B	A	B	A	B
N America	434	13	13	61	34	0	0	68	14	118	50	82	34
Eur & Rus	819	0	0	8	16	0	0	1	2	119	35	1	23
Oceania	98	6	7	13	11	9	2	9	17	9	8	40	18
Asia	394	16	28	17	18	36	8	18	30	15	14	81	46
Africa	362	98	63	55	85	70	34	145	124	34	25	232	61
C America	69	5	3	8	6	4	2	7	8	5	2	19	9
S America	629	89	246	40	55	198	126	81	176	20	19	468	67
World	**2806**	**228**	**360**	**202**	**225**	**317**	**173**	**329**	**370**	**321**	**153**	**922**	**257**

[1] A: suitability classes "Very Suitable" and "Suitable", corresponding to yield levels above 80% and above 60% of theoretical maximum, respectively. B: suitability class "Moderately Suitable" corresponding to yield levels above 40% of theoretical maximum.

Note that the suitability areas for the different energy crops overlap and they can therefore not be added to obtain suitability areas for combinations of bioenergy crops. Source: Fischer et al. (2009).

Supply potentials for energy crops can be calculated based on assessed land availability and corresponding yield levels. Table 5-3 shows the example of rain-fed lignocellulosic crops on unprotected grassland and woodland. In this case, lands with low productivity have been excluded and an approximate land balance was made based on subtracting land estimated to be required for livestock feeding (Fischer et al., 2009).

Note that Table 5-3 details results obtained by applying figures based on the present situation concerning population, diets, climate, and so forth (without extrapolation by trend or assumption). Moreover, it presents just one of many possible situations regarding for example nature protection requirements, crop choice and agronomic practice determining attainable yield levels, and livestock production systems determining grazing requirements.

Table 5-3 Potential biomass supply from rain-fed lignocellulosic crops on unprotected grassland and woodland where land requirements for livestock feeding have been considered.

	Total grass- & woodland	**Of which**		**Balance available for bioenergy**	**Bioenergy potential**	
Regions		Protected areas	Unproductive or very low productive areas	Rough balance where areas req. for grazing has been excluded	Average yield[1] (GJ/ha)	Total bioenergy (EJ)
North America	659	103	391	110	165	18
Europe & Russia	902	76	618	110	140	15
Pacific OECD	515	7	332	110	175	19
Africa	1086	146	386	275	250	69
S&E Asia	556	92	335	14	235	3
Latin America	765	54	211	160	280	45
M East & N Afr.	107	2	93	1	125	0.2
World	**4605**	**481**	**2371**	**780**	**225**	**176**

The numbers represent one of several possible situations concerning factors such as nature protection, diets, climate etc. Calculated based on Fischer et al. (2009).

[1] Calculated based on average yields for total grass- & woodland area given in Fischer (2009) and assuming energy content at 18 GJ/Mg dry matter. Rounded numbers

As indicated, Table 5-3 does not reflect the fact that food demand will likely increase due to population growth and dietary changes involving higher consumption of meat (and other animal food products). These trends are commonly experienced as a consequence of economic growth and improving welfare – with the most marked changes occurring in developing countries. As such, quantifications of longer-term biomass resource potentials need to consider how such parameters change over time.

In order to quantify the consequences of diverging development patterns for critical factors such as diets, productivity and efficiency in the food system, model calculations were made with a physical, bottom-up-type model of the global food and agriculture system, the ALBIO (Agricultural Land use and BIOmass) model. From a prescribed food consumption level, the ALBIO model calculates the land area and crops/pasture production necessary to provide for that level of food consumption.

Three scenarios were constructed to show and evaluate contrasting developments compared to a projection of global agriculture development up to 2030 presented by the Food and Agriculture Organization of the United Nations, FAO(Bruinsma, 2003):

(i) ***Increased livestock productivity*** (IP) is based on the FAO projection but the productivity and feed use of the livestock sector is different with faster growth of livestock productivity and feed-to-food efficiency;

(ii) ***Ruminant meat substitution*** (RS) is based on IP, but 20% of the per capita consumption of ruminant meat (beef and mutton) is replaced with an equal amount (in terms of kg capita^{-1} year^{-1}) of pork and poultry, with the same proportions of pork and poultry as in IP. The rationale for this scenario is that ruminant meat is by far the most feed and land-demanding meat product and even relatively small reductions in consumption levels have significant effects on total land use;

(iii) ***More vegetable food & less food wastage*** (VE) is based on RS but includes a partial substitution of (mainly) vegetable food for meat, and/or a decrease in food wastage at retail and household levels. This scenario was only applied to regions with high per-capita meat consumption and/or high degree of food wastage, and with several limitations on the magnitude of changes, in order to reflect the rather conservative nature of habits and food preferences.

It was found that if food and agriculture develop according to projections made by the FAO, then the global agricultural area is likely to expand substantially – by about 280 Mha by 2030. This outcome limits the potential for expanded cultivation of dedicated energy crops. However, the contrasting scenarios showed that there is substantial scope for land-minimizing growth of world food supply by efficiency improvements in the food chain. The most marked differences are achieved by change in animal food production, and dietary changes toward less land-demanding food. If assumptions are made that faster (yet realistically achievable) animal food productivity can be achieved than FAO assumptions, then global agricultural land requirements could actually decrease by about 230 Mha from current levels, by 2030. If this higher productivity is combined with an assumed 20% substitution of pig and/or poultry for ruminant meat in human diets, then the agricultural area could decrease by an additional 480 Mha. These figures provide for a total land demand of some 1000 Mha less than that projected by the FAO (cf. Wirsenius et al., 2010).

The ALBIO model was also used to quantify future (year 2030) generation of agriculture residues and by-products not required in the food sector. These represent agricultural resources that it might be possible to mobilize on short-to-medium term. Table 4-4 presents results for the FAO projection (designated "Ref" in Table 5-4) as well as two of the scenarios – IP and RS. The results indicate that very substantial quantities of bioenergy feedstock can be mobilized by using residues and by-products in the food sector.

In the end, the competitiveness of the energetic use of food sector residues and by-product streams depends on the development for other uses. However, given that countries agree to strive towards lower end climate targets (2°C or lower) it becomes increasingly likely the bioenergy sector will likely develop into an end user with high paying capacity. As such, the potential that can be mobilized for bioenergy may be larger than that indicated in Table 5-4. However, this would require that out-competed users find other biomass sources. In this context, it is important to point out that bioenergy development will also generate new feed sources for the food sector. For instance, the use of by-products from cereal ethanol and biodiesel production for animal feed is already well established. New developments may also bring new types of (spatial/temporal) intercropping systems providing both food/feed and bioenergy feedstocks from lands that earlier only provided food/feed. Similarly, pastures that earlier were used for grazing only may become transformed into silvicultural systems providing both bioenergy feedstock and grazing opportunities. Having access to a wider set of crops and land use options, farmers can optimize their land use in new ways and it is not so that integration of bioenergy feedstock production will always lead to reduced food output from the land [cf. e.g., Sparovek et al) for sugarcane ethanol integration with cattle production in Brazil; Stewart and Reid (2006) for combined farm forestry, sheep, cereals and cattle systems in Australia; and the Department of Primary Industries (Victoria) (2009) for discussions of increased grazing land, and stock productivity in Australia and the US associated with shelter-belt plantings].

