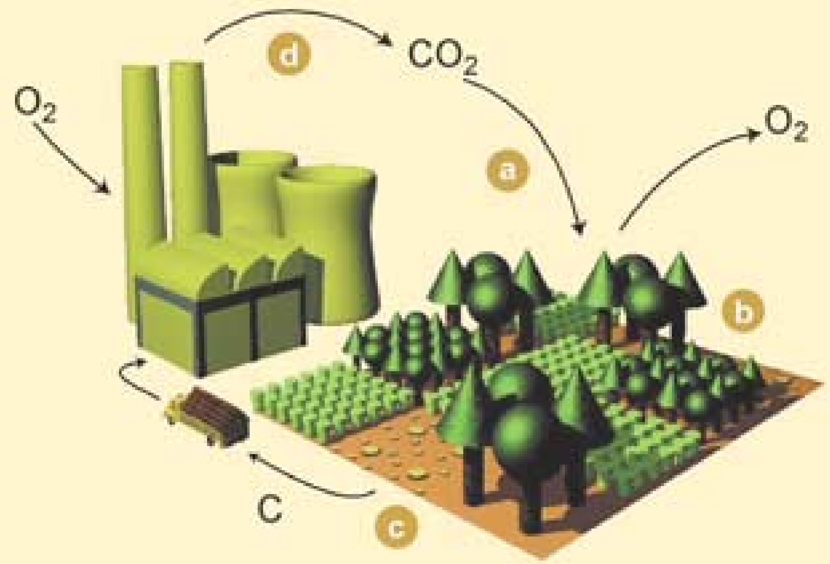
Options for Trading Bioenergy Products and Services

This feature article provides an overview based on the work of Tasks 38 and 40. The opinions expressed are those of the authors.

Introduction

Bioenergy is increasingly utilised to reduce emissions of greenhouse gases (GHG). Various options exist for trading bioenergy and bioenergy services between countries. In this paper, trade in biomass fuels, electricity, renewable certificates, and CO_2 credits are presented as options for business and policy makers as they try to meet increasing energy demands, while at the same time addressing national and international commitments to reduce GHG (CO_2) emissions and increase renewable energy sources.

Bioenergy has the advantage that it is CO_2 neutral, if the biomass is sustainably produced; and biomass fuels can be stored until the energy is demanded by the user, therefore meeting both peak and baseline energy demands. Biomass can take various forms, such as residues from forestry, agriculture, and industry. It can be grown in dedicated woody or herbaceous energy crops, and can be transformed into various solid, liquid, and gaseous biofuels.



Carbon recycling. a: CO_2 is captured by the growing crops and forests; b: oxygen (O_2) is released and carbon (C) is stored in the biomass of the plants; c: carbon in harvested biomass is transported to the power station; d: the power station burns the biomass, releasing the CO_2 captured by the plants back to the atmosphere. Considering the process cycle as a whole, there are no net CO_2 emissions from burning the biomass. (Source: Matthews, R. and Robertson, K. 2002. www.joanneum.at/iea-bioenergy-Task38/publications)

Biomass energy systems include the following services:

- Energy in the form of useful electricity, heat, or liquid/gaseous fuel.
- Reductions of net GHG emissions, thus addressing global climate concerns.
- Other benefits of renewable energy sources, such as job creation, reduction of local air pollution, reduced reliance on a limited resource, etc.

Estimates of the potential contribution of bioenergy range from 100 to over 500 EJ during this century. In developed countries domestic biomass potentials are often used to a high degree, though in some countries untapped potentials remain. Also, there is often a high production cost for biomass in developed countries. In the long term, the pressure on available biomass resources will increase. Without the development of biomass resources (e.g., through energy crops and better use of residues) and a well-functioning biomass market, the often ambitious targets for bioenergy use may not be met.

The development of truly international markets for biomass may become an essential driver for biomass production, as the potential is currently unrecognised in many regions of the world. Many developing countries have a large technical potential for agricultural and forest residues and dedicated biomass production, e.g., sugar cane, wood, or other crops. Given the lower costs for land and labour in many of these countries, production costs are much lower, and thus offer an opportunity to export biomass.

Pellets and briquettes made from sawdust are more suitable for transport than biomass raw materials which are often bulky and of low calorific value (Courtesy BrikettEnergi, Sweden)

Since biomass is an energy source that is present over large land areas, the need for collection and transport systems arises. Conventional thinking is that biomass should be used locally, perhaps transported up to a distance of 50-100 km, to strike the optimum between economies of scale of the conversion plant, and the variable costs of biomass transport.

However, although many trade flows do take place between neighbouring regions or countries, increasingly trade is occurring over long distances. Examples are the export of ethanol from Brazil to Japan, EU, and the USA; palm kernel shells from Malaysia to the Netherlands; wood pellets from Canada to Sweden, etc. Also the European Commission is planning a communication on future prospects for biofuels reflecting on 'the question of measures to promote the production of biofuels, including such production in less-developed countries'. This is happening despite the bulky and lower calorific value of most biomass raw material. These examples and various analyses show that biomass can be economically transported over longer distances, provided that transport occurs in bulk (such as by train or ship), and that biomass can be increased in density to reduce its volume and make transport more cost-effective. Furthermore, analyses of bioenergy trade chains still show significant advantages in GHG reduction potential in comparison to fossil fuel chains.

