Mobilising sustainable bioenergy supply chains: Opportunities for agriculture

Summary and Conclusions from the IEA Bioenergy ExCo77 Workshop

This publication provides the summary and conclusions for the workshop 'Mobilising sustainable bioenergy supply chains: Opportunities for agriculture' held in conjunction with the meeting of the Executive Committee of IEA Bioenergy in Rome, Italy on 17 May 2016.

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EXECUTIVE SUMMARY

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The IEA Bioenergy Technology Cooperation Programme (IEA Bioenergy) held its biannual workshop in Rome on 17 May 2016 in conjunction with the Executive Committee meeting (ExCo77). The workshop on 'Mobilising sustainable bioenergy supply chains: opportunities for agriculture' was prepared in close collaboration with GSE[1], FAO[2] and IRENA[3]. The workshop consisted of three sessions: (1) bioenergy perspectives and mobilisation, (2) synergies in food and energy production, and (3) biogas and applications.

BIOENERGY PERSPECTIVES AND MOBILISATION

Biomass provides significant opportunities to reduce greenhouse gas emissions, increase energy security, increase rural economic welfare, and improve local and regional environmental conditions. There is currently a wide range of possible feedstocks, a variety of conversion technologies, and a number of different end products that can be produced at a range of scales. However, global economic conditions, low oil prices, uncertain political support, and unresolved questions regarding land use change and the sustainability of bioenergy production systems provide a challenging global context to increasing the rate of investment and deployment of bioenergy systems. Substantial progress is needed, which requires policies, investment levels and a business case.

According to FAO, bioenergy offers an opportunity to invest in sustainable agriculture and rural development and therefore to improve rural livelihoods, agricultural practices and thus sustainable development. While the discourse around bioenergy/biofuels is often overly simplistic, one should accept and embrace their complexity. Biofuels or bioenergy per se are neither good nor bad. What matters is the way they are produced. The sustainability of bioenergy is context specific. Therefore its assessment must be based on reality and specific cases, not only models and global studies. Tools and knowledge are available to help governments and operators reduce risks and enhance opportunities for bioenergy development.

Biomass and waste are key elements of major long-term decarbonisation scenarios. In the IEA's 2 Degree Scenario (2DS), biomass and waste represent the largest primary energy source in 2050, with a contribution of 139 EJ. The United Nations Sustainable Energy for All initiative, SE4All, foresees a doubling of renewable energy use by 2030; IRENA's modelling has found that the most cost-effective path to this target involves doubling biomass use and tripling modern biomass by 2030, to a level of 94 EJ, compared to a current level of 53 EJ, of which half is considered 'traditional' biomass use.

Achieving such a large increase in biomass use will be a great challenge, but there are various opportunities to meet this challenge. Sustainable intensification of agriculture can play a particularly important part, for example through yield increases, more thorough collection of surplus agricultural residues, and energy crops on marginal or degraded lands which are not in productive use. Development agencies have a vital role to play to stimulate developments in agriculture that can simultaneously improve food security and energy access, both of which are key sustainable development goals.

1 Gestore dei Servizi Energetici

2 Food and Agriculture Organisation of the United Nations

3 The International Renewable Energy Agency

SYNERGIES IN FOOD AND ENERGY PRODUCTION

Agricultural crop residues constitute a large biomass resource from managed lands. They can provide an additional source of revenue for agricultural producers, and may be a low cost, sustainable feedstock for the production of bioenergy and bio-products. Fuel quality, dispersion and low energy density are the main challenges to mobilise such residues. In terms of environmental sustainability, the main concern is to maintain sufficient organic carbon content in soils to ensure their long term health and productivity. Guidelines for farmers on sustainable harvest rates and crop rotations are needed, though various groups have estimated that between a quarter and half of the agricultural residues could be harvested without harming long-term soil quality.

Lignocellulosic bioenergy crops include perennial grasses and fast-growing tree species grown in relatively short rotations, producing biomass both for energy and other purposes. These energy crops can be cultivated on soils of varying qualities. Such cropping systems can be integrated into agricultural landscapes to make better use of available resources. They can provide multiple benefits (ecosystem services) in addition to the harvested biomass, both on marginal lands and productive lands. However, marginal lands generally provide moderate yields and require optimised logistics, soil amendment and strict sustainability criteria, but there are options to improve their status. More conventional crops such as sugar cane or sugar beet could also provide opportunities on 'surplus' land, as well as flexibility in use between food, energy and biobased material markets.

Agroforestry systems can combine food and energy production. These systems may aim to improve the livelihoods of smallholder farmers in developing countries by providing local energy security for their developmental needs, in addition to food. Examples demonstrated by ICRAF show that such systems can boost agricultural yields of some crops and can provide local energy for the operation of farm machinery. These systems also demonstrated positive environmental impacts, for example in terms of biodiversity and ecosystem services.

Open access to forests in developing countries often leads to undervaluation of wood, to inefficient and wasteful production and use and to uncontrolled deforestation. Currently firewood and charcoal supply 80% of Sub-Saharan Africa's energy needs. According to GIZ, an increased investment in a sustainable and modern wood energy development can contribute significantly to the national and local economies and to improved health conditions. Land use planning, security of tenure, government incentives and an efficient system of supervision and enforcement are required to make this happen.

BIOGAS AND APPLICATIONS

Biogas can fit into a platform of technologies and agricultural practices that, when applied in synergy, are able to store additional carbon, increase soil fertility and the net primary production at the farm, mitigate emissions from the farming sector, increase the organic matter of the soil and contribute to the fight against climate change at the local level while improving food security. This approach is promoted by the Italian Biogas Council as 'BiogasDoneRight'. The primary feedstocks for biogas are livestock effluents (manure), agro-residues and agro-wastes, cover crops before or after cash crops, and food or perennial crops that are used to revegetate abandoned lands.

Agro-industrial residues present a significant potential to produce biogas in Southeast Asia. Using wastewater from starch and palm oil mills for biogas production is economic, environmentally beneficial and saves fossil resources. Avoided greenhouse gas emissions (in particular methane in open palm oil mill effluent (POME) ponds or empty fruit bunches (EFB) dumps) can be high. The regulatory framework in Indonesia is still a barrier to the implementation of such systems. Thailand has experienced widespread deployment of biogas in agro-industries over the last decade. This has resulted in considerable savings in energy expenditure and significant reductions in environmental impacts by efficiently treating large volumes of highly organic wastewater. Industrial biogas has now become a mainstream technical option for starch and palm oil mills in Thailand, and all major facilities have a system installed or under development.

Co-digestion of grass silage, slurry and seaweed (macro-algae) is an option being considered in Ireland. There is a particular issue with (rotting) seaweed on Irish beaches, and cultivation of seaweed can also be considered in association with fish farms, where it can help with nutrient disposal.

Biogas can be used to facilitate intermittent renewable electricity through conversion of biogas to electricity when demand for power is high and conversion of electricity to methane ('power-to-gas') when demand is low. Biological processes can also be used with hydrogen from surplus electricity to upgrade biogas to biomethane.

Another option is to use biomethane in transport. Italy is at the forefront of this application. The high share of natural gas vehicles and filling stations in Italy is key to the development of biomethane, which is considered as an 'advanced biofuel'. Injection into the natural gas grid and registration of these flows in a centralised database facilitates the large-scale introduction of biomethane.

GENERAL CONCLUSIONS

Based on good practice examples, there is a consensus among FAO, IRENA, IEA and IEA Bioenergy that it is possible to increase the production of biomass for energy, while enhancing sustainable agriculture and food production systems. Moreover various alternatives can be applied to increase carbon storage in soils, which fully contributes to climate change mitigation strategies. As a result, integrated policies for agriculture, energy and climate can support concurrent positive impacts in these different fields.

In terms of the role of biomass in the future energy system, it was acknowledged that bioenergy potential is substantial and increases are reasonable under various assumptions. On the other hand it will be a major challenge to reach certain targets. Bioenergy systems are quite complex, as is their management for sustainable growth. Complexity can discourage policy makers from taking on the challenge. Moreover different sectors (agriculture, forestry, power, industry, buildings, transport) need to cooperate in order for the potential to be realised. There is a significant job ahead: FAO, IEA, IRENA and IEA Bioenergy will jointly engage in advising policy makers and stakeholders on the opportunities for biomass and in sharing good practices.

Some concrete actions were defined:

- A consolidated message (2-4 page communiqué) from FAO, IEA Bioenergy and IRENA will be jointly prepared to highlight opportunities for increased bioenergy use in synergy with agricultural and forestry production, and in furtherance of food access, energy access, and other sustainable development goals (SDGs) as well as in support of the COP 21 agreements
- A dialogue will be organised on the assumptions behind different estimates of biomass potentials and different scenarios of bioenergy supply so that consistent messages can be brought to the public.

The PowerPoint presentations can be downloaded from IEA Bioenergy's website http://www.ieabioenergy.com/iea-publications/workshops/.