Thus it can be concluded that while there are certainly local limits to expanding agriculture output, on the larger regional/global level significant biophysical potentials exist for expanding bioenergy feedstock production in agriculture. However, realization of the potentials require significant agriculture development, not the least in tropical areas where agriculture at present perform at levels far below what can be achieved with modern agronomic practices.

Table 5-4 Scenarios of amount of residues and by-products in the global food and agriculture system around year 2030

Numbers refer to the amount potentially available for bioenergy purposes (in exajoules) and its share of total amount of by-products and residues produced within the system.

Category	Scen.	World		East Asia		East Europe		Latin Am. & Caribb.		N. Africa & West Asia		N. America & Oceania		South & Central Asia		Sub-Saharan Africa		West Europe	
TOTAL	Ref	70	35%	20	42%	5.1	51%	8.2	24%	3.1	33%	11	49%	9.6	24%	7.4	28%	5.1	50%
	IP	76	41%	22	48%	4.3	50%	11	39%	3.1	36%	10	47%	14	37%	7.2	28%	4.8	48%
	RS	79	45%	22	51%	4.3	51%	11	42%	3.1	39%	9.9	48%	15	44%	8.3	34%	4.7	50%
Cereals straw and other crop residues	Ref	30	34%	9.1	40%	2.8	49%	2.2	20%	0.2	7.0%	6.5	54%	2.8	17%	4.3	36%	2.2	48%
	IP	34	40%	10	46%	2.3	50%	4.7	42%	0.2	8.3%	5.8	52%	4.6	28%	4.1	33%	2.0	45%
	RS	39	46%	11	50%	2.4	51%	5.2	46%	0.4	17%	5.8	53%	6.8	41%	5.3	42%	2.1	47%
Manure (incl. straw used for bedding)	Ref	16	22%	4.4	30%	1.3	48%	2.6	15%	1.3	33%	2.3	41%	1.8	11%	0.6	5.7%	1.5	48%
	IP	17	29%	4.3	36%	1.1	45%	2.5	23%	1.2	36%	2.4	42%	3.9	31%	0.6	6.1%	1.4	47%
	RS	15	31%	3.8	39%	1.0	47%	2.2	23%	1.0	34%	2.2	44%	3.5	34%	0.6	6.9%	1.3	49%
By-products in food industry, food waste, etc	Ref	24		7.0		1.0		3.4		1.7		2.0		5.0		2.5		1.4	
	IP	24		7.4		0.9		3.7		1.6		1.9		5.1		2.5		1.4	
	RS	24		7.3		0.9		3.7		1.6		1.9		5.0		2.5		1.4	

5.2 Forest biomass

A quantification of current production of industrial roundwood is shown in Figure 5-2 indicates the size of this biomass supply in relation to the size of the national and global energy systems. The present global industrial roundwood production amounts to 15-20 EJ (2-3 GJ/capita) of biomass per year. For comparison, about 390 EJ (60 GJ/capita) of fossil fuels were commercially traded globally in 2005 (BP 2007). The total biomass flows – including also the flows considered to be potential bioenergy feedstocks – are substantially larger. Felling losses are estimated to correspond to roughly one-third of the global wood removals, with substantially larger relative losses in tropical developing countries (Krausmann et al. 2008)[89]. In addition to this, large volumes of wood are cut during silvicultural thinning operations, which are an integrated part of forest management.

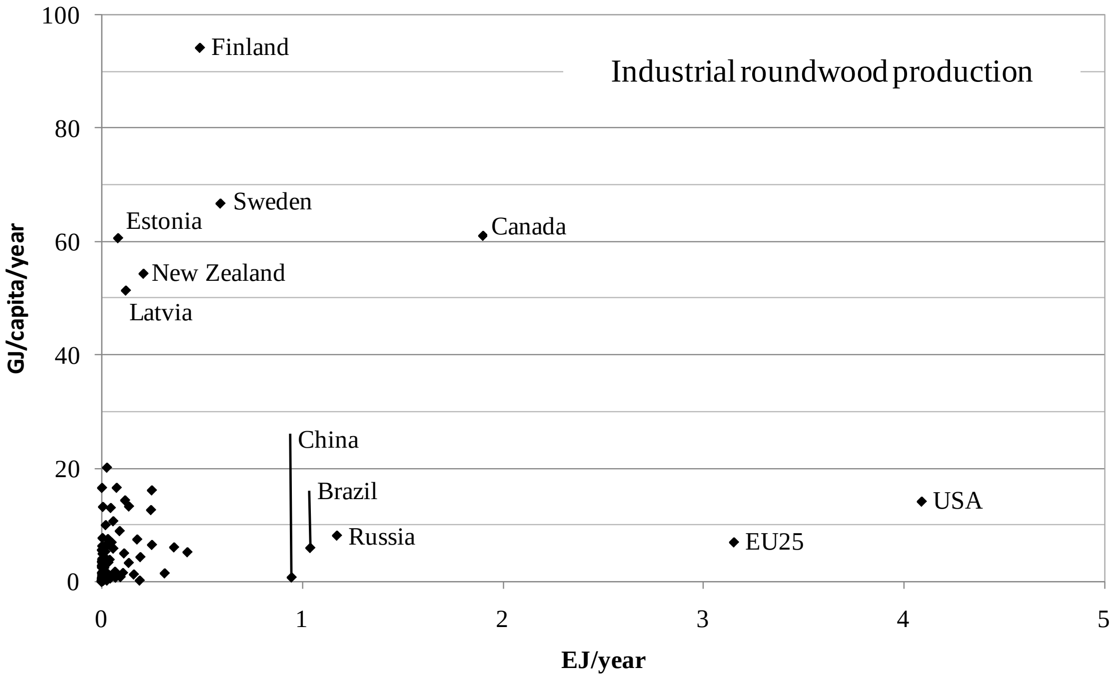

Figure 5-2 Production of major industrial roundwood in the countries of the world: average for 2000-2003 (roundwood), converted to energy units.

The figure shows the dominant industrial wood producers in the world and the production per capita in different countries. Based on data provided by the UN Food and Agriculture Organization, FAO (FAOSTAT, 2008).

Figure 5-3 below indicates for the case of Europe the feedstock supply prospects for forest biomass, showing the current wood removals and also the prospects for increased removals from forests. Current removals on forests available for wood supply (x-axis in Figure 4-3) consists of (i) the part of fellings that is removed from the forest and (ii) the removals of trees killed or damaged by natural causes such as windfalls, insects and diseases (natural losses). It excludes silvicultural and pre-commercial thinnings and clearings left in the forest, and natural

[89] Krausmann, F., Erb, K., Gingrich, S., Lauk, C., Haberl, H. Global patterns of socioeconomic biomass flows in the year 2000: a comprehensive assessment of supply, consumptino and constraints. Ecological Economics 65 (2008) 471-487

losses that are not recovered. The volumes of removals are indicative of the magnitude of the current biomass flows in the forest sector that might be available for energy purposes, a the forestry by-product streams (felling residues, silvicultural and pre-commercial thinnings, and processing by-product streams in the forest industry such as sawdust and black liquor) are of the same magnitude as the biomass flow in the form of products. It is important to note that the products are also used for energy to a significant extent after having served their primary function – however there is of course a significant temporal delay. The current removals are given in comparison to the domestic gross energy consumption, which means that the further to the right a country is in Figure 4-3, the larger is the current removals in relation to the country's gross energy consumption. Sweden and Finland have the largest annual removals in EU, corresponding to roughly 600 and 500 PJ, respectively, and as can be seen in Figure 5-3 the extraction is also substantial relative to the domestic energy use. The three Baltic States and a few other MS also have a significant forest extraction relative to their own energy use. Forest wood extraction is also large in France and Germany, but compared to the energy use in these countries it is marginal (only a few percent). Forest extraction in Poland is about half the level in Finland, and in Austria it is roughly one-third the Finnish level.