One of the main drivers for increasing the use of bioenergy is to reduce CO_2 emissions. Biomass is a CO_2-neutral energy source to the extent that CO_2 uptake by plants for growth equals the release of CO_2 from the energy conversion. In national GHG inventories the use of biomass will result in less emission reported from using fossil fuels; CO_2 emissions from bioenergy are reported, but not counted in national totals. Thus the relative benefit of biomass leads to an improvement in the national GHG inventory. When biomass is traded between countries, the exporter will experience a CO_2 flux from the atmosphere to his land, whereas the importer will experience a CO_2 flux from his energy system to the atmosphere, both roughly cancelling each other out. In cap-and-trade programmes of GHGs, gross CO_2 fluxes from biomass oxidation should not be counted in the GHG inventory of the consumer if a GHG incentive to use bioenergy is to be maintained. Technically, if biomass is produced sustainably (no net addition of CO_2 to the atmosphere), both producer and consumer experience a zero carbon stock change, and the consumer will experience a reduction in CO_2 emissions from fossil fuels in their inventory.

Demand for bioenergy is increasing as concerns about climate change lead to implementation of policy measures that favour renewable energy sources over their fossil-fuel-based competitors. Examples of such policy measures and mechanisms are renewable energy mandates, feed-in tariffs for electricity from renewables, trading of green certificates and cap-and-trade systems for GHG. Demand is also driven by price mechanisms such as subsidies and taxes. All of these mechanisms seek to internalise the externalities of fossil fuel use in terms of climate change and other impacts, and provide a more balanced energy choice.

Loading logs for transportation by truck (Courtesy UK Forest Research Photo Library)

There is not only a demand for useful energy, but also for 'climate friendly' energy systems and energy systems that bring with them all the other advantages of renewable energy. Biomass energy can help meet all three demands. It is noteworthy that the first benefit, useful energy, must usually be provided at the location of demand, whereas the other two types of services are less dependent on location. It does not matter where reduction of GHG occurs, because the atmosphere is well mixed globally and an emission (or reduction therein) will have an equal effect wherever it occurs. Similarly, many of the benefits of renewable energy (such as decreased use of limited fossil fuel resources) will not depend on where the biomass is used, although these benefits do occur locally.

This suggests that biomass may not have to be transported in all circumstances, especially where the demand is largely for climate friendly and renewable energy sources. Instead, it may be possible to convert biomass into useful energy at the place where it occurs, and 'transport' the produced electricity, to the location where these services are in demand, or possibly trade the nonmaterial services such as 'CO_2 neutrality' or 'renewable features' under mechanisms such as those identified above.

Matching Supply and Demand for Bioenergy Services

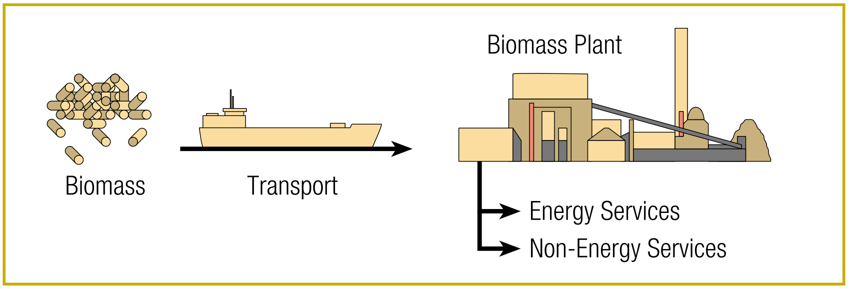
Energy supply and demand can be considered at different levels e.g., country, region, company, or individual projects. This discussion will refer for convenience to the location with energy demand as 'Country D' and to the location with surplus biomass supply as 'Country S'.

