

Innovation in Bioenergy Business Development

Summary and Conclusions from the IEA Bioenergy ExCo60 Workshop

This publication provides the summary and conclusions from the workshop on 'Innovations in Bioenergy Business Development' held in conjunction with the meeting of the Executive Committee of IEA Bioenergy in Munich, Germany on 29 October 2007.

The topic of the workshop was in tune with recent developments in the work of the Bioenergy Implementing Agreement, which is increasingly concerned with business and implementation issues and their inter-relationship with policy development. The Committee wanted to seek exposure to new ideas from outside experts.

IEA Bioenergy

IEA BIOENERGY: EXCo:2008:03



BACKGROUND

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The workshop programme consisted of four sessions. The first provided an opportunity to discuss how Governments could create conditions for business growth through the development of institutions and policy measures. The second session provided for some industry perspectives. The third discussed some efforts aimed at removing barriers to the implementation of technologies once beyond the R&D stage, and the final session discussed issues relating to technology deployment in the developing world.

The workshop consisted of eight presentations from invited speakers, mostly working outside the IEA Bioenergy Agreement. The main points made by the speakers are summarised below.

SESSION 1: CREATING THE CONDITIONS: INSTITUTIONS AND POLICY INSTRUMENTS

Emission Trading and Business Opportunities – Martin Gavelius, Öhrlings PricewaterhouseCooper

Martin Gavelius based the first part of his presentation on the results of PWC's annual power utility survey. The survey indicates that the power utilities sector appears ready to make the changes that arise from the threat of climate change. Renewable and nuclear power are at the top of company agendas in each of the four world regions, ahead of clean coal and carbon capture and storage which are seen as options for the longer term.

The report had also looked at the impact of EU Emission Trade Schemes (ETS). Over 66% of European respondents reported that this had stimulated investment in renewable energy systems, with 60% of respondents believing that carbon prices under the second allocation period would be between 10 and 20 Euro/tonne.

Respondents believe that the factors below will be important in making the EU ETS successful in future:

- Extending the schemes to embrace other industries.
- Longer term trading periods to ensure greater certainty.
- Auctioning rather than benchmarking.
- A global and generally accepted approach to monitoring, reporting and compliance from regulators, scheme participants, financial investors and intermediaries.

The EU is setting an ambitious renewable energy target of 20% by 2020 compared to the current level of only 6.5% – an intended increase of over 200% in 13 years. Meeting these targets will rely heavily on wind and biomass, including an 80% increase in biomass for heating. Biofuels will provide the only large-scale substitute for petrol and diesel in transport.

The EU is also leading the way as far as finance for projects via Initial Public Offerings (IPO's) are concerned, with around 55% of world value invested in the EU. But the USA leads the field as far as venture capital investment is concerned with 72% of world value, and 46% of issued patents. Most parts of the EU lack investment, with over 40% of European Cleantech investments coming from the UK. There is also a shortage of Cleantech companies in the EU – probably because of a dearth of investors prepared to take above normal risks. Business is therefore reliant on business angel activity.

Cleantech venture capital investment expanded rapidly in 2006. 70% of investment is concentrated in the energy sector, with increasing interest in bioenergy. For example, Swedish energy and environmental investments have increased by 300% from Q4 2006 to Q1 2007. 74% of venture capital companies see 'Cleantech' as the most interesting sector for future investments.

While there are strong drivers for investment in the bioenergy sector (such as future electricity spot prices, green certificates, future carbon prices and biofuel market developments), investment in this sector is still seen as more risky than some other sectors, with a market risk premium of around 4.5%.

The profitability of bioenergy-to-electricity projects is sensitive to future electricity prices and to biomass fuel prices. However, sustained growth in investment in the sector is to be expected.