The net annual increment (NAI) minus current removals (y-axis) is a rough indication of how much the removal can increase in a given country. NAI refers to the average annual volume of increment of all trees, with no minimum diameter, minus natural losses. It is thus equivalent to natural forest growth in a year (minus the natural losses). Countries close to the dotted diagonal have an unused NAI that is roughly equal to the current removals or, in other words, the total NAI is roughly twice the magnitude of current removals. The further up a country is in the diagram, the larger is the non-used NAI compared to the country's gross energy consumption.

As can be seen, several countries could increase their removals from forests substantially, although in many countries this possibility to increase the removals is still rather small (less than 10 %) in relation to the country's gross energy consumption. For the entire EU, the current wood removal corresponds to about 5% of the gross energy consumption in energy terms.

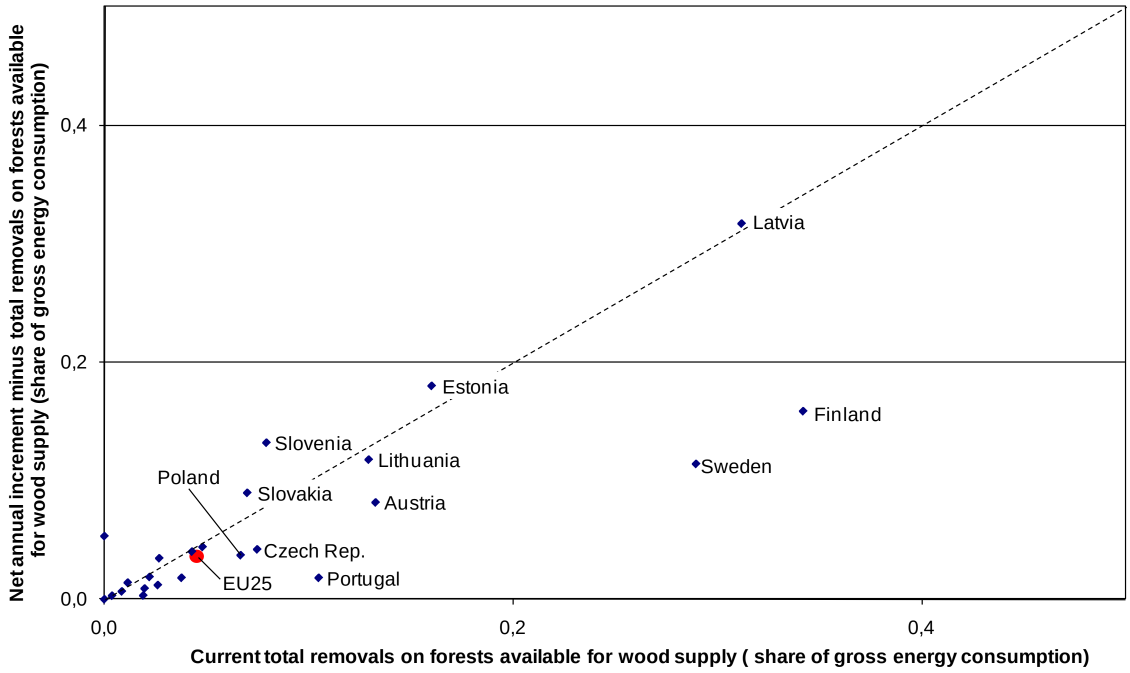

Figure 5-3 Comparison between current gross energy consumption and: (x-axis) wood removals on forests available for wood supply; and (y-axis) the balance between net annual increment and current removals in the MS.

The forest extraction and balance are converted to energy units based on assumed energy content of 10 GJ m-3 of wood and then divided by each country's gross energy consumption. Data sources: Eurostat statistical database and E.C.

6 Discussion and Conclusions

In the opening section of this report it was suggested that "*keys to unlocking the potential of bioenergy"* – or at least insights into their form – might be found via examination of a number of 'key' parameters.

While for some issues, the complexity and dynamism of the field may only allow this conclusion to provide indications of the directions that might be taken, the queries originally introduced on page 6 (Section 1.2) are taken up again here. As such, the concluding discussions for this report address:

- how and where biomass supply chains are developing – and the forms they take;
- where institutional weaknesses are apparent, and the manners in which bioenergy proponents may seek to overcome them;
- how might a professional system serving the bioenergy sector arise and serve global biomass supply chains;
- how policy positively and negatively affects bioenergy development – and where bioenergy proponents can better influence policy;
- which potential sources and forms of biomass (bioenergy carriers) appear most interesting or feasible for "acceleration".

6.1 How and where are biomass supply chains developing that can serve global bioenergy markets and which forms are they taking?

Chapter 3 presented a range of bioenergy carriers that are trading on national and international markets at large volumes. It is clear that a vibrant industry with both breadth and depth is emerging around the world. However, as well as demonstrating the wide range of biofuels as an indication of strength, this report has argued (Section 3.1) that there is a dilemma associated with the very diversity and flexibility of 'bioenergy'. This sub-section briefly reiterates details of diversity while the next section addresses the nature of institutional challenges to the emergent industry.

6.1.1 Major bioenergy carrier supply chains

While not an exhaustive list, a number of major bioenergy carriers produced at large volumes, (or emerging as large volume products) that were noted as examples in this analysis include:[90]

- Ethanol;
- Value-added solid wood fuels (e.g. 'pellets' and briquettes);
- Agricultural by-products;

[90] Pursuant to the discussions of widespread legitimacy concerns, major vegetable oil products traded as biofuel feedstocks have not been addressed here. This however, does not infer that they do not have 'major' flows and major industries in their own right.

- Woodchips;
- Roundwood (logs);
- Foodstuff industry by-products;
- Methanol, DME, FT-diesel, methane and other biofuels produced via biomass gasification routes.

6.1.2 Diversity of form

Among the bioenergy carriers above, and among other biofuels discussed elsewhere in the report, the following observations regarding diversity were also documented.

- Fuels fall in all forms: solid, liquid and gaseous fuels and range from fuels for local use, to fuels or energy carriers for large-scale export industries.

- Processes to produce fuels from bioenergy carriers span from simple and traditional processes all the way to highly technical and advanced systems – many of them still subject to research and development.

- Cultivation activities or the sources have markedly different locations and forms and the structure and scale of these varies widely. Biomass for bioenergy is produced from all scales of agriculture from small-holder farmers to large agricultural estates and industrial scale agriculture operations. Ownership structures vary just as widely from freehold, to collectives, lease farming, industrial corporation ownership, to state-owned lands and more.

- Certain biomass/bioenergy industries are central components of local/regional or national economic activities (e.g. forestry, palm oil, wheat, etc.) while others are niche industries that as yet have limited importance within the jurisdictional economic sphere.

- 'Central' industries are often highly integrated with other supply chain activities and with other industrial activities (e.g. the production of food or feed), or are based on 'by-product flows. Differing levels of market resilience, financial and political support, and capacity to enhance (or disrupt) other sectors are associated with interdependence.