Trading Energy Carriers

Biomass Fuels

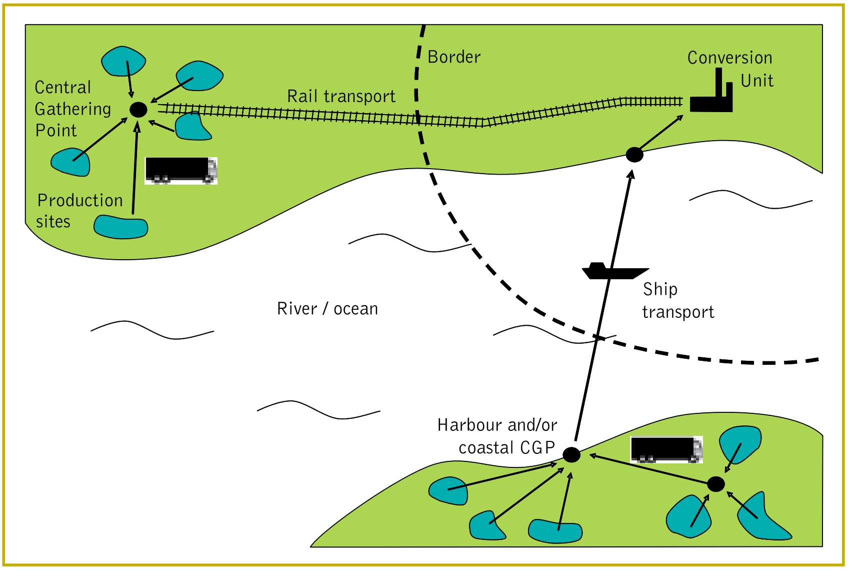
Some world regions (for example Latin America and Eastern Europe) have a larger bioenergy production potential than others, a combination of large land areas with good crop production potential, low population density, and often extensive agricultural practices. Consequently, various countries may become net suppliers of renewable bioenergy to countries that are net importers of energy. For example, there is growing interest in exporting bio-ethanol from Brazil to Japan and the USA. In order for bioenergy to be available to importing regions, transport of biofuels over relatively long distances is necessary. This, however, implies extra costs, more complex logistics, and additional energy losses compared to more local utilisation.

The possibilities for exporting biomass-derived commodities to the world's energy markets can provide a stable and reliable demand for rural communities in many (developing) countries, thus creating an important incentive and market access that is much needed in many areas of the world. For many rural communities in developing countries such a situation would offer good opportunities for socio-economic development.



International bioenergy trade can include direct transport of biomass materials (chips, logs, and bales), intermediate energy carriers (such as bio-oil or charcoal), or high quality energy carriers such as ethanol, methanol, Fischer-Tropsch liquids, and hydrogen (Source: Joanneum Research).

Factors such as the biomass production method, the transport type, and the order and choice of pre-treatment operations are of importance. The design of the supply chain will influence the costs and energy efficiency, via a large number of variables, such as transport distance, dry matter losses, fuel prices, total volumes transported, and equipment performance.



International bioenergy logistics - schematic representation of possible biomass and bioenergy trade chains (Source: Copernicus Institute)

Various drivers for international bioenergy trade can be distinguished:

- *Cost-effective GHG emission reduction.* At present, the demand for biomass is growing due to climate policies of various countries. Where indigenous resources are insufficient at the required quality and cost, imported material may be an attractive alternative to local biomass supplies.

  Use of proper reference systems is crucial: the GHG mitigation potential of biomass use is strongly affected by, for example, the carbon intensity of power generation in both the importing and exporting countries. This is true for bio-oil export from Karelia (Russia) to the Netherlands. The possibilities for using biomass for CHP in Karelia (as well as the relatively low distribution density of forest residues) and the relatively efficient power generation in the Netherlands indicate that local use of biomass resources may be preferred over export in this particular case. In the case of wood pellet export from Canada to the Netherlands and other Western European countries, the opposite is true.

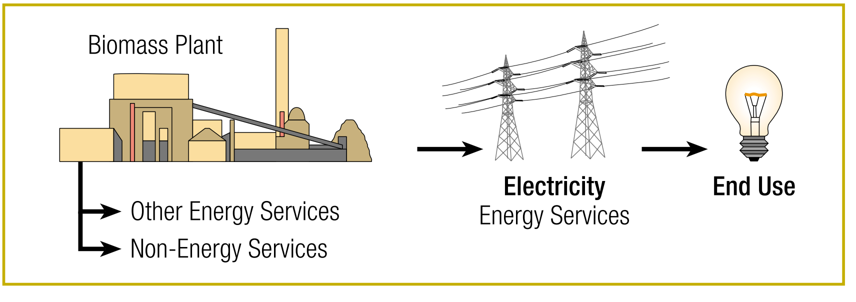
- *Socio-economic development.* Many institutions and much research have indicated the potential strong positive link between developing bioenergy use and local development. For various countries, exporting bioenergy in the future may provide substantial benefits for their trade balances.

- *Sustainable management and use of natural resources.* Large-scale production and use of biomass for energy will involve use of (additional) land. When biomass production can be combined with better agricultural methods, or restoration of degraded and marginal lands it can provide a sustainable source of income for rural communities.

- *Fuel supply security.* Biomass may diversify the total portfolio of fuels used and imported by countries, thereby reducing the risks of supply disruptions in terms of both quantity and price, especially in the case of biofuels for transport since they replace oil imports.

Electricity

International trading of electricity is already established. Electricity produced from biomass will usually be CO_2 neutral, and can be an effective means of meeting energy demands of the electricity importer while at the same time not adding to the CO_2 emissions of the exporting country. That is, neither the importing nor the exporting country experiences any GHG emissions from the transaction.



International trade in electricity produced from biomass. (Source: Joanneum Research)

Countries may be importers or exporters of electricity for only parts of the year, parts of the day etc., depending on peak load demands, electricity price variations, and other factors. When electricity is traded, CO_2 emissions will be accounted for in the national GHG inventory of the country where the emission from electricity production occurs. Thus, it is conceivable to meet an emission reduction target by reducing domestic electricity generation and making up the shortfall through imports. This is most likely to occur where not all countries in a region are subject to emission limitation and reduction commitments.