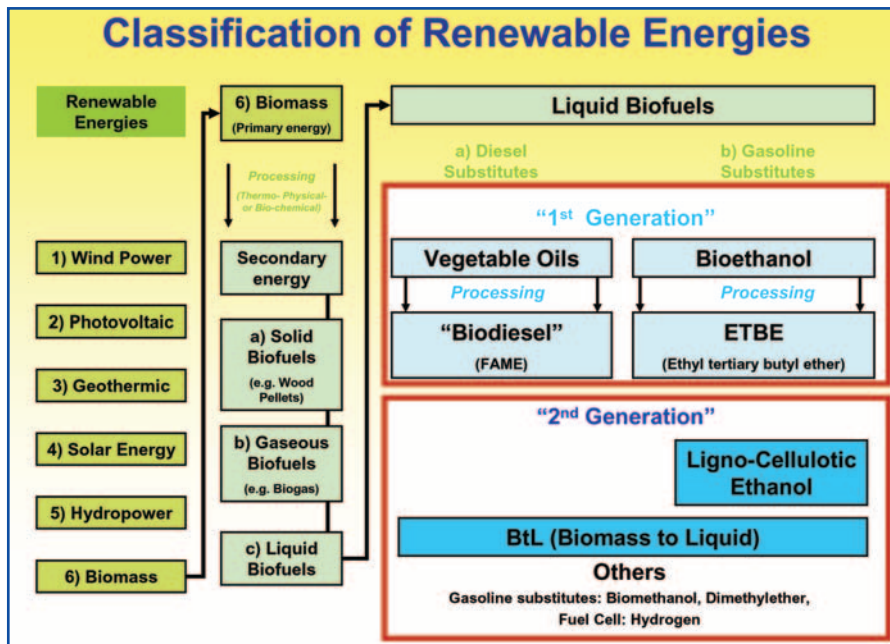
The Role of Policy and Institutions – Hans-Harald Jahn, European Investment Bank

The European Investment Bank (EIB), set up in 1958 under the Treaty of Rome, is a source of long-term finance. It provides support for investment in six EU priority objectives which include energy and environmental sustainability. As an AAA-rated borrower, EIB can offer its partners advantageous loan rates and longer loan maturities. EIB will support projects which are risky, economically sustainable, and environmentally sound.

The EIB is supporting the EU Bioenergy Action Plan and the EU Climate Change Programme and in the energy sector is focussing on five core areas:

- Renewable energy.
- Energy efficiency.
- Research, development and innovation in energy.
- Security and diversification of internal supply.
- External energy security and economic development (neighbour and partner countries).

EIB is able to fund up to 75% of investment costs when key policy objectives are met in this sector.



PowerPoint Slide from Presentation by H-H. Jahn.

As far as biofuels projects are concerned the key preliminary screening criteria which are applied are as follows:

- Environment and Climate Change.
 - Greenhouse Gas Emission savings.
 - Other environmental effects such as reduction of desertification etc.
 - Agricultural practices.
- Different Policies at Different Levels.
 - Country's, EU's and EIB's renewable energy policy.
 - Domestic regulation, taxation in place for biofuels blending.
 - Other policies.

EIB's assessment indicates that '1st generation' biofuels technologies are the best developed technical processes available at industrial scale, and the only realistic option to achieve the EU's 2010 biofuel targets. These processes have low conversion costs when compared with 2nd generation technologies. However high quality feedstock is needed and co-product sales are crucial to sustainable project cash flow. Therefore EIB's present strategy aims to:

- Support sustainable and viable 1st generation projects.
- Support R&D for 2nd generation biofuels.
- Avoid 'White Elephants' and the creation of overcapacities.

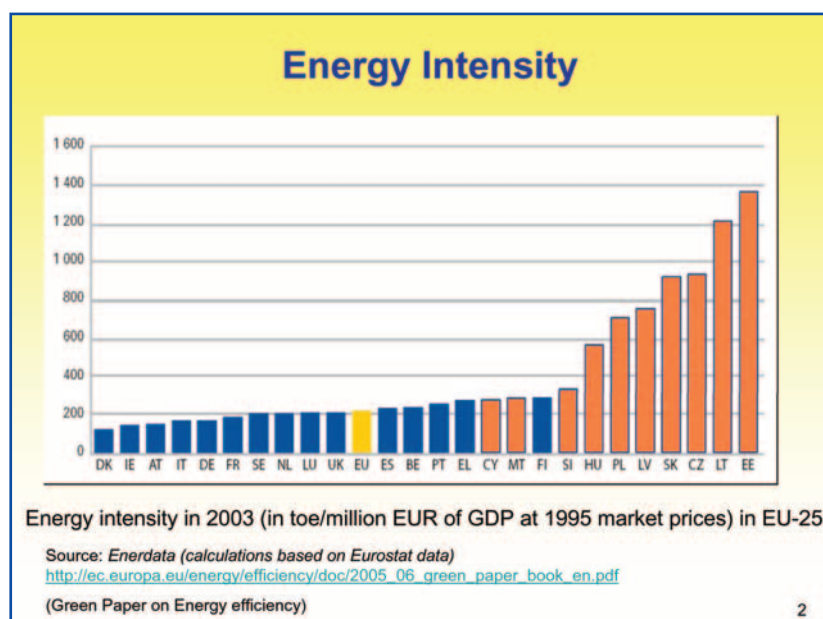
As EU policies are developed EIB will aim to:

- Support projects which are in line with the strategy to achieve 2020 targets.