WORKSHOP

WELCOME SPEECHES

The participants of the workshop were welcomed by representatives of the co-organisers of the workshop: GSE, IEA Bioenergy, FAO and IRENA.

Luca Benedetti of GSE welcomed all participants to their premises in Rome. GSE's mission is to promote, support and monitor renewable energy in Italy. He emphasised the role that biomass for energy can play. The key for using biomass is sustainability.

Kees Kwant, the chair of IEA Bioenergy, identified the goals of the workshop, which were to look at opportunities for bioenergy, with a focus on agriculture, and to consider what was possible or achievable with biomass and the actions needed to realise this. He stressed the importance of cooperation between the different international organisations including IEA, IEA Bioenergy, IRENA and FAO.

Olivier Dubois stressed that FAO had been working on bioenergy for more than 25 years, but that its work in this area had really expanded around ten years ago. The FAO data on wood energy statistics is an important reference. In addition to the work on sustainable energy for and from agri-food systems, including bioenergy, FAO has a mandate to work on sustainable bio-economy guidelines.

Dolf Gielen of IRENA noted that with the Paris Climate Agreement the importance of renewable energy significantly increased. Bioenergy is expected to represent around half of global renewable energy in 2030 (for all end uses), but it is not developing at the same rate as other renewable energies such as wind and solar (for electricity). Therefore a realistic outlook is needed, also considering modern versus traditional bioenergy. IRENA is setting up a dedicated bioenergy programme with three pillars: (1) feedstock availability, (2) conversion technologies and (3) enabling policy frameworks.

Session 1: Biomass perspectives and mobilisation

MOBILISING SUSTAINABLE BIOENERGY SUPPLY CHAINS: GENERAL CONCLUSIONS OF THE IEA BIOENERGY STUDY

Tat Smith, University of Toronto, Canada

Tat Smith presented the main conclusions of a study carried out in the past three years, with involvement of many IEA Bioenergy experts. The overall objective of this project was to identify factors critical to enhancing the mobilisation of sustainable bioenergy supply chains. The project focused on five supply chains which were evaluated from both the 'bottom up' and 'top down': boreal & temperate forests, agricultural crop residues, regional biogas, integration of lignocellulosic crops into agricultural landscapes and cultivating pastures and grasslands. Some of these would come up again in other presentations in this workshop.

Significant opportunities exist to reduce greenhouse gas emissions, increase domestic energy security, increase rural economic welfare, and improve local and regional environmental conditions through the deployment of sustainable bioenergy and bio-based product supply chains. There is currently a wide range of possible feedstocks, a variety of conversion technologies, and a number of different end products that can be produced at a range of scales. However, the global economic downturn, low oil prices, lack of global political will, and unresolved questions regarding land use change and the sustainability of bioenergy production systems provide a challenging context to increasing the rate of investment and deployment of bioenergy systems around the world. The study confirmed that feedstocks produced using logistically efficient production systems could be mobilised to make significant contributions to achieving

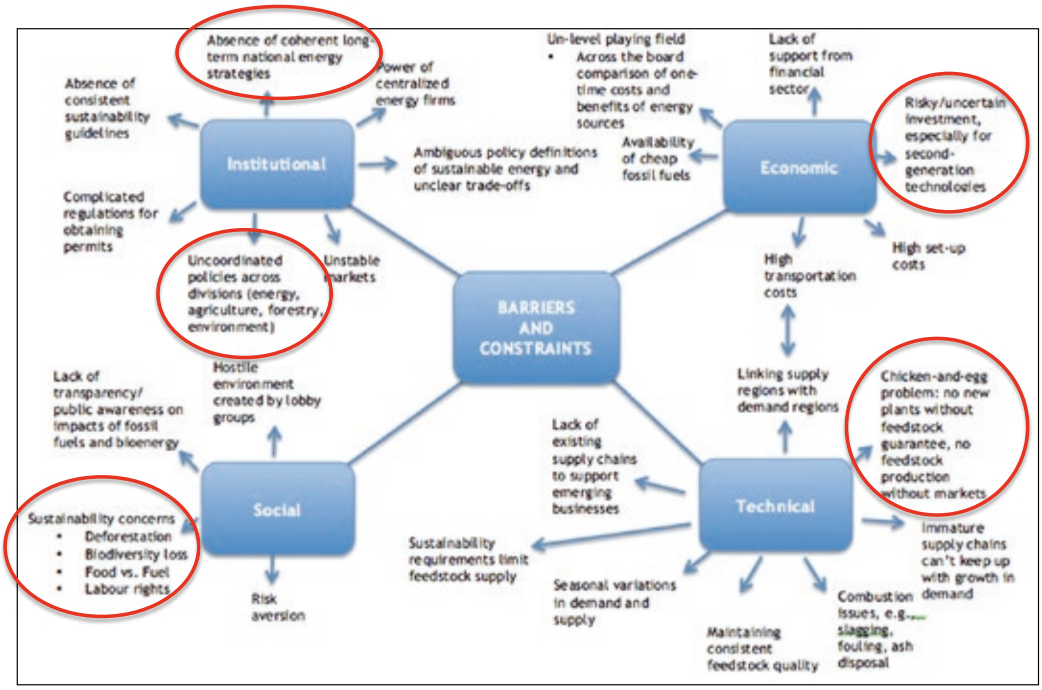

Figure 1: Barriers and constraints to bioenergy supply chain mobilisation (Smith)

global targets for bioenergy. However, important barriers to large-scale implementation exist in many regions. The mobilisation potential identified in the study would depend on increases in supply chain efficiencies and profits, expanded market opportunities, and strong policy support to mitigate stakeholder and investor risk and bolster confidence.

WHAT FAO THINKS AND DOES ABOUT SUSTAINABLE BIOENERGY

Olivier Dubois, FAO (Food and Agriculture Organisation of the United Nations), Rome, Italy

Sweeping statements on bioenergy sustainability are often untrue:

'Food crop feedstock always compete with food': This is not the case if bioenergy is additional to food production through yield increase or if good practices are implemented.

'Energy crops and residues never compete with food': Energy crops can compete indirectly through the competing use of land and through reduced flexibility between food and energy markets; residues for bioenergy may compete with other uses (soil management and animal feed).

'Simple solutions to reconcile food and fuels are readily available': Solutions exist but their implementation is not simple.

Sustainable bioenergy is complex, but one should embrace this complexity rather than oversimplifying things. Assessment of bioenergy sustainability has to be evidence-based, contextualised and integrated.

Land issues: The issue is often more about whose and what land than how much land. This has a lot to do with land and natural resources governance. Fortunately, one can refer to the internationally agreed voluntary guidelines on sustainable tenure governance of land, forests and fisheries. There can be a risk of indirect land use change (iLUC) but models to assess iLUC risk oversimplifying the reality. There are ways to minimise ILUC risks and it is more constructive to focus on these.

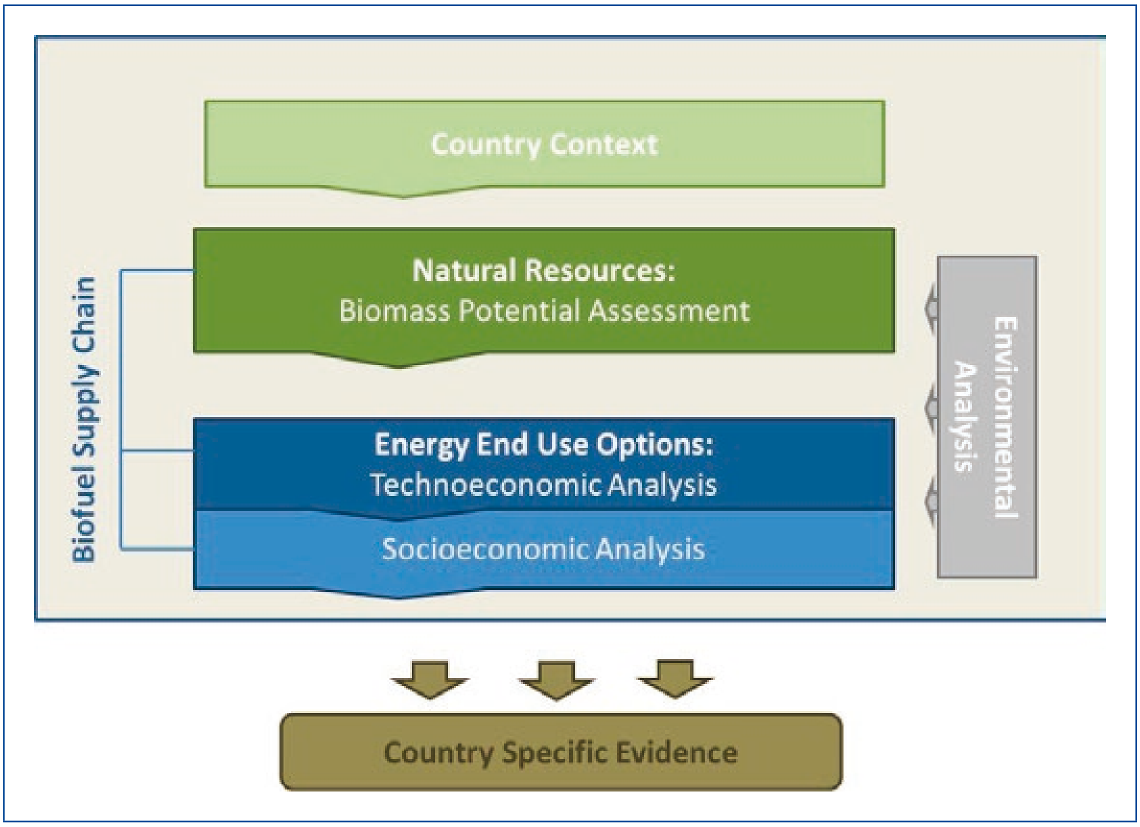

Figure 2: BEFS (Bioenergy and Food Security) Sustainable Bioenergy Assessment (FAO)

Food price issues: There is a link between bioenergy and food prices but bioenergy is one amongst many other factors that influence food prices. Effects should not only be considered at international level but perhaps more importantly at country, farmer and household levels, where it matters.