- Linked to the above, some bioenergy sector activities are well established, large scale, have extensive professional networks, traditions, and clear identities. Other bioenergy industries are only emerging and lack most of these properties.

- Technologies, techniques and infrastructure for distribution, storage, shipping, etc. are established for certain bioenergy carriers (e.g. ethanol) while for other carriers (e.g. woodchips) there remain challenges for achieving acceptable logistics performance (cost, health and safety, material loss-related etc.).

- Political, social and land-use questions related to a large number of biomass/biofuel options remain unresolved – or indeed are still emerging. The sensitivity of each part of the sector to such sectors varies widely.

- The production of some bioenergy carriers is highly interdependent (or is perceived as so) upon other social, environmental and economic issues (e.g. rural development, carbon sequestration, biodiversity, water availability and quality, local or regional food prices, etc.) while other carriers are perceived as more stand-alone items.
- The horticultural 'development level' of some bioenergy carriers (e.g. a range of agricultural crops) is relatively high, reflecting decades of plant breeding etc., while for other carriers, the process of plant breeding or hybridisation for productivity enhancement, specific chemical or physical properties, etc. is as yet in its infancy.
- Trade forms, networks of trade actors, typical contract forms between sellers in the form of individual producers or cooperatives, and buyers in the form of agents, distributors or end users are dynamic and vary widely – both between different energy carriers and within markets for individual fuels.

- End-users of fuels vary widely and range from large-scale combustion (e.g. power stations, heating plants and/or combined heat and power plants) via medium scale (e.g. industrial boilers) all the way down to small-scale users (e.g. single-family dwellings, small domestic apartment blocks, schools, small public buildings etc).

- There is widely varying levels of interest or engagement from the fuel sector in upstream integration in production, or in the establishment of key institutional parameters to support the industry (e.g. establishment of monitoring/verification procedures for meeting standards/sustainability certification requirements).

As such, a picture of widespread global availability of bioenergy carriers, and a high degree of interchangeability of biomass types, supply systems and supply sources has been presented. A broad answer to the question posed is that the industry is developing nearly everywhere, and the key promise of a resilient supply system that is not dependent upon a small number of large central supply sources (as in the case of fossil oil).

However, as was also noted in the introduction, only a few of these emerging sources are likely to be able to support large scale bioenergy supply chains in the near term and this report has focused upon existing forestry, existing agricultural systems and emergent combined food/fuel strategies as prime areas for mobilisation. Moreover, as the following discussion points note, this analysis accords great importance to institutional aspects of the industry as the key factors to "unlock" the potential in these areas.

6.2 Where are important institutional weaknesses apparent and how might bioenergy proponents seek to overcome them?

Following on from the discussion outlining how bioenergy is available nearly everywhere and has many forms and levels of complexity, is recognition that this introduces considerable confusion in the eyes, minds and debates of society. Section 3.1 also presented the dilemma that in some cases the very diversity and flexibility associated with 'bioenergy' presents a significant institutional challenge to the emergent industry. It has been argued that evidence of good function within one context (e.g. one type of biofuel or one biomass production system) does not automatically serve as evidence of trustworthiness within a broader context.

This sub-section summarises the institutional weaknesses identified in this report and then points to a number of pathways that industry proponents can follow in seeking to address them. A number of these points are also followed up in Sections 6.3 and 6.4.

6.2.1 The absence of a coherent picture of desirable biofuels

The wide range of fuels, supply chains, industries and so forth has delivered a complex institutional environment. Indeed, in Section 3.2 significant room was given to discussions of how all the 'competing' product, conversion technology, supply chain, market, or service designs and the industry sub-groups forming around them present challenges. Chief among these were that:

- forms of 'conflict' or competition amongst the sub-groups that can be counter-productive for the industry as a whole can arise, and have arisen;
- confusion and uncertainty for existing and potential stakeholders is introduced (encompassing a wide range of stakeholders such as the general public, NGOs, financiers, and governments to name but a few); and
- efforts towards collective action needed to support the industry are constrained.

The analysis presented pathways that may offer partial-resolution for this challenge with work towards implicit agreement on dominant designs and common standards being presented as important for the sector. However, in recognition of the diversity of the sector (that shall never disappear); considerable flexibility is required when examining the concept of 'convergence around a dominant design'. The analysis stressed that while examples at a lower level of complexity, such as quality and performance standards for solid biofuel pellets, or even evolution of supply chains and contract forms into standard forms, may be relatively straightforward, a key issue is much more likely to be about establishing standards for 'total impact acceptable from the supply chain system'. This is an issue that closely related to efforts towards so-called 'sustainability certification' of biofuels. More feasible items within such 'standards' are already being pursued with initiatives examining the 'carbon intensity' of different liquid biofuels well underway, and moves towards minimum GHG savings requirement for biofuels already slated. A broad industry resolution and management of this area was presented as being potentially pivotal for the potential of bioenergy being leveraged.

A contributory factor also presented as being important to the achievement of wider acceptance of bioenergy carriers and their production chains is the pursuit of legitimising activities through third-party actors. Among other things this points to the inevitability of the need for third party certification of actions, products and production systems in a number of areas. It also will bring with it a series of constraints upon the industry – it can be anticipated that not all such constraints shall contribute to overall systemic efficiency or effectiveness when viewed from a technical perspective.

The term 'partial-resolution' is deliberately chosen as it was also pointed out that there will be winners and losers if and when the industry and the market establish clear (and demanding) standards – it is probable that organizations with 'better' biofuels according to such standards will gain more than others as an industry's legitimacy is strengthened.

The first winners in a category may be those first generation biofuels that do deliver high performance in GHG emissions and overall system efficiency (e.g. Brazilian sugar-cane with high yields and low carbon footprints, and certain European ethanol production systems where heat recovery/utilisation infrastructure and links to animal feed demand provide for high performance). In the longer term, there are great expectations of second generation biofuels. This sector of the bioenergy market already explicitly markets the superiority of 2nd

generation fuels over 1^{st} generation in key areas and is increasingly winning support from policy-makers (e.g. for subsidies etc.) and industry opinion-formers.

6.2.2 An emerging but ill-defined bioenergy profession

The second category of institutional weakness addressed was that presented by the limited definition of a 'global bioenergy profession'. While this analysis recognises a wide range of federations and associations in many countries, it concludes that forms of counterproductive 'conflict' or competition amongst the sub-groups still pose constraints. Such groups have a vital role to play in stimulating the rate at which the bioenergy sector and its supply chains grow by affecting the diffusion of knowledge about its new activities and thus also the extent to which it is publicly or officially supported (or tolerated). This however, requires effective trust-building and reliability-enhancing strategies within the industry, and the clear establishment of a 'good reputation' in comparison to other industries.