- Support viable technologies for 2nd generation production plants.

EIB is currently supporting two UK plants using sugar beet and wheat to produce ethanol, along with an expansion of wood pellet manufacturing capacity in Germany and Finland. In addition indirect support has been made available for a range of small-scale biogas plants in various European locations.

There will be a particular focus on urban renewal and waste water projects in Eastern Europe, where there are many opportunities to upgrade district heating schemes and sewage treatment works, and per capita energy use is much higher than in the rest of Europe.



PowerPoint Slide from Presentation by H-H. Jahn.

SESSION 2: INDUSTRY PERSPECTIVES

Advancing Cellulosic Ethanol – Alain Destexhe, Novozymes North America Inc.

Novozymes is a world leader in industrial enzymes, and had a total market value of DKK 15 billion in 2006. Enzymes account for 95% of turnover. More than 600 products are sold in 130 countries and 40 different industries. Around 13% of sales income is invested in R&D. This has led to more than 5,000 granted or pending patents. The main production sites are in USA, China, and Denmark.

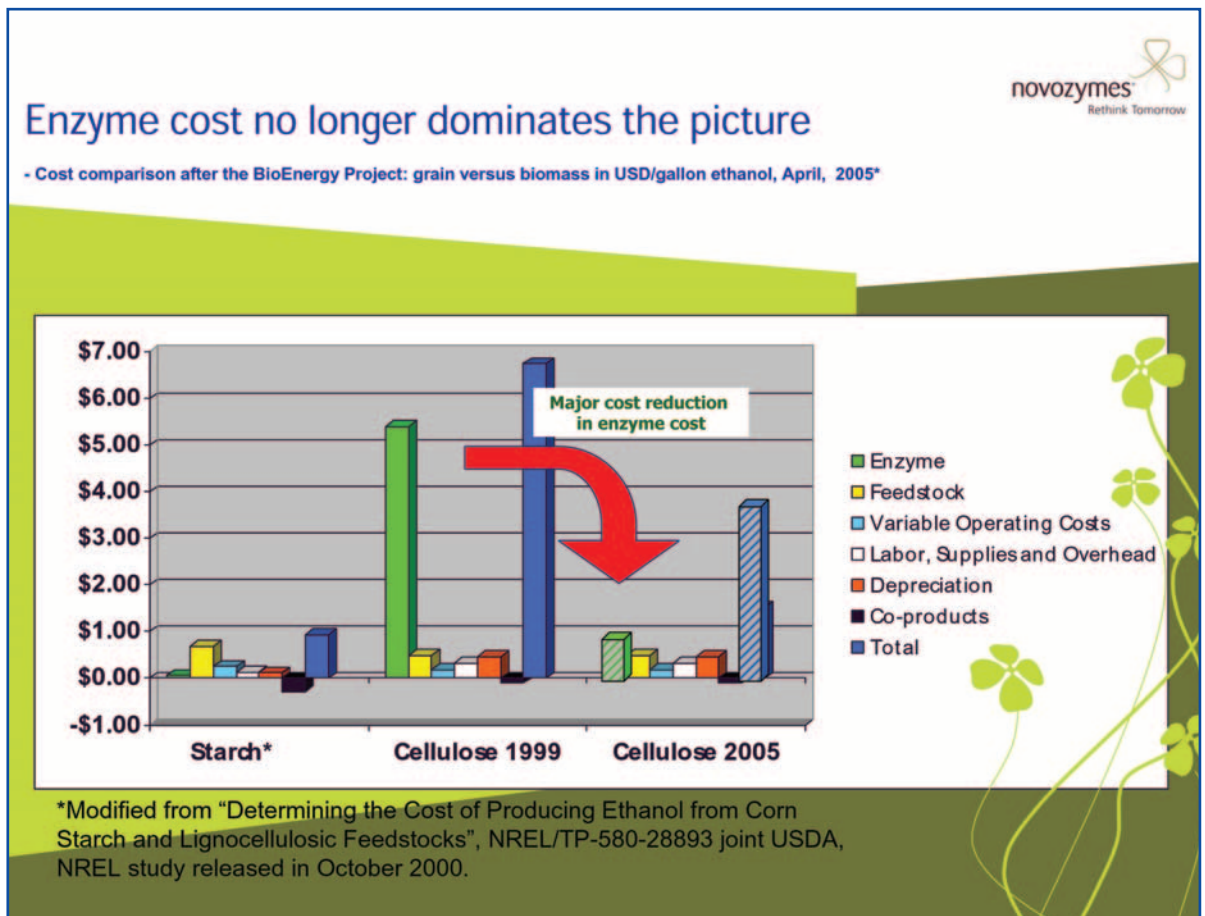
As the largest supplier of enzymes to the fuel ethanol industry Novozymes expects to see a 20-25% growth in business in this sector in the next four years. Their raw starch hydrolysing process is used in the corn to ethanol process in the USA, and they are developing collaborations with a number of international players in Europe, South America, and Asia. Unless a breakthrough happens, they expect fuel ethanol growth will be dominated by sugarcane and starch through 2020 when cellulosic biomass may take over as starch and sugar become expensive and scarce.