What is needed is (1) an *in-depth understanding* of the situation and of related opportunities and risks as well as synergies and trade-offs; (2) implementation of *good practices* by investors/producers in order to reduce risks and increase opportunities; (3) an *enabling policy* and institutional environment to promote the implementation of good practices; (4) appropriate *monitoring and evaluation* of impacts and the performance of good practices and policy responses; (5) *political will, capacities and good governance* to implement the above. FAO has developed the '*FAO Sustainable Bioenergy Support Package*' to cover these issues.

FAO's key messages on bioenergy:

- The sustainability of bioenergy is context specific. Therefore its assessment has to be based on reality, not models and global studies.
- Tools and knowledge are now available to help governments and operators reduce risks and enhance opportunities for bioenergy development.
- Biofuels per se are neither good nor bad. What matters is the way they are managed.
- Bioenergy should be viewed as another opportunity for responsible investment in sustainable agriculture and rural development.

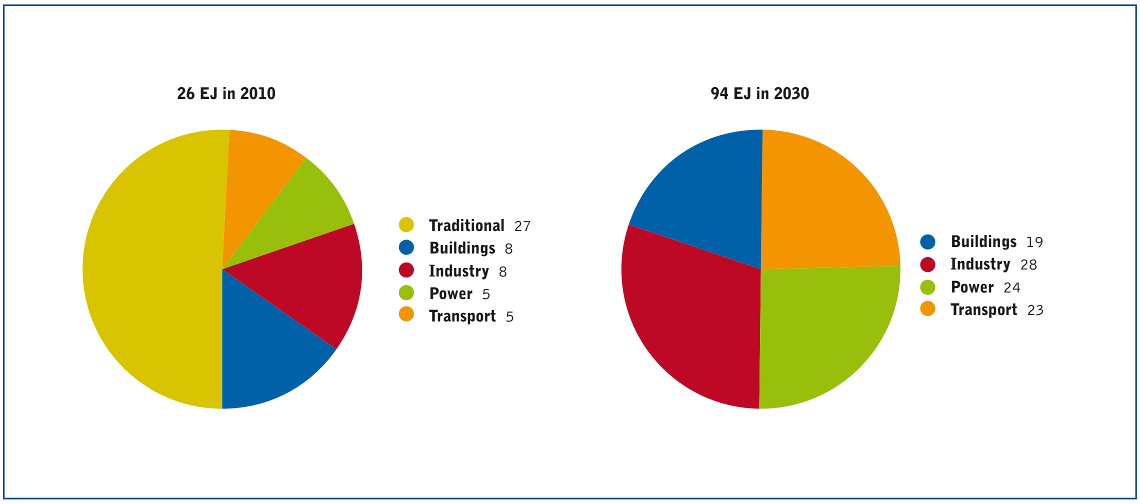

Figure 3: Modern biomass may more than triple from 2010 to 2030 (IRENA)

BOOSTING BIOENERGY: SUSTAINABLE PATHS TO ENERGY SECURITY

Jeffrey Skeer, IRENA (The International Renewable Energy Agency), Bonn, Germany

The UN Sustainable Energy for All (SE4All) initiative has posited a target to double the share of renewable energy by 2030. IRENA's REmap analysis indicates that a least-cost path to this target can imply a tripling of modern bioenergy for power, heat (for industrial processes and buildings) and transport. However, providing the necessary volumes of feedstocks for this growth will require major scale-up; and major scale-up will require consensus on the potential to provide feedstocks sustainably, without interfering with the world's growing food requirements or abetting global warming.

A recently published IRENA report on 'Boosting Biofuels: Sustainable Paths to Greater Energy Security', indicates substantial potential to expand both food and fuel supply sustainably, without encroaching on forest or grassland carbon sinks. Approaches examined include boosting yields of food crops and associated residues on existing farmland, freeing up existing farmland for biofuel crops through further yield improvements, reducing losses and waste in the food chain to free up additional farmland for bioenergy crops, improving livestock management to free up pastureland for bioenergy crops, encouraging afforestation with rapidly growing tree species, and cultivating algae. The overall sustainable potential for 2050 is estimated to exceed projected liquid fuel needs for transport.

The following policies and measures are suggested to realise a major share of this potential:

- accelerate improvement of crop yields by expanding extension services to disseminate modern farming techniques
- improve understanding of logistical approaches for cost-effective harvesting of farm and forest residues
- collect comprehensive data on land that could be used for sustainable wood and grass crops, including likely yields
- conduct in-depth research on practices for cultivating rapidly growing trees and grasses on pastureland that could sequester carbon and enhance biodiversity
- institute more secure land tenure and better governance to provide incentives for more intensive land management

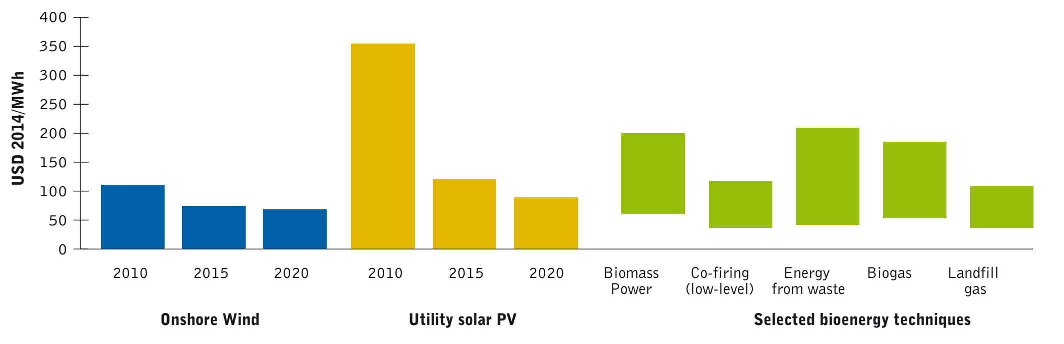

Figure 4: Historical and forecast global weighted average generation costs for new onshore wind and utility PV plants vs. current reference global bioenergy Levelised Cost of Electricity (LCOE) ranges (IEA, 2015).

- provide incentives to plant trees on degraded lands
- reduce food waste and losses, for example through improved food labelling regulations in developed countries and through investment in refrigeration and roads in developing countries
- demonstrate cost-effective technologies for producing biofuels from lignocellulosic feedstocks which typically have higher yields per hectare than conventional biofuel feedstocks.

BIOENERGY MARKET CONSIDERATIONS – CHALLENGES AND OPPORTUNITIES

Pharoah Le Feuvre, IEA (International Energy Agency), Paris, France

Biomass and waste are key elements of the IEA's long-term decarbonisation scenarios, representing the largest primary energy source in 2050, with a contribution of 139 EJ in IEA's 2 Degree Scenario (2DS)[4]. The commitment arising from the 2015 COP 21 global climate agreement to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C will require a deep transformation of the energy system, and the necessity to sustainably increase bioenergy's role within it.

The IEA's Medium-Term Renewable Energy Market Report 2016 (MTRMR 2016) outlines the current status of market development, and medium-term forecasts for bioenergy and biofuels across the power, heat and transport sectors. Analysis conducted for the MTRMR 2016 indicate that annual bioenergy power capacity additions have been relatively steady in the region of 5-6 GW over 2010-2015, with agricultural residues making key contributions in markets such as China, Brazil and India. However, within the power sector faster deployment of alternative renewable technologies such as onshore wind and solar PV have resulted in a relatively lower contribution from bioenergy to overall renewable power generation. In addition, cost reduction trends for these technologies could focus bioenergy deployment on the most promising projects e.g. those with lower investment costs, low cost fuel sources such as wastes and agricultural residues, and in areas with strong complimentary policy drivers such as waste management or rural development.

4 Source: IEA's Energy Technology Perspectives 2016. The 2DS lays out an energy system deployment pathway and an emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C.