Both biomass and electricity trade will lead to GHG emission reductions in the inventory of the importing country. The magnitude of reductions, and thus the viability of these two options, will depend on the GHG intensity of the energy system in the importing country, i.e., what type of energy carrier and conversion system is displaced (baseline scenario). Usually this will be a marginal power plant that would have gone into operation (or would have increased its level of output) in the absence of the electricity import. If this marginal production system is a rather inefficient coal-fired power plant, then the GHG reductions will be greater (by a factor as high as three) than if the marginal plant works on natural gas using state-of-the-art technology.

The Amer biomass co-firing power plant in the Netherlands. (Courtesy Essent, the Netherlands)

One of the key advantages of this trading option is that production of renewable energy can be optimised in power plants with better technologies and economies of scale that could not be realised without the increased flexibility and increased demand of trade.

Logically, electricity trading is limited to areas where the grid offers sufficient capacity and the effectiveness decreases with increasing distance. It is important to ensure that there is appropriate labelling when electricity from renewable sources is purchased.

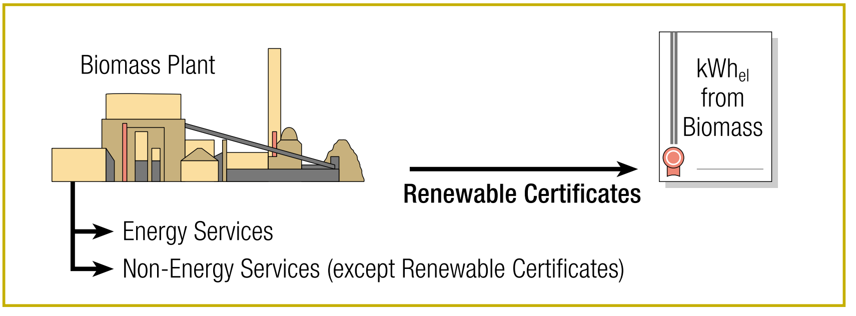
Trading Non-energy Services

'Non-energy services' include benefits from biomass energy that are unrelated to the energy as such. Examples are environmental, social, and emission reduction benefits compared to other energy sources. The emission reduction benefits are packaged in various forms and, for example, change their owner in emissions trading schemes. Industry tends to be supportive of emissions trading since it enables a given emissions target to be met at lower cost than with conventional regulations. The cost savings are possible because there is more flexibility in the choice of where emissions are reduced. Sources with low-cost reduction opportunities can implement larger reductions and sell their surplus reductions. Sources with high-cost reduction options can save money by purchasing surplus reductions from other participants instead.

Renewable Certificates

'Renewable certificates' can be used to meet the demand for the renewable energy, e.g., in the context of national renewable energy targets. The 'renewable certificates' represent the local services and benefits of the renewable energy, such as pollution abatement and jobs, but not necessarily the CO_2 emission reduction as this could lead to double counting, if for example CO_2 is covered by a cap-and-trade programme.

This option allows Country S to produce renewable energy above and beyond its own national targets and then sell the remaining amount in renewable certificates to Country D, while using the electricity in domestic markets. Country D in turn will be able to meet domestic targets of renewable energy sources by importing certificates to the extent that their national legislation on renewables accepts certificates from other countries. Policy makers in Country D may want to allow imported certificates only when Country S already meets any standards it may have domestically.



Trading renewable certificates (Source: Joanneum Research)

Much flexibility exists, as Country S could also sell the electricity without the renewable certificates separately (see 'Electricity' above). In any event, the renewable aspect of the energy must not be double counted. The renewable certificates of the energy can either be attached to the energy purchase, or removed and sold separately to those buyers that only need a renewable energy quota for their own portfolio. Flexibility also comes from the fact that both electricity and certificates can be sold to different purchasers at different times, so that maximum revenues can be achieved.

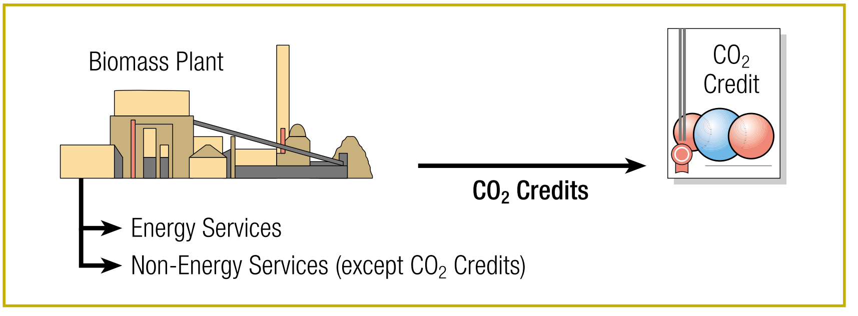
Green certificates are already traded within the EU. For example, utilities in the Netherlands have been importing significant amounts of green certificates for the last few years. Currently, certificates can be imported and sold as 'green electricity' in the Netherlands only from countries whose system of issuing Guarantees of Origin has been approved by the EU. Currently, these countries are Sweden, Finland, Denmark, Austria, the UK, and the Netherlands.