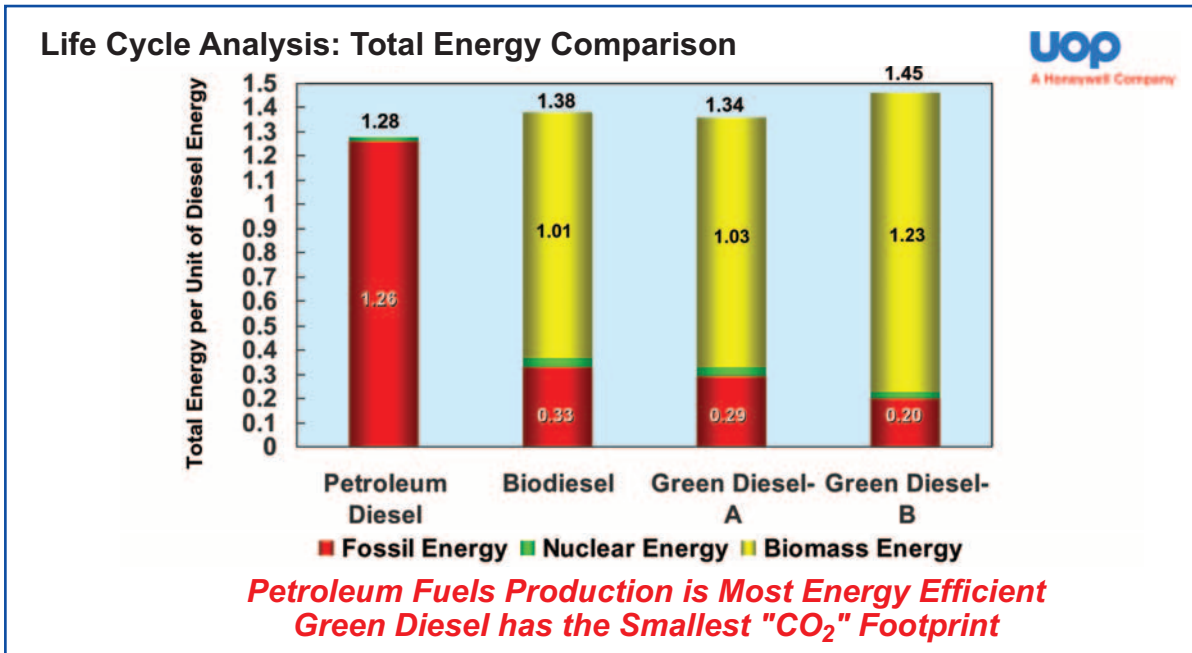
Many challenges remain to be solved before the cellulose to ethanol process matures, and there is a need for process integration. However enzyme costs no longer dominate the

picture, following recent work by Novozyme and NREL and funded by US DoE which led to a 30-fold reduction in enzyme cost. It is now anticipated that 2nd generation bioethanol will prove to be a very attractive replacement for gasoline for both economic and environmental reasons. However the 1st generation bioethanol market must be established in order to facilitate the transition towards 2nd generation bioethanol, by establishing the infrastructure and logistics.

Good progress has been made, but many pre-treatments do not fully solubilise the hemicellulose fraction in biomass. These pre-treatments are attractive as they generally have lower capital cost and are friendlier to fermentations. Hemicellulose deconstruction requires many more enzyme activities, but hemicellulases are generally poorly expressed relative to cellulases, so they cost more. The goal is to devise a hemicellulase mixture that is cost effective.

Novozymes believe that it will be four years before a commercially viable cellulosic ethanol production process will be available. As far as enzyme development goes, scale-up will need to take place, along with evaluation of enzyme production and further improvements in enzyme performance. Integration of process steps and reduction in capital costs coupled to the evolution of more flexible pilot plants using a wide feedstock range will be required, along with continued governmental support.