Bioenergy remains the largest contributor to European Union (EU) renewable heat production. High shares of bioenergy in heat have been achieved in Nordic and Baltic countries through a combination of significant biomass resources, supportive policies and security of supply drivers. In addition, it has been observed that countries with lower renewable heat shares, such as the United Kingdom and Netherlands, are starting to make notable progress through the application of policy mechanisms. The role of agricultural residues in the provision of renewable heating in Denmark, where straw is a key input fuel for co-generation and heat only plants supplying local authority district heating schemes, was also highlighted. Data was presented to demonstrate that the utilisation of district heating and cogeneration are key means of increasing bioenergy's contribution in the heating sector for countries seeking to increase renewable heat deployment. It was also demonstrated that low oil prices are creating additional competition for bioenergy heating solutions by stimulating oil boiler installations in some European markets. However, the stability of biomass pellet prices compared to cyclical heating oil costs is a key consideration over the life of a heating system.

With regard to transport, an overview of the current status of development in advanced biofuels was provided. A significant advanced biofuels contribution, together with improved fuel economy and electric vehicle market expansion, is central to decarbonisation of the transport sector. However, the industry is currently in the early stages of development and stable and long-term policy frameworks are needed to facilitate expansion and to realise the significant scope for industry cost reduction.

PANEL DISCUSSION ON BIOMASS PERSPECTIVES

Moderated by Kees Kwant, NL Enterprise Agency, the Netherlands, chair of IEA Bioenergy

Targets

IEA's 2 Degree Scenario (2DS) for 2050 assumes a role of 139 EJ for biomass and waste. IRENA suggests a target to double biomass use and triple modern biomass by 2030, to a level of 94 EJ, compared to a current level of 53 EJ of which half is traditional biomass use. The magnitude of the challenge is considerable and may push certain systems to their limits; the level of intensity of harvesting has to greatly increase. Therefore fundamental system changes may be needed, in addition to support for "game changers".

According the IEA, the ambition of doubling was developed in line with the SE4ALL initiative to double the share of renewable energy in the global energy mix by 2030, and bioenergy indeed should play a key role in progress towards this. However, decarbonisation of the energy system can be achieved in different ways. As such it is important that the current state of market trends is recognised as there is a disconnect between current levels of growth and the high biomass contribution required by the doubling objective in just 15 years. To accelerate scale-up, long term policy certainty is needed to provide investor certainty. A participant in the audience remarked that aspirational goals might lose credibility if there was no concrete plan on how to actually achieve these.

IRENA stated that it might be difficult to reach these ambitious targets, but not impossible. There are many opportunities in different areas and it doesn't all have to come from forests. In particular agriculture can have a major role, e.g. through yield increases, the use of agricultural residues or energy crops on certain marginal or unused lands. There is an important role for development agencies to stimulate developments in agriculture in order to improve food security, energy access and reduced food waste.

According to FAO it is possible, at least in theory, to provide food and fuel, although in practice it is not straightforward. There are clear examples where growing non-food crops (like cotton in Africa) have provided money for farmers to invest in higher food crop yields. There are major differences between theoretical, technical and practical potentials. An important hurdle is the discourse against bioenergy which is over simplistic. On the other hand, potential figures should not be oversimplified.

Complexity needs to be addressed in estimating potentials for energy scenarios. IEA and IRENA agreed to discuss assumptions behind potentials in more detail.

Actions and priorities

Substantial progress is needed, which requires policies, investment levels and a business case. Sustainability of biomass can be demonstrated in many cases. A scientific basis and justification are needed and are mostly available. Certification can be positive, but impacts for small players should be considered if this were to be made obligatory. Reports on good agricultural practices can be very constructive.

The highest priority should be given to a positive profile for the role of biomass and advice/ guidance to policy makers, in the frame of the Sustainable Development Goals (SDG) and the Climate Goals (COP21). Simpler messages are needed as well as solid evidence that through concerted efforts "win-wins" are possible. Messages need to be focused on the needs of countries, e.g. energy from waste in China, agricultural biomass in Brazil or a greater focus on heat demand and coal phase-out in Europe. Replication of mature solutions (e.g. landfill gas, co-firing) can be very cost-effective in certain regions.

An example was given of West African countries. Five years ago bioenergy was demonised, whereas now the ECOWAS region has a regional strategy on bioenergy. This demonstrates the power of education and knowledge transfer.

Initiatives like SE4All, where companies are involved can also help. Investments are needed from private companies, who require stable long term policies to justify the risk in making the relevant investments. IEA Bioenergy has a lot of knowledge in its network and can facilitate the business sectors moving forward.

In the discussion it was reiterated several times that there was a need to advise decision makers. Securing investment in biomass projects can be challenging compared to other renewable technologies, and the complexity of the ongoing debate concerning sustainability considerations can deter investors. For FAO and other panel members it was clear that bioenergy was needed to reach the 2°C target, and that all biomass types should be considered. FAO, IRENA and IEA Bioenergy agreed to work together to develop a communiqué of 2-4 pages, linking bioenergy with Sustainable Development Goals (SDGs) and COP21.

Biobased economy and cascading

Traditional biomass markets (food, wood) include bioenergy as a co-product (in contrast with dedicated bioenergy crops). Wood products and most food crops provide a substantial amount of residues that can be used for energy, and if these markets are flourishing, bioenergy opportunities will also grow.

The 'energy comes last' part of the cascading principle is often problematic. Where it is consistent with maximising the value of resources over time, it can make sense, for example to use high quality wood firstly to build houses or furniture, so displacing carbon associated with concrete or other material. On the other hand for lower quality wood, such as the residues often left to decay in the forest, immediate use for energy should not be discouraged as this will typically displace fossil fuels. What matters (carbon content, cost of production, added value) and the sequence of use (cascading) depends on local circumstances. Moreover, energy is a fundamental in each production process, including in biobased products.

It is important to move developing countries in the direction of modern cooking stoves, which are two to three times more efficient and far less polluting than traditional systems. These modern stoves can greatly reduce pressure on forests in developing countries, which have been harvested at unsustainable rates.

Carbon price

A fair carbon price can move matters in the right direction. Biomass provides an opportunity to actually reduce CO_2 levels in the atmosphere (provide negative emissions) through carbon capture and storage/carbon capture and utilisation (CCS/CCU) or through increasing soil organic carbon. Carbon pricing can reinforce efforts to grow forests and manage them in a sustainable way. Lessons learned from the European Union Emissions Trading System (EU ETS) should be considered, where the CO_2 price is much too low.

International trade?

Bioenergy should increase everywhere; potential issues are region dependent. The ability to meet local demand differs, e.g. in various regions the bioenergy potential exceeds local demand. Biomass is not only a local matter, but also a global resource. International trade provides positive examples of price security, which can give confidence for building biomass plants.

Conclusion:

1. FAO, IRENA, IEA and IEA Bioenergy agree that it is possible to increase the production of biomass for energy, while enhancing agricultural or forest production systems. Moreover various concepts increase carbon storage in soils, which is fully compatible with climate mitigation strategies.
2. FAO, IRENA and IEA Bioenergy agree to work together to develop a communiqué of 2-4 pages, linking bioenergy with Sustainable Development Goals (SDGs) and COP21.
3. A dialogue will be organised on assumptions behind biomass potentials so that consistent messages can be brought to the public.

Session 2: Case studies and strategies showing synergies in food and energy production

Agriculture is expected to provide food and feed, and potentially other products, for example, fibre or bioenergy products, while avoiding as much as possible negative impacts on soils, water, biodiversity and climate. Agriculture is also expected to provide other benefits such as employment opportunities and benefits associated with a varied cultural landscape. Society expects that emerging bioenergy systems will reduce impacts caused by the existing - primarily fossil - energy systems, and that policies are developed to address risks associated with bioenergy implementation and to promote good outcomes. In this session the focus is on opportunities in agriculture including synergies in food and energy production.

MOBILISING AGRICULTURAL CROP RESIDUES FOR ENERGY AND HIGHER VALUE BIO-PRODUCTS

Niclas Scott Bentsen, University of Copenhagen, Denmark

Agricultural crop residues constitute a large biomass resource from managed lands, and using part of the resource as a renewable energy source has little risk of unwanted indirect effects such as indirect land use change and competition with food production. It can provide an additional source of revenue for agricultural producers, and may be a low cost, sustainable feedstock for production of bioenergy and bio-products. Global technical potential in the 2030-2050 period is estimated at around 30 EJ per year. As part of the IEA Bioenergy project on mobilising sustainable bioenergy supply chains, options and barriers for further deployment of agricultural residues for energy in Canada, the USA and Denmark were analysed.