CO_2 Credits

Concerns about global climate change have led to limits on emissions of GHG. One outcome of this concern is the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) which places limits on the emissions of industrialised nations in the period 2008 - 2012 (the 'first commitment period').

The Kyoto Protocol foresees flexibility in meeting the targets, using the concept of emissions trading. For example, countries that over-comply with their targets can sell emission allowances to countries that would otherwise not meet their targets. CO_2 trading provides the flexibility of investing in those places where energy investments (either replacement of existing facilities or investments to meet new energy demand) are due anyway, thus reducing the costs of CO_2 mitigation.

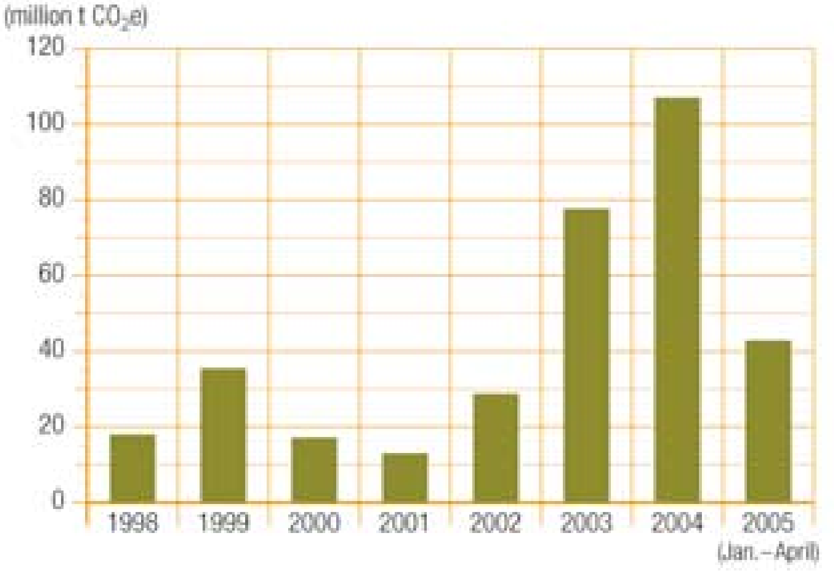
The Protocol also foresees that emission-reducing projects carried out in other industrialised nations (Joint Implementation - JI) or in developing countries (Clean Development Mechanism - CDM) can generate GHG credits that are tradable. Governments of industrialised countries with Kyoto commitments have begun to invest in JI and CDM projects, for example the Netherlands or Austria - see examples below.



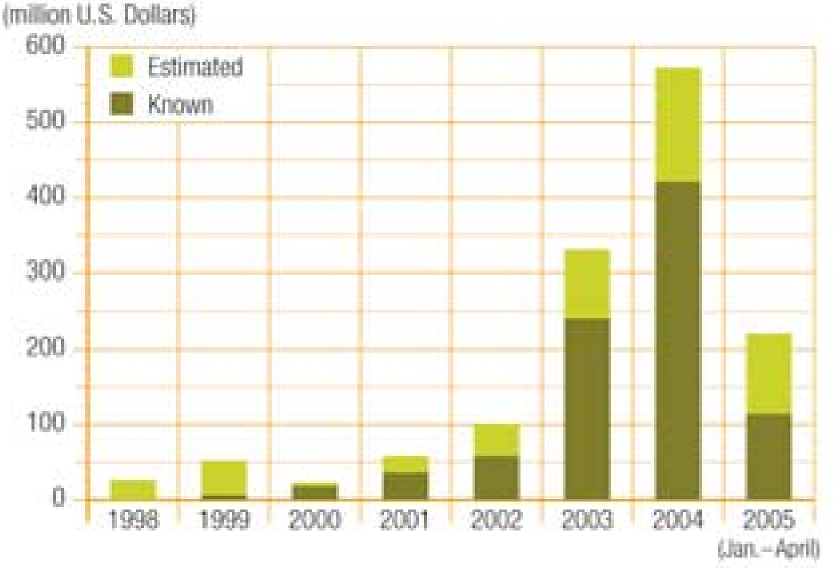
Trading bioenergy CO_2 credits (Source: Joanneum Research)

In the case of bioenergy, trading CO_2 credits would mean that a biomass conversion plant is put in place in the 'seller' country and CO_2 credits are sold to the 'buyer' country. The amount of credits will depend on the baseline scenario of the 'buyer' country whereas for physical biomass or electricity trade the baseline scenario of the 'seller' country is of interest. That is, JI and CDM projects may be especially worthwhile where the marginal energy supply is very GHG intensive.