PowerPoint Slide from Presentation by K. Holder.

Creating a Sustainable Biomass Infrastructure – Keith Holder, UOP LLC – A Honeywell Company

UOP has processes in place now for the conversion of vegetable oils via hydrogenation to diesel; petrol and jet fuel, and expect to have processes for lignocellulosic and algal feedstocks available by 2010.

Hydrogenated green diesel products have a high cetane number, low density, and excellent cloud point, and are similar to gas-to-liquids products, but are more profitable. They can be a valuable blend component since they allow low value fuels to be blended into ultra low sulphur diesel, and a reduction in cetane enhancing additives.

Growing concerns about the sustainability of biofuels centre around three main areas.

- Environmental: loss of biodiversity, soil erosion, nutrient leaching, soil and water pollution and deforestation.
- Land and water: competition for land and water resources that are already in high demand.
- Food supply: using resources which make a small impact on the fuel market, can have a large impact on food supply.

The development of 2nd generation technologies can ease these issues by making fuels from cellulosic wastes and crops which are less land intensive than starch/sugar-based crops. Fuels from cellulosic wastes could make a significant contribution to the availability of fuels for transport. Algal oils could provide a new route to biodiesel, Green Diesel and JP-8 (military jet fuel).

UOP are working as part of a US DoE project. This project recognises that pyrolysis-derived bio-oils are relatively inexpensive to produce, but that there is little market for the resulting crude bio-oil product. Selective hydro-treating will be used to generate higher value biocrude. UOP will work with the National Laboratories NREL and PNNL to examine the feasibility of bio-oil upgrading in a petroleum

refinery. The objective of this project is to upgrade biomass pyrolysis oils to petroleum refinery feedstock in a cost-effective manner. The project consists of six tasks:

- Preparation and characterisation of various sources of pyrolysis oil.
- Characterisation of pyrolysis oils from different biomass feedstocks.
- Optimisation of the hydroprocessing conversion process.
- Creation of a database which correlates pyrolysis oil properties with processability, product properties and is used to define standards.
- Conceptual designs and a process model for economic studies.
- LCA of the optimised process configuration.

So far three pyrolysis production tests have been completed, two using corn stover and one mixed wood. Chemical analyses and material balances have been completed and the oils characterised. Continuous-flow bench-scale reactor hydroprocessing tests have been performed to test catalysts and processing conditions with the recovered products analysed at PNNL and UOP to determine composition and value. An ACCESS database has been developed to manage the data from the pyrolysis and hydroprocessing tests. This provides a tool to analyse the field of data to determine important processing trends and potential process improvements. Initial results indicate that a carbon recovery rate of around 50% can be achieved, and that green diesel should have a lower carbon footprint than E85 ethanol.

UOP believe that Green Diesel is a first step in creating a sustainable biomass infrastructure. It is an excellent fuel, requiring an investment similar to biodiesel but with better economics. Cellulosic waste and algal oils have the potential to make significant contributions. However technology breakthroughs are required in biomass collection and densification, in the conversion steps for lignocellulosic wastes and in algal oil growth, harvesting, and oil extraction.

SESSION 3: CREATING THE CONDITIONS: IMPLEMENTATION

Biomass Heating: National Implementation in the UK – Keiran Allen, The Carbon Trust

In 2005 The Carbon Trust published a Biomass Sector Review to help identify where it could best help to deliver carbon savings by accelerating the development of the sector. The key findings were:

- Biomass has the potential to deliver material carbon savings today (up to 5.6 MtC per year using UK resources alone).
- Liquid biofuels are not the most resource-efficient use of biomass (both in terms of the 'cost of carbon' and the total volume of carbon saved) using current technology.
- Using biomass for heating via combustion and displacing fuel oil gives the most cost-effective carbon savings from bioenergy (without subsidy) at the present time.

Although biomass heating is not a new renewable energy technology and is already deployed in the UK there is currently a very low market penetration with current UK deployment estimated at ~0.6% of total heating requirement. The Carbon Trust launched the Biomass Heat Accelerator project, which has a project budget of £5 million over five years and is designed to address the key barriers faced by the technology in the UK which are:

- Financial: Longer paybacks and high up-front costs represent significant obstacles for typical customers.
- Political: 'Stop-Start' nature of public support mechanisms discourage long-term investment/business planning/consolidation.
- Fuel supply: Lack of Market infrastructure, *perception* of fuel availability and price risk and large variations in quality control amongst suppliers.
- Poor end user understanding: Unaware of the technology generally, which can lead to over-specification and other implementation errors.
- Legislative issues: Current legislation does not prevent biomass from being installed, but was not designed necessarily with the nuances of biomass heating in mind.