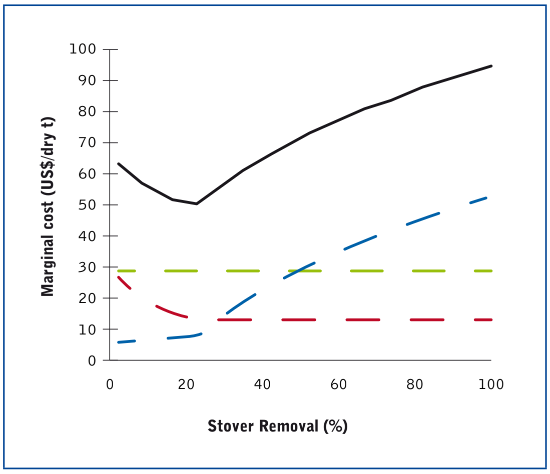

Figure 5: total marginal cost of removing corn stover (Scott Bentsen)

In Denmark approximately 25% of a total annual production of 5.5 to 6 million tonnes of straw is allocated to energy purposes because of long term policy support and mandates. In Canada there is no large scale energy generation based on agricultural crop residues due to an abundance of forest residues, but the potential is estimated at 48 million tonnes (dry). In the USA as much as 125 million tonnes could be available depending on price and very little of this potential is currently used.

Policies and support mechanisms have shaped technological focus and development differently in the three countries analysed. In the USA cellulosic ethanol is supported through the Renewable Fuels Standard (RFS2); in Canada high value products and materials are the focus; while combined heat and power production or district heating has been the common use in Denmark.

A number of barriers have to be overcome to develop agricultural crop residue supply chains further. Fuel quality is particularly an issue for thermal conversion to electricity production, and the more general heterogeneity of the feedstock is challenging. The resource is dispersed and has a low energy density. Sufficient political support and economic incentives are required to build up and develop sustainable business cases for agricultural crop residues. In terms of environmental sustainability the main concern is to maintain sufficient soil carbon content to ensure long term soil health and productivity. More information and guidelines for farmers on sustainable harvest rates and crop rotations would be beneficial to avoid soil mining and to ensure long term sustainability.

Figure 6: straw on the field (courtesy of Maletta)

BIOMASS PRODUCTION IN SUSTAINABLY MANAGED LANDSCAPES

Ioannis Dimitriou, Swedish University of Agricultural Sciences, Uppsala, Sweden

Much attention has been directed in recent years to biofuel cropping systems in agriculture and associated land use, and there are concerns that an expanding bioenergy sector will increase the impacts caused by existing agricultural systems.

Lignocellulosic energy crops can be cultivated on soils of varying qualities providing relatively high biomass output per unit area. Plants include perennial grasses, such as switchgrass, miscanthus, and others, and fast-growing tree species, such as willows, eucalyptus, poplars, and others, grown in relatively short rotations both in coppicing systems and/or after replanting following each harvest. They represent a promising option for producing biomass for energy and other purposes and are referred to as one of the most efficient options for reducing greenhouses emissions through fossil fuel displacement. Studies that assess bioenergy potentials for the longer term consistently report that the production of biomass in dedicated plantations is a prerequisite for reaching higher end biomass supply potentials.

During the last two decades several predictions, mostly in Europe but also in other parts of the world, have indicated the possibility of a dramatic increase in agricultural areas dedicated to energy crops in response to European energy and climate targets. Similarly, dedicated energy crops on agricultural soils have repeatedly been identified as an attractive option for bioenergy supply in North America, Australia, and other parts of the world, also with reference to a range of additional environmental services. Emerging options for converting lignocellulosic biomass into refined solid, liquid and gaseous fuels give access to new feedstock resources and more benign feedstock production systems.

It is well-documented that such cropping systems can be integrated into agricultural landscapes to make better use of available resources and provide multiple benefits in addition to the harvested biomass. As a minimum, such systems can – through well-chosen site location, design, management and system integration – offer additional ecosystem services that, in turn, create added value for the systems. Understanding the positive and negative impacts of different agricultural land management options is critical for the development of management regimes that balance trade-offs between environmental, social and economic objectives that may be partly incompatible. For wider implementation of such systems, however, it is not only necessary to put forward successful case studies, but also to communicate them in a way that would cause decision-making to be in favour of stable and long-term policy incentives towards such biomass production systems. In general this does not seem to be the case in large parts of the world.

Figure 7: energy crops in landscape management (courtesy of Dimitriou)

BIOENERGY FROM AGROFORESTRY CAN LEAD TO IMPROVED FOOD SECURITY, CLIMATE CHANGE, SOIL QUALITY AND RURAL DEVELOPMENT

Navin Sharma, ICRAF (World Agroforestry Centre), Kenya

The working hypothesis of food versus fuel is a false dichotomy. Care has to be taken that the biofuels and the income they generate are additional to that from existing food production, and not hindering it or increasing pressure for land use change. If biofuels are produced carefully using alternative feedstocks that do not compete with food crops and if incorporated in the agricultural landscape in such a way that they do not contribute to land use changes, biofuels can demonstrate a considerable potential. More productive feedstocks and systems are needed to ensure that overall farm productivity is sustainably increased, enabling biofuels to be produced over and above the current baseline of food production, and without harming the environment. Biofuels become all the more important if they are targeted at improving the livelihoods of smallholder farmers of developing nations by providing local energy security for their developmental needs e.g. running farm machinery and other household activities. In that way they can actually increase food security. Biofuels hold out the promise of making rural areas more energy independent as well as generating new and important income sources.

Figure 8: agroforestry system (courtesy of Sharma)

The World Agroforestry Centre (ICRAF) is implementing a four-year Programme for the Development of Alternative Biofuel Crops in partnership with centres of excellence in Africa, Asia and Latin America. Nearly a billion hectares of agricultural land already has more than 10% tree cover and 1.6 billion hectares of land worldwide has the potential to be under agroforestry (Nair and Garrity, 2012). The presentation showcased a pilot study using agroforestry systems with non-food oil bearing trees. The system has demonstrated that it can boost agricultural yields of some crops and can provide local energy for running farm machinery. The system also demonstrates the positive environmental impacts, e.g. in terms of biodiversity and ecosystem services.

SUCCESSFUL INITIATIVES IN DEVELOPING COUNTRIES IN THE FIELD OF WOOD ENERGY DEVELOPMENT

Karl Moosmann, GIZ (Deutsche Gesellschaft für internationale Zusammenarbeit), Germany

Reliance on wood fuel remains high for a large proportion of the world's population but especially those in Sub Saharan Africa. Sourcing wood fuel from open access forest often leads to undervaluation of wood, to inefficient and wasteful production and use and to uncontrolled deforestation. In Sub-Saharan Africa, the existing wood fuel industry is contributing to 52% of forest degradation and is therefore considered the number one driver of deforestation. Most traditional kilns for charcoal production have an efficiency of around 10% - 12%. More efficient kilns exist but attempts to introduce them on a larger scale have failed due to low prices for firewood and charcoal, which render investment in more efficient technology unattractive. Transporters and wholesalers gain disproportional profits. According to research undertaken by Yale University, landowners and the government receive minimal shares, for example, in the case of Kenya an estimated 0 to 3% of the profit along the charcoal value chain. Demand for solid woody biomass is likely to grow at an annual rate of 1.9% up to 2030 according to IRENA projections, with most of the projected increase occurring in Asia and Sub-Saharan Africa. Currently firewood and charcoal supply 80% of Sub-Saharan Africa's energy needs. Improved stove technology is rarely used by a majority as long as wood remains a perceived "free" resource. Women play a key role in the wood energy sub sector as users, producers, collectors and sometimes traders. There is a high potential to create jobs, for men and for women.

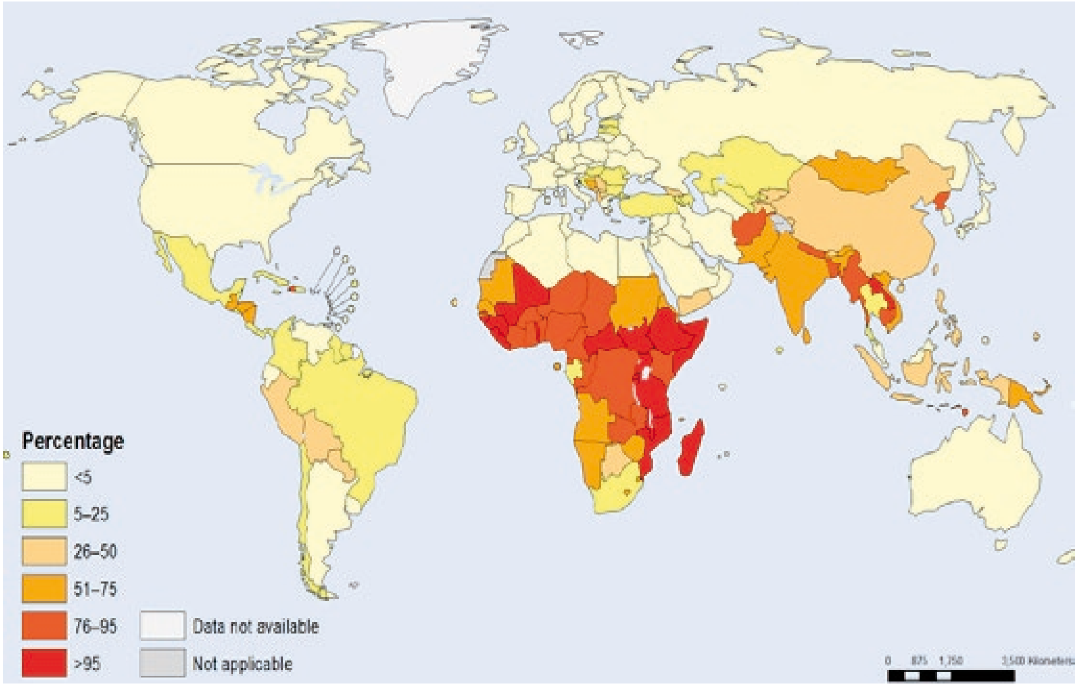

Figure 9: Population using solid fuels for domestic purposes (%), 2012 (WHO 2013)