Among the issues referred to in this study that are relevant to the performance of a profession, the following observations are held to be of note:

- the bioenergy sector, its production systems and supply chains do not yet have clear and transparent rule-based systems for decision-making and problem-solving;

- the sector still lacks defined boundaries, formal and informal professional recognition and established sector-ethics and norms;

- the separate components or links in international biomass/bioenergy supply chains vary between energy carriers and among geographical areas, moreover, many have not yet evolved into forms that are suitable for joining together in an effective or efficient manner;

- for a number of international biomass/biofuel trade chains, the required stable relationships and linkages stakeholders and geographical areas have not yet formed, nor have actors with ownership or accountability over several chain components widely taken form;

- the links to established educational curricula and programmes in many areas remain somewhat vague and tenuous;

- the manner and forms in which bioenergy professionals and their organisations present bioenergy product or service offerings are neither internally or externally transparent – key stakeholders cannot ascertain clearly what they are comprised of, or how they perform in comparison to competing offerings;

- marketing and lobbying efforts from the sector and industry information material, be they individual or collective, still display marked inconsistency, and either implicitly, or explicitly reflect the competing nature of offerings – this is especially apparent in emerging 'areas of challenge' such as biodiversity, carbon intensity, and food versus fuel debates where differing views and agendas are common.

However, these 'symptoms of a young industry' can be addressed and to some extent overcome by deliberate action by the industry to promote increasing professionalism and identity (as was discussed in some detail in Sections 3.2.1, 3.2.3 and 3.3 of this report). Once the bioenergy sector establishes higher levels of intra-industry level of trust, they can then begin to establish more stable interactions with government institutions, other industries, and other external stakeholders. In recognition of this, the theme of actors in the industry working together within a professional identity is taken up in Section 6.3. That discussion provides more detail of how the fostering of a number of professional association forms (or vehicles for collective action) such as industry councils, cooperative alliances, and trade associations can address institutional weaknesses. It also highlights the importance of the creation and dissemination of information regarding the competencies of the new business area, and the development of links to formal education programmes.

6.2.3 An uncertain and at times uncomfortable relationship with incumbent industries

Bioenergy production systems and supply chains overlap and interact with other sectors and there are a wide range of potential synergies or conflicts with different industries. The institutional weaknesses affecting the nature of inter-industry relationships, particularly those with incumbent industries, are closely related to the issues of identity and profession discussed in the previous sub-section.

Among the weaknesses referred to in this study that are relevant to the manner in which the bioenergy sector manages relationships with other industries, the following are held to be of note:

- the industry does not have well defined boundaries or a sufficient degree of homogeneity (or perceptions of such within the market) – among other things, this fails to provide a clear basis for negotiating and compromising with other industries;
- the sector does not yet display well organised defence of boundaries and markets;
- the industry does not yet effectively manage the gathering and dissemination of information on the technical benefits – and tradeoffs – of advanced bioenergy concepts in key areas such as land utilisation, energy carrier and chemical lifecycle performance;[91]
- the sector has not developed clear strategies for the presentation of such information in forms suitable for a range of social stakeholders;
- the sector does not yet have consistent strategies for dealing with critique of the bioenergy industry, its relative efficacy, or its level of conformity to the existing norms; as such, the progress of bioenergy sector activity and its supply chains towards broad legitimacy is constantly undermined by rumours, inaccurate or skewed information – to date, much critique has been levelled by other industries or institutions with vested interests in the resources vital to the sector, moreover such action has served to induce, or promote legal and regulatory barriers to the industry;
- the industry has not yet created reliable and stable relationships with other established groups that control resources critical to the bioenergy sector;

[91] While the packaging and marketing of the accrual of positive external effects for various stakeholders (the environment, rural poor, developing nations etc.) that provide a sound moral ground for the support by government is important, the recognition and addressing of the weaknesses, inefficiencies and trade-offs is also very important.

- there are not yet widespread and formal third party processes or review that can both increase the acceptance of activities by external stakeholders, but also to constrain some parts of the industry that engage in activities with potential for negative reputational impacts.

Throughout this report it has been argued that the management of relationships with other industries can help maintain the availability of resources for the bioenergy sector, and the conditions on which they are available. While this sometimes involves direct competition for important resources or markets (e.g. related to land and land use with parts of the agricultural industry; over wood or fibre with some wood-based industries; related to fibre with the pulp industries; pertaining to overlapping markets with solid, liquid, and gaseous fuels, and so on) in some cases those important resources are investment capital and political support. In other cases the competition or 'conflict' may be more obscure. Other stakeholders that can be considered as parallels to 'incumbent industries' include environmentally and socially oriented NGOs, and UN bodies such as the FAO, UNEP, etc. The case has been presented that such actors have a 'stake' in the utilisation of resources such as land and water – and other parameters such as 'social cohesion', biodiversity, and so forth. The apparently antagonistic stance of some environmentally and socially oriented NGOs can also be viewed from this perspective. When such actors are perceived as 'an established industry', and when the important resources they compete for are seen as 'public approval' or 'political attention', or even the 'right to deem a biomass feedstock as acceptable' then the need to manage relationships becomes clearer.

6.3 How might a professional system serving the bioenergy sector and global biomass supply chains arise?

The insights into institutional factors affecting the bioenergy sector – and thus the mobilisation of its supply chains – that have been summarised in the last three sub-sections point strongly towards the need for the development of a recognised profession. They also provide guidance for areas where the existing professionals of the bioenergy sector need to focus attention. This analysis has outlined a number of areas where the formulation of strategies is required that can generate increased perceptions of reliability and reputation. These in turn can lead to greater trust and better relationships with stakeholders and resource holders. It has been argued from many viewpoints that the gaining of stakeholders trust within and around the sector can provide a basis from which to build a knowledge base both in the industry and society. Moreover, it can provide for cooperative and/or collaborative exchange with other industries. Such interactions in turn make it easier for the sector to organize itself collectively and to build a sound reputation for their industry.

Spheres for the professional system to act within were examined in two separate discussions within this analysis.

Building professional corps – Section 3.2.3 presented how professionalism within the sector is important to progress. In addition to the development of skilled professionals and vocational workers, the industry needs to create information regarding the competencies of the new business area and assist in its dissemination. As well as the obvious role for training professionals for the sector, the formation and maintenance of links to formal education programmes is an important part of defining the language, concepts etc. that other external opinion builders such as the mass media use in their interpretation/representation of the sector. In this light, it is vital that the sector seek to support the formalisation of bioenergy related courses (both vocational and university based), degrees and post-graduate studies.

Moreover, the management of the relationship with other industries is a vital role for growing 'bioenergy profession' and the professional networks attached to the sector – the development of these management skills (as distinct from 'technical' skills alone) is also a key area for effort.

Collective action in the bioenergy sector Section 3.2.1 in particular addressed the role of collective action in the form of industry councils, cooperative alliances, trade associations, and the like, in pursuit of effective trust-building and reliability-enhancement. Among other things, the discussion touched upon how such representatives of the industry must communicate for: public trust and acceptance; to ensure that domestic and industrial consumers trust the 'systemic performance'[92] of the energy carriers they purchase; and to build and maintain a *'good reputation'* of the industry relative to other industries – particularly in environmental and social spheres. While intra-industry competition over product/service designs and standards is inevitable (e.g. due to the field's diversity) the ongoing discord within the industry contributes to confusion and uncertainty among external stakeholders. Collective action in 'bioenergy countries' must work towards reducing such institutional barriers as it does in some countries (such as Sweden). With a global supply chain focus however, it is proposed that there is much more that can be done beyond national-level activities or interests.