So far the project has focussed on financial performance of past projects to identify opportunities for development. A representative sample of 49 projects provided capital and operational expenditure data. The results from the project showed a very high degree of variability in capital costs. Analysis identified the main 'cost centres' where focused engineering work may be able to reduce installed capital costs, and indicated that capital cost reductions of up to 25% of today's levels could be achieved. The main areas include:

- Civil engineering: Boiler houses and fuel stores often responsible for high-cost installations.
- System sizing: Evidence indicates that many systems have not been size optimised. Many opportunities exist to improve capacity factors of systems in future.
- Business processes: Biomass heating companies are SMEs. Efficient business processes could help reduce overhead cost per sale and free up capacity.
- Lean manufacturing: Opportunities exist for UK-based manufacturers to manufacture lower-cost devices to compete with imported products.

- Alternative plant sourcing: Many components of a biomass project could be sourced locally or at lower cost.
- Remote monitoring: Design for minimal attendance/early fault diagnosis could reduce call-out costs.

Interestingly the data suggests a link between grant levels and capital costs – either grants are allowing projects to go ahead that would otherwise have not been viable, or they are leading to higher than expected prices.

European Cleantech and Bioenergy – Pat Burtis, Amadeus Capital Partners

Amadeus is a leading UK technology venture capital (VC) firm with offices in London and Cambridge, UK, founded in 1997.

There are compelling long-term macro drivers encouraging investment in the clean technology and clean energy sectors including:

- Rising global demand (and prices) for energy; increasing de/re-regulation; energy security.
- Commodity, materials, and resource supply constraints.
- Urbanisation.
- Increasing environmental pressures, e.g., climate change (and increased willingness to pay by society).
- Technology innovation and cross-over.

It is also a sector with a demonstrated success record, with large and growing markets (e.g., solar, biofuels) and some major exits (i.e., cases where VC funding has done its job and the investors can pull out with a healthy profit). Europe is a promising area for investment because there is a strong European technical platform for spinouts in both academia and industry underpinned by a strong government and quasi-government capability (such as at the Fraunhofer Institute, VTT, Carbon Trust, etc) and there are lots of 'stealth' or undiscovered Cleantech companies who have made significant progress. Europe also has a more favourable regulatory and consumer environment than the USA with less competition and more cooperation among investors. On the other hand the European market also presents some challenges, particularly:

- A lack of strong managers, with fewer serial entrepreneurs than the USA.
- Fragmented markets and inherent trade barriers driven by different regulatory regimes and markets, language and cultural differences and legal complexity.
- Nascent venture capital infrastructure with smaller funds, smaller rounds, and few pan-European funds.

In the USA deal size has been increasing, and VC's are increasingly getting involved in the pilot and early commercial scale plant construction. By contrast, the European Cleantech Venture Capital Sector is still much smaller. This constrains involvement in plant investment and means that there are less funds available to fund projects through the difficult 'valley of death' pre-commercial phase.

Typically a VC will invest in between 1 and 3% of the potential projects which are available and which emerge successfully from the thousands of projects which are generated by research and make their way through early

commercialisation stages with independent funding from their founders and business angels. Of these about 30% fail, 30% survive and only 30% generate the target return for investors (typically a 10 fold growth in five years).

As far as the bioenergy sector is concerned the main areas of promise appears to be in biofuels and in gasification. The biofuels sector is stimulated by the high growth potential, particularly for bioethanol. Particular opportunities will be associated with:

- novel enzymes for the efficient utilisation of wastes and cellulosic feedstocks,
- innovative process developments which simplify the process or remove process stages,
- alternative feedstocks such as algae,
- new fuels (such as butanol or DME), and
- supply chain innovation.

The gasification sector is also likely to grow in response to both the energy and waste management agendas, with the EU Landfill Directive creating an urgent need to reduce the amount of waste going to landfill. Gasification is a flexible technology which can open up power generation and biofuels markets.