Available technological improvements need to be implemented within a sound policy and regulatory framework. Sustainable production of wood fuel can then be economically attractive, especially if all stakeholders along the value chain are consulted. The commitment of government, especially at sub national levels is of central importance. Land use planning is an indispensable precondition for sustainable forest management and security of tenure is one of the most significant framework conditions. The introduction of a differential taxation system is a leverage instrument to initiate a switch from an exploitative to a sustainable wood energy supply system. Tree planting subsidies can be a self-financing investment through an improved and differentiated taxation system for wood energy products. To make this work, an efficient system of supervision and enforcement is required. An increased investment in a sustainable and modern wood energy development can contribute significantly to the national and local economy and to improved health conditions. It can promote gender equality and contribute to forest protection and climate change mitigation.

SUSTAINABLE PERENNIAL BIOENERGY CROPS IN MARGINAL LANDS

Emiliano Maletta, Bioenergy Crops/CIEMAT, Spain

World production has been growing steadily and faster than population, causing a rising trend in agriculture and food output per capita. Such growth has been achieved with very little addition of land. Land use for agriculture peaked around 1990 and has been stagnant or declining since. Yields, management, genetics and more efficient cropping system methods are responsible for most of the change. On the other hand, land suitable for rain-fed crop production that is neither forested, nor built-up, nor otherwise protected, nor under crop, is quite abundant. Projections of future agricultural growth, even under very conservative scenarios, does not envisage much increase in the use of extra land. An estimated 1.4 billion hectares of prime and good land and 1.5 billion hectares of marginal land would comprise the total area with potential for bioenergy use (land use for crops was excluded).

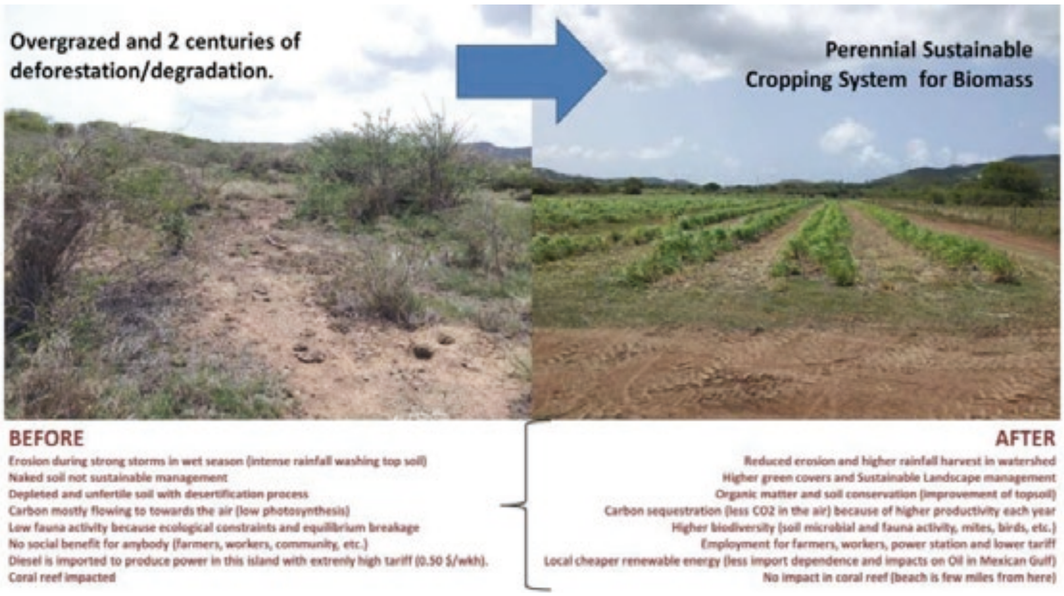

Figure 10: example of switch from degraded land to perennial cropping system (courtesy of Maletta)

The question is how marginal are those marginal lands. Marginal lands often suffer a) land abandonment, b) degradation, erosion and lack of biodiversity, c) low soil organic matter and d) deforestation and overgrazing patterns creating bare soil cover. Perennial agriculture in general can be integrated into rotational models with hedgerow and contour lines mitigating erosion processes.

In general there are two paradigms for energy crops: (1) high costs, inputs and yields which often require prime land, or (2) low inputs, moderate yields with a focus on increasing organic carbon or ecological services on marginal lands. Some crops have a very low cost in low yielding farmlands and can be cost effective, but they may require a larger collection area. Perennial bioenergy crops help to improve soil organic matter, can be cost effective and have a very positive energy balance and a very low (or even carbon negative) footprint. Marginal lands require optimised logistics, soil amendment and very strict sustainability criteria but there are options to improve their status.

Session 3: Biogas and applications

There are a variety of situations where biogas from agricultural residues such as from food crops, food processing and manure has provided a sound economic basis for combined heat and power or biomethane production to supply energy for rural communities and industries. This session presents a range of applications with the focus on opportunities for the agricultural sector.

BIOGAS PRODUCTION FROM SEAWEED, GRASS SILAGE AND SLURRY IN RURAL COASTAL AREAS

Jerry Murphy, University College Cork, Ireland

Six European countries have committed to 100% green gas in the gas grid by 2050. The route to green gas includes a number of technologies and feedstocks. Biogas production from slurries and crops is a mature industry, which is being applied in many countries. The presentation explained studies on co-digestion of grass silage and slurry and the potential resource in Ireland.

Algal biogas is a technology for the future and macro algae (seaweed) in particular was discussed. The presentation mentioned the issue of (rotting) seaweed on beaches, the cultivation of seaweed in association with fish farms, the specific methane yields of a range of seaweeds, the variation in yield with season and how the ensiling process could both store the seaweed and increase the methane yields. On the other hand, micro-algae could be used as a means of upgrading biogas and can be cultivated on digestate reducing the required land spread area.

Figure 12: seaweed on the beach in Ireland (courtesy of Murphy)

The presentation explored the use of biogas to facilitate intermittent renewable electricity through demand driven biogas systems, producing electricity when demand for power was high, and producing methane from electricity when demand for power was low. Biological methanisation could be used to upgrade biogas to biomethane using hydrogen from surplus electricity and in essence convert surplus electricity to a methane carrier.

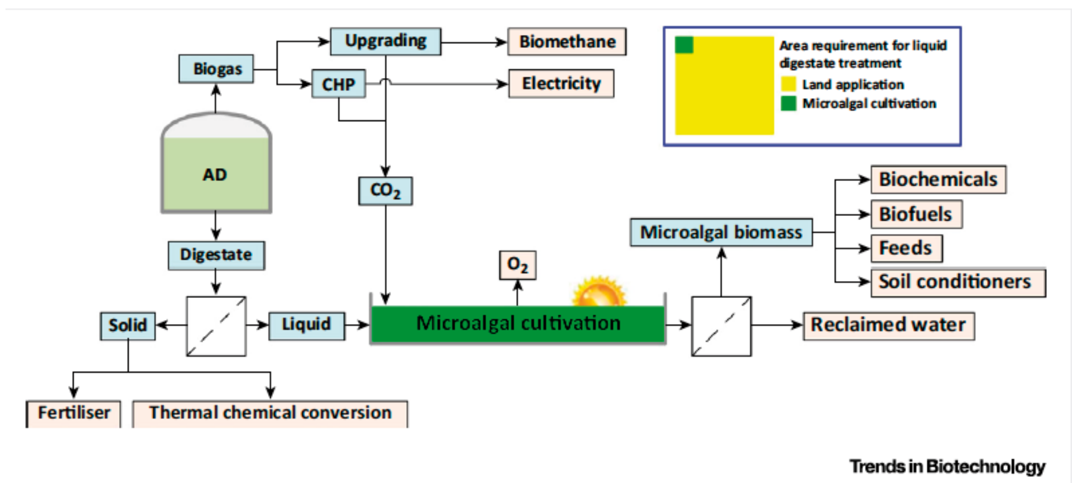

Figure 11: combining anaerobic digestion with microalgal cultivation (source: Xia, Murphy in Trends in Biotechnology)