Action to promote progress in global bioenergy supply chains The content of this concluding chapter has noted many areas of weakness. The reader will also note that many of the actions required to overcome such weaknesses have been discussed within the report – with examples of many being drawn from current practice. Thus, a clear message from this work is that such actions are ongoing and should be built upon – there are few if any areas where the sector is to start from scratch. While not an exhaustive listing, nor a summary that seeks to demonstrate recognition of all progress thus far, action in the following areas by the bioenergy 'professional collective' is deemed important:

- to seek to enhance the understanding of the sector by a broad range of social stakeholders; in particular it is suggested that gathering and dissemination of (open and transparent) information on the technical benefits – and tradeoffs – of key biofuel cycles in key areas such as land utilisation, energy carrier and chemico-physical lifecycle performance be performed;

- to promote broader acceptance of sector activities via the development of common and transparent strategies for communicating the technical complexity, the potential trade-offs, and the management strategies being pursued, in the more 'difficult' areas of bioenergy (e.g. competition for land with food production, threats to biodiversity, etc.) – all in recognition that much is already being done, but that the success of work has been varied;

- to promote broader acceptance via concentrated efforts to even more closely align bioenergy systems (particularly advanced bioenergy systems) with established, better understood or 'taken for granted' systems such as the petrochemical refining sector, the pulp and paper sector, the specialist chemical sector and more; again whilst such

[92] A deliberately broad meaning is implied here – this could encompass a range of contexts all the way from the functional quality of a biodiesel in an engine, or a pellet in a furnace, to the life-cycle impacts of a biofuel as assessed by detail life cycle assessment.

efforts are clearly evident today, we recommend an explicit strategy of highlighting positives and dealing with potential negatives (see above);

- to facilitate understanding and acceptance via the encouragement of intra-industry relationships and trade associations – and in particular tasking them with the roles of supporting the progress of advanced bioenergy in a coherent and coordinated fashion, and working closely with the policy community.

In more general terms, this analysis has also provided evidence that each of the generic strategies outlined in Section 2.2 are relevant to the sector in some way. Summarising these in the context of 'unlocking the potential of bioenergy', the professional actors and organisations need to continue and accelerate efforts to:

- pursue and shape alliances with other related industries, organisations and institutions that have control over the resources that the bioenergy sector requires – the ongoing mobilisation of collective action in the form of industry associations will be a key part of such activities;

- work to support development of a professional guidance system or general 'codes of conduct' for the bioenergy profession – within such work, the language, terminologies and 'ways of doing things in the bioenergy business' need to be refined so that they are both acceptable and readily recognisable for key external stakeholders;

- facilitate convergence around a 'dominant design' – in this instance there is, and shall never be a 'standard biofuel' – rather the relevance of this category of work is related more to minimum standards of social, environmental and technical performance for bioenergy carrier supply chains as compared to alternatives; rather than just a burden for the industry, these developments also need to be pursued proactively as a key 'licence to operate' issue;

- rationalise, streamline and encourage the utilisation of consistent messages and information in key areas (e.g. in political lobbying or responses to critique in areas such as environmental/technical fuel system performance, recognition of strengths and weaknesses of differing energy carriers, need for subsidy support, etc.) – in the recognition of growing evidence of poor performance from some parts of the industry, it appears likely that such processes will unavoidably involve the uncomfortable reality of the 'bioenergy collective' that have fuels that fall within the 'dominant design' mentioned above, distancing itself from some biofuel supply systems;

- support and promote the 'legitimisation' of biofuel supply chains via assessment and approval processes via recognised and respected third-party actors – with this strategy principally contributing to the consistency and trustworthiness of information from the sector, particularly that utilised in collective marketing and lobbying activities required to promote the industry;

- create and promote linkages with established educational curricula – with this work serving multiple purposes such as providing vocationally and professionally trained personnel; reinforcing the mainstream messages, language, and codes of conduct for the industry; contributing to widespread recognition and more complete understanding of the sector's activities, and so forth.

In essence, the list of recommendations above relate to ensuring that professional systems and organisations within those systems develop into increasingly mature and accepted institutions. As has been indicated above, professional systems should have both industry-internal and external functions. External and inter-industry functions have significant influence on the fostering understanding and acceptance via various forms of communication to, and interaction with stakeholders. Intra-industry roles also need to focus on improved flows of information and functions that serve to provide a stronger 'internal efficiency' such as the operation and coordination of trade chains and production systems, but they will also need to take on some 'controlling' or 'quality control' role regarding what the industry stands for, and what constitutes suitable or acceptable behaviour and performance.

6.4 How policy affect bioenergy development – and how might policy be influenced?

Examination of policy interventions for biofuel chains presented in this report indicates immaturity, and it can broadly be said that they have functioned in manners different to that originally envisaged. The examples of policy interventions presented have stimulated the industry in a number of ways, but areas can also be seen where they have also retarded development. Policy interventions can negatively affect both the actions of the industry, the responses from external stakeholders, and the overall reputation of the sector. This study has indicated that issues of legitimacy are already one of the biggest challenges facing the sector, and that this is also reflected in the policy sphere.

At least three important and substantially interwoven themes have been observed in cases and these are briefly discussed below. All of these also point to areas of need for 'policy-influencing work' for the bioenergy professional collective that has been extensively referred to in earlier discussion.

The first can be perceived to be variation in the 'quality' of policy interventions in their role to support bioenergy technologies, supply systems and trade. An obvious inference being that if the policy has too many flaws then there is higher potential for outcomes being substantially different from the original stated goals, and higher potential for damage to the industry. In two of the cases presented (e.g. ethanol and RME systems), contributory factors to negative effects included that the policy frames in place supported systems that: may be outdated or soon outdated by some emerging or potentially disruptive technology system; had limited potential for improvement in comparison to alternatives; did not offer demonstrable gains in (some) key policy areas (e.g. GHG emissions); or supported goals that themselves may not have long term stakeholder legitimacy (e.g. increased plantings of oil seed crops). Even the case presented as a 'successful mobilisation' for a global biofuel supply chain (the Australian pellets case) was in essence an unexpected outcome of an intervention that has only partially met the goals that were originally set for it. Moreover, policy cases also displayed elements of problems with legitimacy. The need to make policy that will be legitimate among stakeholders in the longer term was clearly an area requiring work in all of the cases presented.

The second point relates to the areas where investments from the side of industry seem to have gone awry; not just because they were reliant upon the policy for economic viability, but also because, to varying degrees they failed to fulfil categories of 'technology system quality' defined within the description of 'quality' policy interventions. The inference in this case being that if the technology system has too many flaws (and particularly if it does not deliver performance in line with policy goals), then policy support will eventually reduce or disappear. As the cases show, for the bioenergy sector, this can happen even if there are strong lobbies to protect the interests of the technological system. Again the RME and ethanol cases reflected this theme strongly. Industry (or the bioenergy collective) must test its systems better in this regard. The theme of 'winning technologies', 'dominant designs' and so forth – and the role of the bioenergy collective in supporting those systems that have high performance that has been taken up in previous sections, is central to this process.

The third area is related to the diligence of industrial and political sphere research and intelligence gathering as carried out by industry actors. While the 'wisdom of hindsight' of course makes it easier for analysts to see problems *ex post*, it does seem that industry should have seen some of these problems coming much earlier than they did. The inference in this third area is that factors such as inexperience, a lack of established norms for decision-making and problem-solving, and the absence of a 'market history' have contributed to difficulties. Examples were found where the due diligence processes undertaken by actors in the bioenergy field were insufficient in the areas of a) assessing the vulnerabilities of their technologies to varying market influences, and b) the vulnerabilities of their businesses to policy shifts. It may also be that industry sectors with vested interests (e.g. agricultural producer associations supporting canola/rape or wheat production for biofuels) will generally be 'blinkered' in this regard and may always seek a way to make their system appear strong, or to convince themselves that it is. It is observed that this appears to involve such actors convincing themselves of the infallibility of their system as they seek to gain or maintain political support. This analysis has identified a strong need for the bioenergy sector to develop strong internal control mechanisms – strengthened by third party controls – to help ameliorate such phenomena.