SESSION 4: OPPORTUNITIES IN THE DEVELOPING WORLD

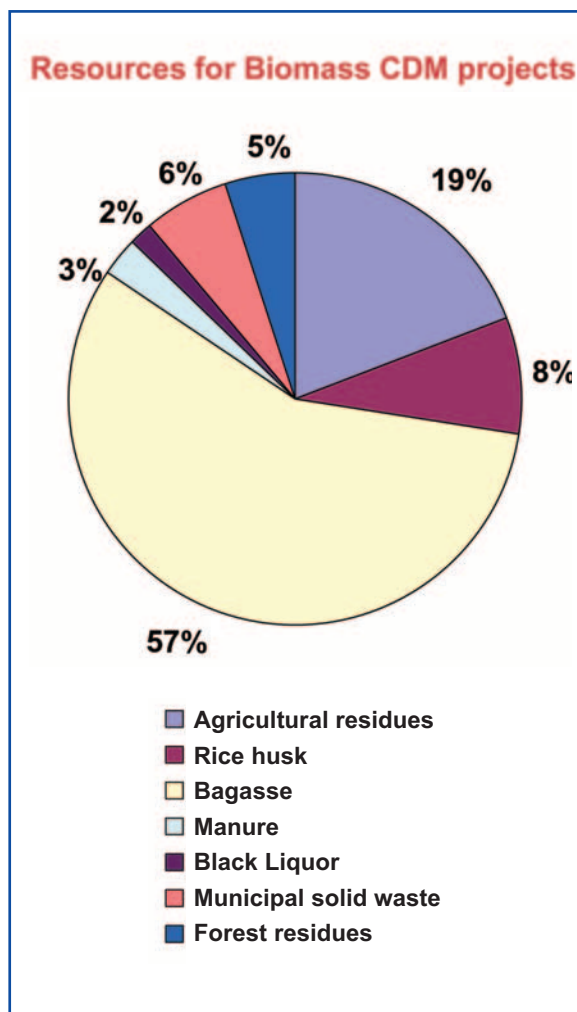
Business Development in Developing Countries – Irmgard Herold, New Energy Finance

Investment in renewable energy has been growing rapidly in recent years and amounted to £75.4 billion in 2006, and was expected to grow by a further 25% in 2007 to \$94.5 billion. In 2006 there was a further sum of \$33.2 billion involved in mergers and acquisitions.

The wind sector attracted most funds – 38% of the total, with biofuels and biomass and waste projects the next most significant technologies. There was a shift towards investment in countries such as China and India. This is set to continue, with for example China setting an ambitious targets to increase biomass power generation to 5.5GW in 2010 and to 30GW by 2020.

The financial case for projects can be influenced very significantly by the availability of credits (CER's) from the Clean Development Mechanism (CDM). Biomass projects are very important within the CDM, providing 43% of all projects and 20% of their capacity. The internal rate of return (IRR) of a biomass project is on average increased from 10 to 18% by the availability of CER's. For biogas projects typical IRR's are boosted from 7 to 21%. Average biomass project size has been growing, particularly in China where it has now reached around 1MW. China is now the largest generator of CER's with around 19.2 GW of accredited projects.

An analysis of the feedstock used for biomass CDM projects indicates that the majority of projects (57%) involve bagasse as feedstock, followed by other agricultural residues (19%) and rice husks (8%).



PowerPoint Slide from Presentation by I. Herold.

Pro-poor Investments in Biofuels: the case of *Jatropha* – Andreas Renner, The Global Exchange for Social Investment (GEXSI)

Jatropha is an oil bearing tree crop which grows well in tropical zones. It is receiving much attention because of its properties which include:

- drought resistance,
- an ability to grow in marginal soils which are not suited to food production,
- ability to benefit from high insolation levels to produce high yields, and
- low capital intensiveness which means that income can be generated in disadvantaged regions.

After 20 years of small-scale community based *Jatropha* projects, commercial investments have started to take place and are increasing rapidly, with recent strategic investments from BP/D1 Oils, Sunbiofuel Ltd, GEM Madagascar and Indian and Chinese investors. *Jatropha* is already a competitive energy crop with low production costs and no need for tax breaks and an ability to act as a substitute for diesel at world market prices. The profitability of *Jatropha* may be improved as additional revenue generating opportunities are explored – for example by using the pressed cake or by gaining carbon credits.

However there are some risks associated with expanding *Jatropha* production.

- *Jatropha* has never been used on a commercially scale (beyond local soap production) and agronomic research has only just started.
- *Jatropha* is suited to high-risk countries as far as politics and the legal framework are concerned.
- Socio-economics aspects need careful consideration.
- Harvesting is labour intensive.

There are also a number of issues associated with the logistics and distribution of *Jatropha* oil, since there is a lack of transport infrastructure and either a market has to be developed for direct sales of pure plant oil or else biodiesel refineries need to be constructed. There are also issues associated with financing *Jatropha* projects since Venture Capital Funds tend to focus on clean technology developments rather than on agriculture where short term return on investment may not be available.