There are several arrangements in which corporations, governments, or groups of these, purchase carbon credits either directly or indirectly through 'carbon funds'. Examples of the fund approach are the World Bank's Prototype Carbon Fund (PCF), the Community Development Carbon Fund and the Biocarbon Fund. For further details see *www.carbonfinance.org.*

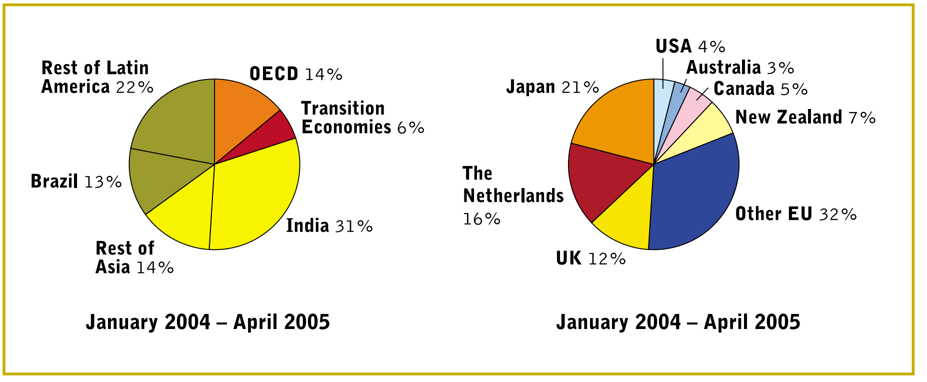


Annual volumes (million t CO_2e) of project-based emission reductions traded up to 2012 vintages (Source: Lecocq, F. and Capoor, K. 2005. State and Trends of the Carbon Market 2005. Carbon Finance Business, World Bank, www.carbonfinance.org)



Estimated total market value per year in million US dollars, nominal (Source: Lecocq, F. and Capoor, K. 2005. State and Trends of the Carbon Market 2005. Carbon Finance Business, World Bank, www.carbonfinance.org)

Another example is the European Emissions Trading System (ETS) which caps the emissions of combustion installations with a rated thermal input exceeding 20 MW, as well as those from other companies in the metal, mineral and pulp and paper industries above certain thresholds. The ETS also allows companies to invest in JI and CDM projects, and thereby provides a link with the Kyoto Protocol Mechanisms.



Pie chart on left: Location of emission reduction projects and share of volume supplied.
Pie chart on right: Buyers of emission reductions and share of volume purchased.
(Source: Lecocq, F. and Capoor, K. 2005. State and Trends of the Carbon Market 2005. Carbon Finance Business, World Bank, www.carbonfinance.org).

Effectiveness of Trading Options

Policy and business decision makers will consider a host of criteria when determining the way to most efficiently reconcile supply of and demand for renewable energy. Questions to be addressed are whether a cost-effective biomass potential, and whether applications for biomass, exist domestically. If both biomass resource and applications are available locally then the trading options explained in this paper might be less attractive. However, if local resources are scarce but domestic applications exist then the biomass trading option might be of interest. If neither the resources nor the applications exist, then the purchase of renewable certificates and/or CO_2 credits is the only remaining option.

Decision makers must also evaluate the environmental and social aspects of the different options. Biomass energy can, among other benefits, help diversify energy sources and supply local jobs. It is important that environmental, socio-economic, agricultural, energy, climate, and trade aspects are considered in policymaking.

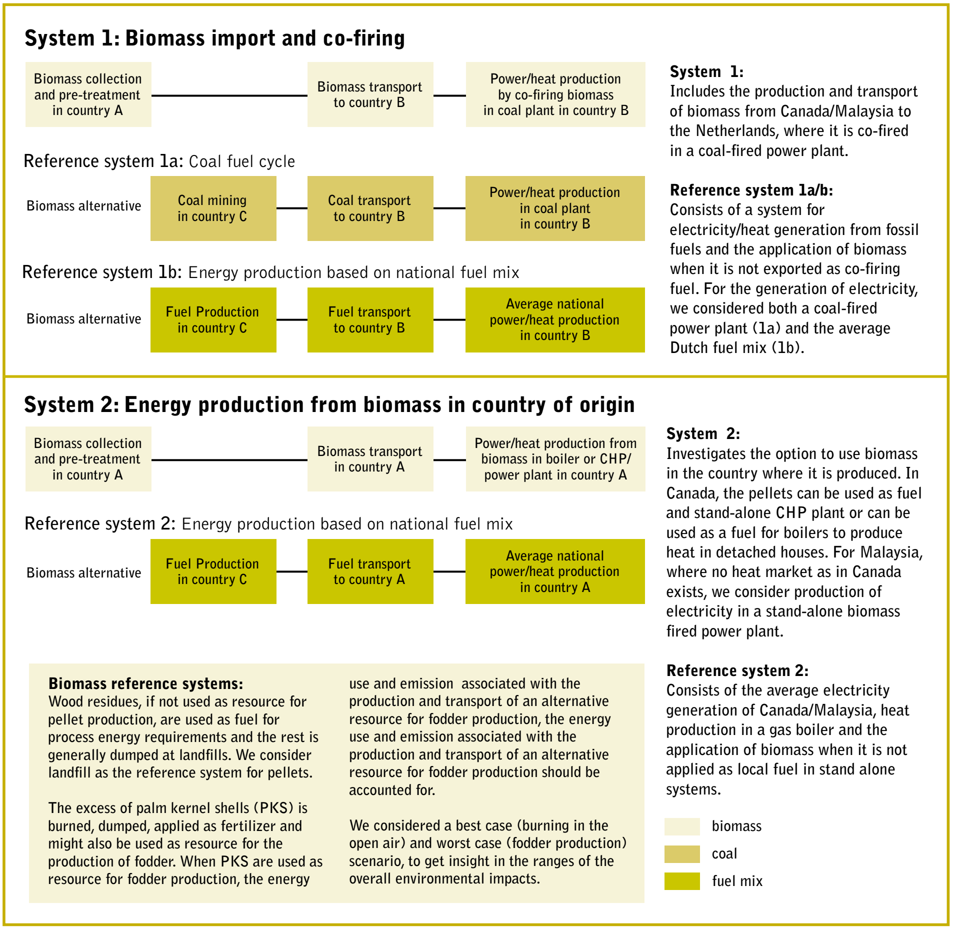
Listed below are groups of criteria that may be important to policymakers, as well as decision makers in the energy sector, and the general public (energy users). This list is indicative, as there may be additional criteria that apply in specific situations, and some of the criteria below may not apply in all cases. For simplification, the term 'services' is used as a generic term to mean the energy content, CO_2 reductions, and other features of renewables.