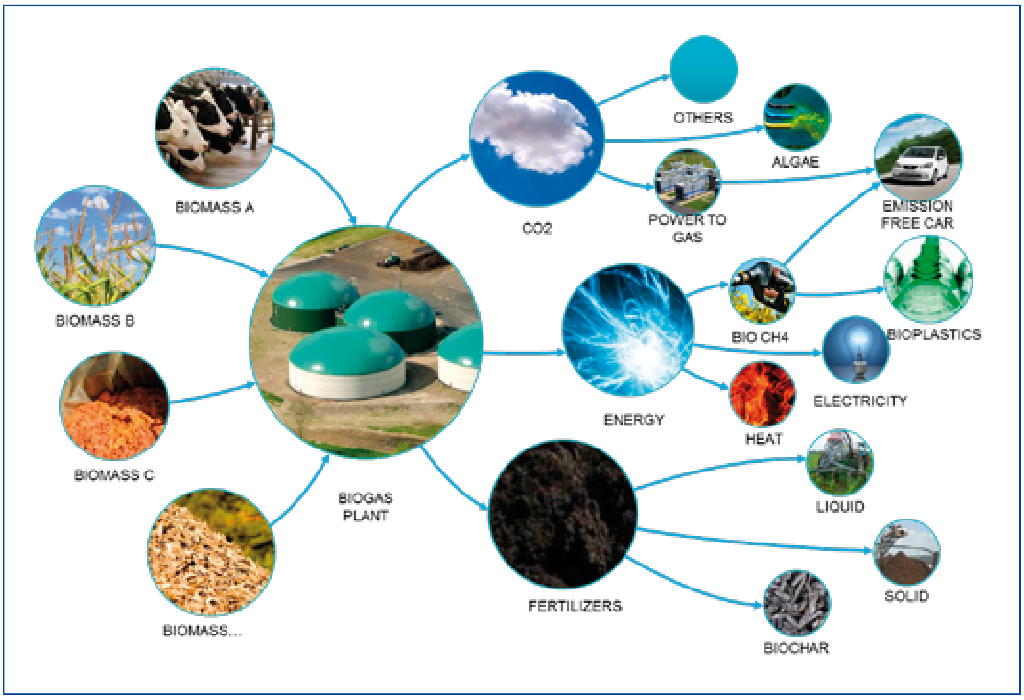

Figure 13: biogas refinery: a flexible distributed multipurpose plant (CIB)

A model was proposed of a coastal digester including co-digestion of grasses, slurries and seaweed and employing either micro-algae or power to gas systems to upgrade biogas to biomethane.

'BIOGASDONERIGHT' AND SOIL CARBON SEQUESTRATION

Piero Gattoni, CIB (Italian Consortium on Biogas and Gasification), Italy

The Italian Biogas Council (CIB), a network that represents more than 450 Italian agriculture entrepreneurs, referrs to the term *BiogasDoneRight* to describe a technological platform that allows the adoption of a combination of technologies and agricultural practices that, when applied synergistically, are able to produce additional carbon storage, increase soil fertility and Net Primary Production (NPP) at the farm, mitigate emissions from the farming sector, increase the organic matter of the soil and contribute to the fight against climate change at the local level while improving food security.

The principle of BiogasDoneRight combines different options to lower emissions from agriculture:

- mitigate emissions from agro-residues and wastes (avoid fugitive methane emissions)
- keep the soil covered all year round, thus increasing photosynthesis and rotations
- increase soil fertility via greater crop residues, manure and digestate applications
- disturb the soil as little as possible, through minimum tillage, strip tillage, sod seeding, precision farming and increased rotation techniques
- lower fossil inputs in fertilisation and energy use, through organic fertilisation, nitrogen fixing crops, biogas and biomethane in agricultural mechanisation
- improve Nitrogen Usage Efficiency (NUE) through increased organic fertilisation, drip irrigation with digestate liquid fraction, cover crops, etc.
- increase Net Primary Production (NPP) through increased Water Usage Efficiency

(WUE) applying drip irrigation, food or perennial crops to revegetate abandoned lands, increased field capacity due to greater soil organic carbon content and its water buffering capacity

- apply lower pesticides and Plant Protection Product inputs, direct seeding on cover crops, increased organic fertilisation, increased pollinator insects and increased biodiversity.

The anaerobic digestion infrastructure is central in this approach, building on livestock effluents (manure), agro-residues and agro-wastes, cover crops before or after cash crops and food or perennial crops to revegetate abandoned lands. This provides biogas as well as organic fertilisers without lowering food & feed production and can be part of a future biogas refinery system providing electricity, heat, transport fuels, biomaterials and fertilisers.

PALM OIL RESIDUES FOR BIOGAS PRODUCTION

Heinz Stichnothe, Thünen Institute, Germany

Palm oil represents approximately 40% of global vegetable oil production, of which more than 50% is produced in Indonesia and over 30% in Malaysia. The global demand for palm oil is projected to increase from 51 million tonnes in 2012 to 75 million tonnes by 2050, most being used for food purposes. The predicted demand can be met by crop-area expansion and yield increase. Ensuring domestic food security will probably be the main driving force for increased palm oil production in Africa and South America, while Malaysia and Indonesia will remain the main exporters of palm oil.

The annual potential of residues from palm oil mills in Indonesia is 35 million tonnes of empty fruit bunches (EFB) and 110 million m³ of palm oil mill effluent (POME). POME digestion and co-composting of EFB and POME are proven technologies. Biogas production from EFB is, however, still in its infancy.

Figure 14: Empty fruit bunches Indonesia (Stichnothe)

By using the annual palm oil production figure for 2015, more than 1 million tonnes of methane could be generated from POME, or approximately 32 PJ. If EFB were used for biogas production, between 60 and 100 PJ could be generated in addition. Cost benefit analysis for POME treatment systems utilising biogas for electricity production suggest investments in biogas installations can be recovered within a period of less than five year.

Biogas production from oil palm residues is associated with a very favourable GHG budget. Closed tank digestion prevents spontaneous methane emissions from EFB decomposition as well as from commonly applied open POME ponds. One cubic meter of POME can release up to 12 m³ methane emissions, equal to approximately 200 kg CO_2-eq. In a worst case scenario where EFB is dumped, one tonne can cause GHG-emissions equivalent to 1,000 kg CO_2-eq. Consequently, using residues of palm oil mills for biogas production is economic, environmentally beneficial and saves fossil resources.

The utilisation of residues provides more energy - particularly as heat - than is actually needed at palm oil mills. Hence, palm oil mills could be the basis of biorefineries that simultaneously produce food, fuel (e.g. biodiesel) and chemicals (e.g. 1,3-propanediol).

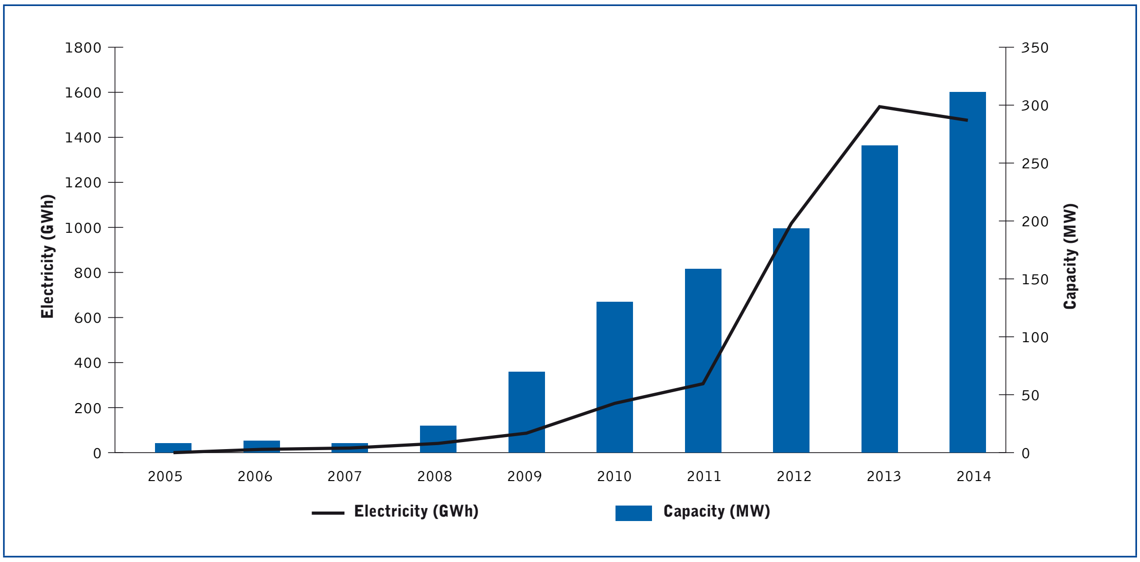

Figure 15: evolution of electricity sales from biogas in Malaysia (Siteur)

Despite the promising opportunities, there are several barriers in Indonesia including an inconsistent regulatory framework, issues relating to implementation of national regulations, public perception, limited access to finance and low planning security. It is also acknowledged that biogas in Thailand has been much more successful (see presentation by Siteur). One of the reasons for this difference is that residues in Thailand are frequently managed by external operators while in Malaysia and Indonesia plantation and mill operators are in charge of managing the residues. In the latter case, as managing the residues is not their core business, their focus is on the plantation itself and management of the mill.