Further, the cases indicate that the development of strategies for communication between the policy sphere and the bioenergy community that are objective, transparent and recognise these problematical issues and potential tradeoffs are required.

As a final comment, with the possible exception of the emergence of international sustainability certification schemes, this study has not found significant examples of policy instruments that set rules and regulations with such cross-chain coverage (e.g. addressing the international biomass/biofuel trade chains). Rather, current markets appear to be growing in response to policies introduced in geographically distinct areas.

6.5 Which potential sources and forms of biomass (bioenergy carriers) appear most interesting or feasible for "acceleration"?

The work documented in Section 5 provides quantifications of biomass resources judged as 'potentially' available in the short to medium term. The prime focus was placed upon biomass resources based upon residue and waste flows in agriculture and forestry, and the development of dedicated feedstock supply systems from these sectors. The point of departure for the work was that, in the near-term at least, major supply flows will be based on plants that are already cultivated at significant scale.

Projections conducted here indicate that there is large potential for new biomass for bioenergy flows to be achieved via 'intensification' and 'efficiency' strategies. Importantly, these strategies would not be based upon the simple expansion of plantings to take up 'all land where energy crops theoretically can be produced'. Indeed, it has been argued that plans to follow such strategies, or even discussions of such, have significant potential to defray the legitimacy of sector. Examples of such issues involve cases that encompass where deforestation or conversion of natural grasslands. Nor are 'intensification' and 'efficiency' strategies discussed here based upon simple 'displacement strategies' (e.g. fuel grown in place of food or feed) – again a major issue for legitimacy.

As with most topics addressed in this study, it is again found that there are two important sides biomass/bioenergy supply in the short to medium term. First, there is the securing of the technical production potential for energy purposes. Secondly, there is the need to maintain, or gain the legitimacy of such production in the eyes of critical stakeholders. Once again, the promotion of deliberate approaches to ensure supply of biomass from sources more acceptable to key stakeholders will be central to this.

Within agricultural systems, the expansion of recent years has been driven by both investment inflows from new investors and by growth and internally funded expansion in response to increasing demand – and belief in growing market potential. A prime example provided within this category is the Brazilian ethanol sector. While not without critique, there is a broad consensus that this industry can perform well against the criteria that external stakeholders are increasingly demanding for biofuels (e.g. sustainability criteria).

Other agricultural sectors have also shown that they can rapidly expand (e.g. crops such as oil palm, maize, soya bean and rape seed) – however, such energy carriers are markedly more contentious and a broad observation would be that the legitimacy of their application in the energy sector is reducing as time passes, and as scientific knowledge of the environmental and social implications grows (in the industrialised west at least).

When such viewpoints are taken into account, major constraints that appear likely to grow in strength, or emerge are related to the legitimacy of bioenergy carriers based in such systems. This links to both discussion of 'certification' schemes taken up in Section 3.2.2 and to expectations that social and political concerns will escalate in the future (as opposed to dying down or shifting to another issue).

Further, this analysis works from the supposition that factors such as steady upward demand for food and land, combined with more focused and effective technology transfer will drive productivity increases in areas where land is already cultivated, but where the yields derived from it are low or relatively low. It is indicated here that it is realistic to generate projections with faster animal food productivity increases than in other forecasts (e.g. the FAO). As a result, this study (and the modelling that underlies it within related studies) yields markedly different results than such projections. Rather than requirements that the global agricultural area expand by some 280 Mha by 2030 in order to meet global needs – thus leaving little room for dedicated energy crops – the contrasting scenarios provided here, show that there is substantial scope for land-minimizing growth of world food supply by efficiency improvements in the food chain. The most marked differences are achieved by change in animal food production, and dietary changes toward less land-demanding food. Indeed, the work here indicates that it is feasible to reduce global agricultural requirements by some 230 Mha from current levels over the period to 2030. If this higher productivity is combined with an additional 20% substitution of pig and/or poultry for ruminant meat in human diets, then the agricultural area could decrease by an additional 480 Mha. These figures provide for a total land demand of some 1000 Mha less than that projected by the FAO.

However, this 'freeing up' of nearly a billion hectares of land for energy production will require degrees of social change. While the scenarios presented here do not require radical change towards widespread vegetarianism (a trend shift that goes against mainstream expectations of dietary trends with development), they do demand shifts such as that from ruminants to pork and poultry, and much more attention to modernisation of agriculture in areas with low productivity (as against viable potential productivity). To achieve such, both social and political effort will be required to achieve both faster changes in land productivity – and shifts to less land demanding food patterns. Such changes do not however, need to rely solely upon choice or norm related issues in human society. Economic drivers are also a feasible driver.

Importantly, as bioenergy becomes a sector with (relatively) higher ability to pay for feedstocks, then economic forces can make it attractive to pursue land-use shifts without necessarily causing expansion displacement implications. Pursuit of spatial and temporal intercropping regimes can be pursued in many climatic spheres. Indeed, as one clear example, the pursuit of farm forestry as a synergistic production strategy alongside food crops and grazing may in many cases be able to yield both food and fuel – in many cases without reduction of food production.

Again examining the other side of the coin, the volumes feasible for relatively near term mobilisation may be larger than even those estimated in mainstream modeling conducted by associations such as the FAO. This places an immediate requirement that current users of biomass find other biomass sources. This discussion has shown that in a number of cases, this issue is one that can also constrain the bioenergy sector – competition in some areas bears with it social or political legitimacy issues. Pursuit of production or processing pathways that deliver synergies with potential competitors, combined with clear communication of the synergies, may be more successful in this regard (e.g. a number of bioenergy-based agricultural systems also generate new feed sources for the food sector; further, combination of food, feed, fuel and material production strategies is central to the so called biorefinery concept – seen by many as a manner in which multiple benefits can be obtained from agricultural biomass).

While more difficult to reconcile with 'short term mobilisation' of biomass, this analysis has pointed out that longer term concerns (particularly technical) should also guide shorter term decision-making. There are already a number of cases where the industry must consider the medium to longer term risks of lock-in when seeking to scale up the sector. The cases in Section 4 also highlight technical issues that limit system efficiency. These can be result from the nature of the fuels themselves (e.g. biodiesel), or limitations of the systems of production. To take an example in this regard, the functionality of fuels themselves can place an important constraint as they already appear poorly aligned with longer term technology strategies. While products such as soya and palm oil can produce large volumes of oil (and at relatively large per hectare yields in the case of palm), they will largely supply the production of esterified diesel fuels. It appears unlikely that such fuels will fit well with mainstream diesel infrastructure (particularly engines) while 2nd generation biofuels fit very well.[93]

Further, while specific parts of the sector may indeed have potential to rapidly expand, issues developed in this discussion such as public expectations indicate that constraints related to acceptance can act in the shorter term. Such issues need to be recognised now and then factored into longer term technology plans for development of the industry. The potential of

[93] Note, however earlier discussion of NextBTL technologies that circumvent this challenge for vegetable oils.

certain parts of the sector to mobilise at large scale may not be optimal. (E.g. a key example being south-east Asian palm oil; while this sector has significant capability to expand to deliver biofuel to markets such as the EU and the US, key legitimacy concerns are very likely to significantly constrain the markets in these jurisdictions – pursuit of this pathway of biofuel delivery has potential to damage the industry in the medium-to-longer term).