Criteria for the Decision Between Different Trading Options	
Supply Potential	What is the technical and economic potential for a sustainable supply of 'services' of the exporting region? Consider factors such as competition with food production, other biomass uses, pressure on existing forests (e.g., deforestation) and local energy demand.
Secure Demand	How will demand for 'services' develop in the importing region e.g., competing (renewable) energy options, development of conversion capacity and indigenous biomass resources, future markets for certificates and credits.
Logistical Capacity	What logistical and conversion capacity is available in importing and exporting countries? Examples are transport infrastructure (harbours, roads), possibilities for co-fired systems, power lines etc. Another example is existing energy infrastructure in the importing country that may be more costly to change than importing certificates/credits.
Reference Systems	What is the reference energy system for importing and exporting countries? For example a low carbon intensity for importer and high carbon intensity for exporter indicate it may be better to use biomass locally and trade bio-electricity, credits, or certificates, or a combination. Similarly, the ability to use CHP in either location can enhance the amount of fossil fuel displaced.
Sustainable Development	What are the opportunities for matching 'services' production and export with rural and sustainable development? This includes issues of job creation, local air pollution etc.
Diversification	Is there a need for diversification of the energy supply mix in exporting and importing countries?
Policies and Regulations	Which trading options are favoured under existing policies such as renewable energy or CO_2 targets and regulations e.g., trade barriers, carbon accounting rules?
Flexibility and Risks	Which options allow more flexibility over time than others? For example, CO_2 credits and green certificates are traded at spot markets and will only be needed at the end of a longer period to close accounts, whereas physical energy carriers have to be imported at the time the demand occurs, i.e., on a continuous basis.

Examples of Different Trading Options

The Netherlands

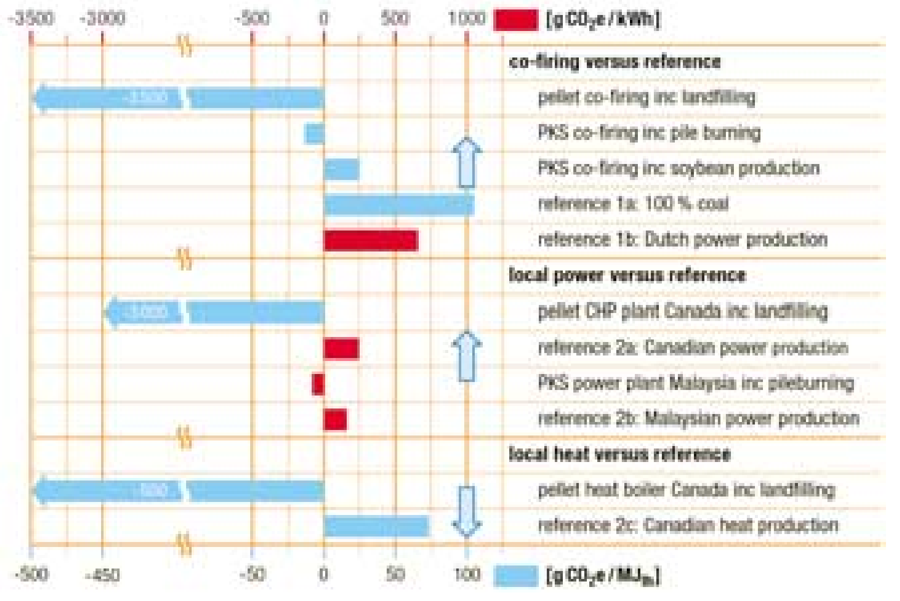
In the Netherlands, several of the different trade options described above are currently used simultaneously. Regarding the physical import of biomass, in 2004 the Netherlands produced approximately 4.9 TWh renewable electricity, of which about 3 TWh were produced from biomass. In turn, of these 3 TWh roughly 1 TWh was produced from imported biomass (e.g., pellets, palm oil, and agro-residues). Most of these biomass streams were imported from Canada and South-East Asia. The Copernicus Institute (the Task 38 team of the Netherlands) carried out a case study on 'GHG Balances of Biomass Import Chains for Green Electricity Production in the Netherlands. For further information see: *www.joanneum.at/iea-bioenergy-task38/projects/task38casestudies/netherlands-brochure.pdf*). Results of this case study are presented below.