RAPID DEPLOYMENT OF INDUSTRIAL BIOGAS IN THAILAND: FACTORS OF SUCCESS

Joost Siteur, Clean Energy Advisor, Thailand

Thailand has experienced a remarkable increase in the deployment of biogas in agro-industries over the last decade. Since the early 2000s, nearly 200 biogas projects have been implemented at starch mills, breweries and palm oil mills, both for on-site energy provision and electricity sales to the grid. These projects provide considerable savings in energy expenditure and significant reductions in environmental impacts, by efficiently treating large volumes of highly organic wastewater. Furthermore, they provide additional revenue streams from the sales of electricity and from emissions reductions. Investments in biogas in Thailand amount to more than US$800 million. Revenue from electricity sales is estimated to be more than US$500 million over the last 10 years. No data is available on savings from on-site energy generation.

In contrast, biogas development in neighbouring countries with significant starch and palm oil industries such as Indonesia, Malaysia and Vietnam have been lagging behind. This presentation provided an assessment of the rapid development of the industrial biogas sector in Thailand, identifying key driving factors and lessons learned, and discussing prospects for further development. Favourable government policies and incentives for renewable energy, the strength of the industrial sector, and the overall investment climate are considered the main drivers for the rapid industrial biogas development. In addition, the potential revenue from carbon credits is an important driver for biogas development, but in practice this potential is essentially not realised.

Industrial biogas has now become a mainstream technical option for starch and palm oil mills, and all major facilities have a system installed or under development. The potential of biogas at the remaining facilities is limited, due to their smaller size and limited operating hours. Nevertheless, there remains large scope for improving the performance and safety standards of existing biogas plants. Many plants are underperforming, mostly due to poor design, improper operational procedures and lack of skilled operators.

To date, most projects are based on wastewater, but in recent years the government has been promoting the development of biogas based on dedicated energy crops, through a special Feed-in Tariff. Efforts are also underway to develop compressed biogas (CBG) for transportation.

THE POTENTIAL ROLE OF BIOMETHANE IN ITALIAN TRANSPORT

Wolfgang D'Innocenzo, Italian Ministry of Economic Development, Italy

Natural gas (NG) in transport is an Italian specialty. More than 800,000 NG vehicles are in circulation in Italy, which is about 77% of all NG vehicles in the EU. The number of NG filling stations in Italy exceeds 1100. Public action to implement natural gas in transport includes low taxation of automotive methane. Use of biomethane in transport to reach the EU 20-20-20 targets and various car scrappage schemes over the years have favoured clean fuel vehicles (CNG, LPG, electricity or hydrogen). This situation is key to the development of the use of biomethane in transport.

Figure 16: natural gas care and fuel station in Italy

Italy is developing an obligation scheme for biomethane in transport consistent with and complimentary to that for liquid biofuels (blending scheme), and taking account of the impact of the provision of a "sub target for advanced biofuels" in the revision of the Renewable Energy Directive.

To comply with the compulsory biofuel blending scheme in Italy, transport fuel distributors can either blend liquid biofuels (biodiesel, bioethanol, etc.) or use biomethane in the transport sector. Given that large quantities of natural gas are used in transport (over 1.1 billion Nm^3 per year) in Italy, biomethane is able to play an important role in substituting natural gas in the transport sector. To do this, transport fuel distributors who also sell natural gas, need to sign long-term contracts with biomethane producers for the purchase of biomethane injected into the NG grid. All contracts and flows are registered in a specific centralised database, managed by the Italian state-owned Renewable Energy Agency (GSE), allowing the latter to trace the flow of biomethane injected into the grid and determine the specific use of it.

Million Nm^3	2016	2017	2018	2019	2020
annual	–	50	100	200	300
cumulative	–	50	150	350	650

Table 1: Estimated development trend of biomethane in transport 2016-2020 in Italy

INTERACTION WITH THE AUDIENCE ON STRATEGIES AND GOOD PRACTICES OF BIOMASS MOBILISATION IN AGRICULTURE

Moderated by Luc Pelkmans, Technical Coordinator, IEA Bioenergy

The discussion covered the issues presented and discussed in Sessions 2 and 3.

Agriculture-energy-climate

A common platform for developments in agriculture, energy and climate should be developed. It is clear that an integrated approach is needed. Increasing food production can go hand in hand with bioenergy and climate change mitigation. It also needs to be positioned within the Sustainable Development Goals (SDGs) and the COP21 agreements.

There is scope for collaboration between several people/organisations in the workshop. A short communication (2-4 page agreed communique) developed by these organisations would be very helpful. Complexity of bioenergy is often not recognised by policy makers resulting in, for example, changes to schemes within a very short period of time. Markets need regulatory stability and a long term perspective. Bearing in mind that regulations/incentives generally vary between countries with differing regional conditions, it is difficult to find uniform solutions. Incentives are sometimes given where there are no markets for the products/co-products which can lead to disappointing results (and reduced interest from the agricultural sector). A good consultation with all the different stakeholders (farmers, power sector, etc.) is needed, as well as a long-term perspective.

A top down approach is necessary to realise the available potential. This implies that good practices and success stories concerning biomass mobilisation and use should be made available to convince policy makers. Bottom up experience and top down (policy makers) push are both important for achieving bioenergy goals.

Sustainability means different things to different people at different scales. Schemes and certification systems can define general principles, but the application has to be considered at local scale, with the viewpoint of local stakeholders in mind. There is a need for performance indicators on good practice.

The traditional approach to wood as an energy source, e.g. for cooking, should not be overlooked, particularly in the context of developing countries (cultural aspect & local economy). It will still be a major part of bioenergy – the aim should be to use bioenergy in a more sustainable way.

Degraded land deserves more analysis and work – it is not the easiest option, and there are generally various reasons why this land is not used. Most probably yields will remain on the low side.

Role of biogas

Biogas can create great opportunities, especially from agricultural residues, waste and manure as feedstocks. It is flexible in terms of input and end use. There is a particular interest in the electricity sector where biogas can play a role in grid stabilisation where there is a high share of fluctuating renewables. Biogas also has advantages in relation to power-to-gas systems. Biogas (upgraded to biomethane) can be attractive as a transport fuel; the question is to decide which application will be best. For example, there are other alternatives for passenger car transport such as electric mobility, while biomethane may be more suited to long-haul transport, particularly in liquid form (LBG).

The scale of anaerobic digestion was also discussed as was the question of who should operate AD plants. In developing countries, the use of biogas in households or on small farms is so far not successful. For farmers it is difficult to extend their business to energy production. Even for larger producers (such as palm oil producers) it is not straightforward to include anaerobic digestion in their business case, although there has been some success in Thailand. On the other hand there seems to be successful examples at farm level, for example, in Italy where anaerobic digestion is considered in a bigger context of reduction in the environmental impact of farming. It may be advisable to implement AD in a cooperative group or together with industry (experts), to deal with greater complexity when upgrading to biomethane or when biorefinery technologies are involved.

There was some discussion on methane leakage in biogas plants. In the absence of anaerobic digestion, agricultural residues or manure storage generally gives rise to much higher methane emissions compared to potential leakages from anaerobic digestion. On the other hand, where fresh material or crops are added, leakage may negate some of the GHG advantages of biogas systems. Reducing leakage is linked to good management practices.

Conclusions

In the workshop various good practice examples of the integration of food and bioenergy production were presented. FAO, IRENA, IEA and IEA Bioenergy agree that it is possible to increase the production of biomass for energy, while enhancing sustainable agricultural and food production systems. Moreover different approaches can increase carbon storage in soils, which fully contribute to climate change mitigation strategies. Integrated policies for agriculture, energy and climate can therefore support positive impacts in these different fields.

In terms of the role of biomass in the future energy system, it was acknowledged that it is substantial and that there is potential. On the other hand it will be very challenging to reach certain targets, accepting that bioenergy systems are quite complex and, in consequence, can discourage policy makers. Moreover different sectors need to cooperate to make it happen. There is a major task ahead: FAO, IEA Bioenergy, IRENA and IEA will jointly engage in advising policy makers and stakeholders of the opportunities for biomass and in sharing good practices.

Some concrete actions were defined:

- FAO, IEA Bioenergy and IRENA agreed to formulate a consolidated message (2-4 page communiqué) to highlight opportunities for increased bioenergy use in synergy with agricultural and forestry production, and in furtherance of sustainable development goals (SDGs) as well as in support of the COP 21 agreements.
- A dialogue will be organised on the assumptions behind different estimates of biomass potentials and different scenarios of bioenergy supply so that consistent messages can be brought to the public.

Acknowledgements

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Luc Pelkmans, the Technical Coordinator of IEA Bioenergy, prepared the draft text with input from the different speakers. Pearse Buckley, the IEA Bioenergy Secretary, facilitated the editorial process and arranged the final design and production.

Further Information

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