GEXSI assists social entrepreneurs and social purpose businesses in developing countries to move 'from aid to market'. GEXSI are working with JSL Analavory in Madagascar in a 300 ha pilot *Jatropha* project. There are plans to extend the project to 22,500 ha at three locations. The aim is to produce 35,000 tonnes of product (*Jatropha* oil) by 2015, with 40% exported to Europe and the rest used on the domestic market in Madagascar.

In a further example in Tanzania, GEXSI is partnering with Tanzania's largest smallholder farmer association, and starting with 2,000 families is encouraging the planting of 1,000 *Jatropha* trees per family on marginal soils, e.g., as hedges. The product will be sold via an advanced purchase agreement, providing secure additional revenue for farmers. The fuel will be processed and distributed by safiAnzania for use in fuel cooking stoves in Dar-es-Salaam. This will lead to improvements in indoor health and forest production through the avoidance of unsustainable fuel wood use.

There are opportunities to further explore the potential of *Jatropha* by initiating or supporting research on the following topics:

- Monitored field trials and strengthened links to international research centres.
- Assessment of the potential and suitable use of alternative energy crops.
- Optimising the energy production process.
- Development of integrated local energy systems.

There are also opportunities to develop policy measures which would enhance pro-poor commercial investments in *Jatropha*. These include:

- Developing the Multi-Stakeholder Process on sustainable *Jatropha* which has been initiated by BioX in September 2007 (under the auspices of the Dutch government).
- Supporting initiatives which address philanthropic investors in financing pro-poor *Jatropha* projects.
- Providing advice to governments in the developing world on suitable bioenergy policy frameworks.

DISCUSSION OF KEY POINTS

In discussion the following key points were highlighted.

- The requirement for a rapid return on venture capital investment associated with biomass and biofuels technologies may be more difficult to achieve than in other sectors (such as software) since the project cycle tends to be longer.
- Venture capitalists are being increasingly drawn into funding for first demonstration scale plants, which require more capital and may have a higher risk profile. This may be where a funding gap will develop as the technologies currently under development mature to this stage, and public funding will be needed to bridge this gap.
- The importance of sustainability on biofuels projects cannot be over stated, and this is a key factor in gaining public acceptance for the technologies. Policies and measures designed to encourage development and deployment of '1st generation' biofuels technologies need to take overall carbon balances into account, and to encourage sustainability in the widest sense.
- Communication is a key issue as far as acceptance by policy makers and the public are concerned.
- Successful policy measures in some countries are not often replicated in others, and there is a need for wider dissemination of policy best practice.
- Industry needs a long-term policy perspective in order to enable investments to be made with confidence, but the duration of policy and support measures needs to be designed such that costs are affordable and over-dependency on government support is avoided.
- Governments and international bodies need to play an important role in the development of internationally accepted standards to enable industry to progress the technologies.
- Technology deployment needs to be industry led. Governments can play a key role in creating the conditions which allow technologies to develop and mature, rather than dictating which projects should proceed.

IMPLICATIONS FOR IEA BIOENERGY

The output from this workshop will be fully taken into account in the work of the current Tasks, and have an impact on the development of future work programmes for the Agreement.

REFERENCES

The presentations from the workshop are available at <http://www.ieabioenergy.com>

ACKNOWLEDGEMENTS

Bjorn Telenius, the Member of the Executive Committee for Sweden, took the lead in organising the workshop with the support of the Technical Coordinator (Adam Brown), Paul Grabowski, and Birger Kerckow, who also acted as rapporteurs. The contribution of the external participants in the workshop is gratefully acknowledged.

Bjorn Telenius also convened an editorial group comprised of the rapporteurs and the Secretary (John Tustin) to prepare and review drafts of this text. John Tustin and Adam Brown facilitated the editorial process and managed the design and publication stages.

IEA Bioenergy

Further Information

IEA Bioenergy Website
www.ieabioenergy.com

IEA Bioenergy Secretariat

John Tustin – Secretary
PO Box 6256
Whakarewarewa
Rotorua
NEW ZEALAND
Phone: +67 7 3482563
Fax: +64 7 348 7503
Email: jrtustin@xtra.co.nz

Adam Brown – Technical Coordinator
Energy Insights Ltd
1, St Hilda's Close
Didcot
Oxfordshire, OX11 9UU
UNITED KINGDOM
Phone: +44 (0)7723 315441
Email: adam.brown@energyinsights.co.uk