Biomass chains versus reference system as documented in the Task 38 case study for the Netherlands.

In terms of physical import of electricity, the Netherlands is a net importer of electricity. In 2003, the Netherlands imported about 17 TWh of electricity, mainly from Belgium and Germany, probably from coal-fired and nuclear power plants.

Regarding the trade in renewable electricity certificates, the Netherlands have imported large amounts of certificates over the last few years. The Dutch demand-side support for renewables was relatively generous from 1999 onwards, causing the number of households using renewable electricity to surge to over two million. As domestic renewable electricity production cannot cover this demand, in 2004 the Netherlands imported approximately 10 TWh of renewable electricity certificates, of which about 75% was from biomass, mainly originating from Finland and Sweden.



GHG emissions of pellets and palm kernel shells (PKS) import and co-firing and use as a fuel in stand-alone combustion systems in country of origin versus reference power/heat production. Axis above: CO_2 equivalents for electricity systems (g CO_2e/kWh). Axis below: CO_2 equivalents for heat systems (g CO2e/MJthe).

Finally, regarding the trade of emission reduction certificates, the Netherlands is actively involved in JI and CDM projects. Carbon credits (see *www.carboncredits.nl*) buy emission reductions for the Dutch government via JI and CDM, and their portfolio includes 23 JI and CDM projects. The total contacted volume was 16 million tonnes of CO_2 in November 2005. Current JI projects in the Dutch programme include mainly wind energy, biomass energy, hydroelectricity, and landfill gas utilisation. The market price is around 5 Euros per tonne of CO_2.

Austria

The amount of biomass energy imported and exported is rather small because Austria has large forest resources. In 2003 2.5 PJ of fuel wood were imported, and 0.9 PJ exported. As well, 4.5 PJ of biofuels were imported, and 6.9 PJ exported.

The Austrian Government has also started its JI and CDM programme (see *www.ji-cdm-austria.at*). One of the seven JI projects under contract so far is a biogas plant in Hungary. Of the other 34 JI projects that are being assessed, four deal with biomass. Also two of the eight CDM projects under contract are biomass power plants based on agricultural residues in India. Another 22 biomass-based CDM projects are being assessed as at December 2005.

JI and CDM Biomass Projects Contracted by Austria				
Type of Flexible Mechanism	**Title of Project**	**Country**	**Technology**	**Emission Reductions by 2012 (t CO_2 equiv)**
JI	Palhalma Biogas Plant	Hungary	Biogas Plant (Digester)	162,608
CDM	APCL mustard crop residue power project	India	Biomass Power Plant	244,000
CDM	Biomass CHP Plant using rice husk	India	Biomass Power Plant	147,000

(Source: Kommunalkredit Public Consulting GmbH)

Concluding Remarks

International trade in biomass or energy carriers from biomass has only recently become part of the portfolio of energy companies and countries to increase the share of biomass in their fuel mix and to meet environmental objectives. This trade is growing rapidly and in the longer term a global market of renewable energy carriers derived from biomass may emerge. There are many potential advantages of such a market. For example, CO_2-neutral biomass resources are utilised efficiently on a large scale; new markets may generate substantial income sources for relatively poor world regions; and energy markets worldwide may become more stable due to a larger number of energy suppliers compared to the current situation. Most important

Long-distance transportation of palm kernel shells from Indonesia to Italy. (Courtesy M. Wild, EBES AG)

Wood pellets being loaded in Canada for long-distance transportation. (Courtesy J. Douglas, Solidaridad)

may be that such a market may lead to development and sustainable use of the vast bioenergy production potential in many regions of the world.

Despite the rapidly developing international bioenergy trade (both liquid and solid fuels) physical trade of biomass (or energy carriers derived from biomass such as liquid fuels) is not always the optimal solution from both a cost and a GHG mitigation perspective. International logistics lead to higher costs and energy use compared to local or regional utilisation of resources. Although with optimised chain design (e.g., involving large-scale transport, transport of high energy-density commodities) such additional costs and energy uses remain modest. Local use and subsequent trading of electricity, CO_2 credits or renewable certificates provide important alternatives.

All these options can contribute to building sustainable biomass markets and increasing the share of biomass in the global energy mix. The variety of products (physical biomass, electricity, carbon credits, and renewable energy certificates) allows countries to select the most efficient mechanism for each unique situation.

Unloading facility at the Amer Power Plant in the Netherlands. (Courtesy Essent, the Netherlands)

Acknowledgements

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