Forest biomass – Shifting from the key focus of biomass from agricultural systems to that of forest biomass systems – while the overall scale of global roundwood production remains modest in comparison to fossil fuel production (e.g. the total EU roundwood production when considered in energy-content terms) is estimated to represent 5% of gross energy consumption), the accelerated pursuit of two strategies are shown to offer considerable additional volume potential. First reduction of felling losses combined with recovery/processing for bioenergy may add significantly to existing potential. Secondly the valorisation of silvicultural fellings for biofuels has significant potential. The latter offers the added bonus of increasing the conduct of the actual thinning activities (often neglected due to the required investment of additional resources) which in turn accelerates forest growth and increases overall forest productivity. As forestry is an established and ongoing industry, the accomplishment of markedly expanded harvest and thinning waste recovery activities should be viewed as a short term strategy of prime importance.

Moreover, as shown in the Australian forestry plantations case presented in Section 4.1, plantation forestry systems can expand rapidly providing significant thinning, harvest waste and processing streams for bioenergy (as well as roundwood-based fuel in some circumstances).

Structural wood and wood fibre recovery systems exist and expansion capacity considerable (proven in EU countries, particularly in the presence of regulatory regimes that require separation and recovery (e.g. EU landfill directive banning landfilling of organic materials). Also an avenue that bioenergy collectives should pursue – the industry offers advantageous valorisation of waste material. Moreover, despite the different first-use lifecycles for fibre (e.g. from weeks for some paper fibre to many decades or even centuries for structural timbers) there is no temporal delay. These materials are in circulation already. In many jurisdictions it is simply the set up of recovery, separation and valorisation systems that is required.

6.6 Concluding remarks and suggestions for future work

At the outset of this discussion document, we indicated a belief that there is a significant gap in the debate enfolding global bioenergy potential. We claimed that there is too little attention paid to how large volumes of biomass for bioenergy may be brought to the market; or where it may be most feasible to mobilise supply chains in the short to medium term. In seeking to add new insights in such areas we have presented and discussed phenomena that can help answer the questions posed at the outset of the report:

How can we mobilise global bioenergy supply chains?

What are the keys to unlocking the potential of bioenergy?

While we cannot claim to have answered these questions, the "keys" outlined in this concluding chapter share common themes and do appear to point consistently towards the types of actions required. Efforts towards the achievement of industry professionalism and maturity, public and political acceptance, aligned collective action, synergistic alliances with incumbent industries, careful application of third-party assessment schemes, the building of resilient technology strategies, and the sourcing of biomass via pathways that remain accepted in the eyes of a broad stakeholder group, have been shown to be vital.

All of these themes – and the difficulties that arise when they are not addressed adequately – are common to other industries that have grown in the past. As such, the bioenergy sector can look to the experiences of others as it seeks to build its own future. We have presented evidence that many of the components required for progress are developing, but that there remains much to be done. Moreover, as the experiences of other 'emerging' industries have been documented in management literature, there are a number of rational and relatively proven strategies that can be used for guidance.

However, this analysis has also been exploratory, and has relied largely on theory to underpin some of the arguments put forward. More evidence from the field is vital to enrich this work and the value it may offer the sector. It is held that focused research work in a number of areas is required. This must concretely document where, how and when the industry might act to achieve advancement of global bioenergy supply chains in the areas outlined in this chapter. A number of examples of work that we consider necessary are presented in sketch form in the text below.

International dissemination and review of this report – while relevant to the work of the Swedish bioenergy industry, this exploratory analysis has a strong international perspective. The potential for the ideas and approaches outlined in this work to enter the discussions, debates and strategy forming within the bioenergy industry will be substantially enhanced if international dissemination and review is achieved. It is suggested that this work be linked to the activities of IEA Bioenergy Task 40 (Sustainable International Bioenergy Trade) and Task 43 (Biomass Feedstocks for Energy Markets) in the near future. In the first instance, discussions can be taken up with IEA Bioenergy decision-makers that propose that this report forms the foundation for a joint work within those IEA networks.

Leveraging the potential of bioenergy collectives – the important roles for bioenergy industry collectives in facilitating the growth of bioenergy supply chains have been discussed and highlighted throughout this report. Moreover, a relatively high degree of development, coherence and influence held by Swedish collectives has been postulated. If these assertions are valid, then documentation and dissemination of Swedish experiences, and the pathways by which legitimacy and influence have been built and enhanced over time, may be very valuable for other less established bioenergy networks around the globe. In turn, strengthening of external international industries has potential to reinforce the Swedish sector and enhance national security of bioenergy supply. It is suggested that work be outlined and developed in areas such as: longitudinal analysis of Swedish bioenergy network development, and translation of key learning into strategies for other countries; and development of cases documenting the emergence of bioenergy collectives in other countries deemed important to global biomass supply chains (with particular focus on Swedish cases).

Strategic planning for provision of vocational and professional skills and knowledge – It has been argued throughout this report that increased and coherent professionalism within the sector is important to achieving the potential of the bioenergy sector – both in Sweden and abroad. A review of the processes underway to meet the demand for skilled professionals and vocational workers is warranted. Also, deeper analysis of how the industry is working to train resources and feed dissemination processes is needed – particularly how links to formal education programmes are being developed and maintained. Again, a process of international benchmarking in this area may provide important input for development of strategies in this area.

Stimulating agricultural intensification, intercropping and land-use change – projections documented in this study indicate very significant potential for new biomass for bioenergy flows to be achieved via 'intensification' and 'efficiency' strategies, and via pursuit of multifunctional land-uses. One example of these are those that seek to include activities such as farm-based forestry rather than just displacement of certain crop types, or market destinations, with others. The analysis has pointed out, from a number of viewpoints, that the sensitivity of key stakeholders in areas such as livelihoods, food-versus fuel, biodiversity, and social-cohesion can place significant constraints upon these strategies. In recognition of the importance of many perception-related issues, it is held that production strategies also need to be carefully combined with explicit planning for legitimacy-retention or enhancement. Qualitative as well as quantitative research work in this area – in the first instance based upon promising or successful cases – may provide the sector with the insights required to achieve large scale acceleration of successful efforts in such areas. It is suggested that initial efforts focus on a review of efforts to achieve agricultural intensity gains in important biomass-for-bioenergy supplier countries, and upon case study documentation of large scale multi-land use efforts – again in countries with significant supply potential. It is envisaged that case study assessment should also address different combinations of incentives, policy drivers, land tenure models and capital mobilisation being applied in different areas.

Mapping effective trans-national biofuel supply chains – many international biomass/bioenergy supply chains remain disjointed and require frequent reformulation and adjustment. They remain somewhat volatile, and stable effective links between stakeholders, clear ownership models, and secure geographical hubs have not yet formed. Moreover, such emerging chains are affected by policy shifts and variation in rules from jurisdiction to jurisdiction – as well as variation in diverse parameters such as availability of capital and political risk. There appears to be a need for assessment of differing policy or market based instruments that can achieve degrees of regulation to address cross-chain coverage and accountability that can support the growth of international biomass/biofuel trade chains.

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