BIOMASS SUPPLY CHAINS

HARVESTING & COLLECTION, PRE-TREATMENT AND UPGRADING, STORAGE, TRANSPORTATION & HANDLING

SUMMARY

Bioenergy plays a key role in mitigating climate change in all sectors of energy supply and the supply chains of biomass are crucial in order to realize the full potential of bioenergy. The technology offers a unique degree of flexibility compared to other renewable energy sources not only in the variety of feedstock, but also the various production pathways, end products and its use in end energy sectors of heating, cooling, electricity and transportation. The efficient operation of all components of supply chains including harvesting and collection, pre treatment, upgrading, storage, transportation and handling is important to ensure a stable supply and reduce overall costs of the technology. This factsheet focusses on supply chains of feedstock sectors including forestry and agriculture.

The first step in the biomass supply chains is the harvesting and collection of feedstock in the forest or the agriculture field which are described in the factsheet. In forestry, the system of felling trees with related machinery can be divided into two categories: Cut to length and tree length systems - each offering its own set of pros and cons. During harvesting of biomass from forest in conventional systems, it is important to leave out impurities to get higher energy content of the final feedstock. This will avoid challenges in the rest of the supply chain. For agricultural biomass, harvesting is usually done in easily accessible areas, but highly dependent on the seasonal variation of the agriculture sector.

Once the biomass is harvested and collected, pre treatment is done to ensure a high standard of fuel which include drying and/or densification to pellets etc. Such processes ensure proper specifications of biomass including higher energy content and lower moisture content so as to facilitate ease of transportation and storage of the fuel. Various modes of transportation including road, rail and sea are used depending on the feedstock volumes and cost of the transportation.

Feedstock costs associated with supply chains form the major share of the total cost of the technology. The overall cost is highly case dependent and the successful management of the supply chains is critical for the success of any investment. Thus, improving the supply chains in terms of efficient harvesting, collection, pre treatment, storage, transport and handling will unlock the immense potential of the technology source.

INTRODUCTION

Bioenergy plays a key role in mitigating climate change, contributing more to the primary energy supply than any other renewable energy source. In all main sectors of energy use; heating & cooling, electricity and transportation, developments in bioenergy are likely to significantly contribute to reaching national and global emission reduction targets.

In 2015, 60 Exajoules (EJ) of energy from biomass were supplied globally. Comparably, the total supply to the global energy system was about 560 EJ the same year.

However, there is a lot of potential yet to be fulfilled. IEA envisages that the bioenergy supply will increase to 160 EJ by 2050 . This is a tremendous challenge and an opportunity as well. Increasing the biomass use to 3.5 times the current use would require enormous efforts from all stakeholders in the biomass supply chain.

Much attention is given to energy conversion technologies and sustainable management of forests and plantations, which indeed are very important issues in order to realize the full potential of bioenergy, and vital when ensuring sustainability of the operations. However, factors regarding logistics as well as design and coordination of whole supply chains, are critical in order to ensure a stable supply and reduce overall costs. Hence, to increase the supply of sustainable bioenergy, a broader supply chain view is necessary to be able to reach the full potential through development of more efficient, cost effective and sustainable supply chains.

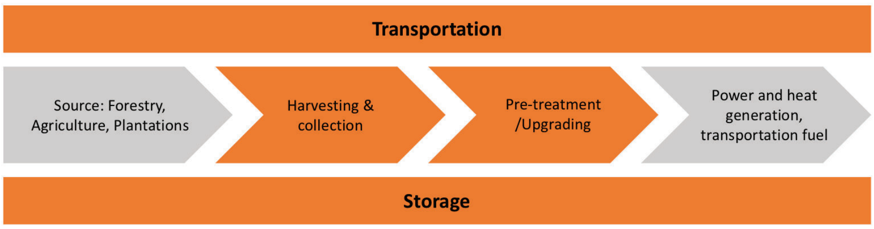

Figure 1. Overview of the main sections of this factsheet.

There are many potential configurations of bioenergy supply chains. Bioenergy offers a unique degree of flexibility compared to other renewable energy sources, not only in the variety of possible feedstock-to-energy pathways, but also since storage is possible in many stages of the supply chain, enabling greater control of production planning and opportunity to balance the supply of intermittent sources such as wind and solar.

This factsheet focuses on supply chains of biomass from forestry, agriculture and plantations of dedicated energy crops. Municipal solid waste (MSW), sewage and industrial sludge are not within the scope of this factsheet. To learn more about bioenergy from MSW, and related supply chains, see the WBA factsheet on Energy Recovery from Waste.

Despite the variety of paths that can be followed in order to convert biomass to useful energy, some steps are commonly involved in the supply chain configurations. This factsheet provides an overview of harvesting & collection, pre-treatment & upgrading, storage, transportation & handling from the source of the feedstock until the fuel enters the final energy conversion process.

HARVESTING & COLLECTION

The biomass harvesting and collection process varies greatly depending on type of feedstock, local conditions and final usage. These processes include advanced systems for collection and harvesting of timber and forest residues; large scale agricultural harvesting systems; and manual collection of firewood for traditional biomass usage in developing countries.

Biomass from Forest

As illustrated in Figure 2, different sources and purposes of usage of the original feedstock affect how it is collected and enters the supply chain of feedstock-to-energy. For instance, some forests or plantations consist of dedicated energy crops, while other feedstock are collected as residues of the conventional forest industry, from sawmills or in the form of harvesting residues that are not appropriate to be used in the wood industry.

Harvesting residues

In slash harvesting, foilage and small branches are collected to be used as biomass fuel, residues that are otherwise often left on site after timber harvesting. Residues are also created in the thinning process, when selected trees are removed in order to allow other trees to grow in diameter. The thinning process can also be used on plantations where trees are mainly used for energy purposes. As shown in Figure 2, chipping can be done on the roadside or at the terminals, either at intermediate storage sites or when reaching the energy or fuel conversion facility.

Tree felling systems

The systems for felling trees, with related machinery, can be divided into two categories: In cut-to-length and tree length systems.

In **cut-to-length** systems trees are felled and processed directly in the forest. They are generally cut to 2-4 meter long logs, with branches and tops removed directly after felling. These residues are left in the forest, either spread out in the harvested area or collected in rough piles. The collection of slash for energy purposes is hence a separate step in the process, with additional costs. The slash is usually left for some time in the forest to dry naturally before collection. Instead of assembling large amounts in storage facilities at plants or terminals, collection can be done when fuel is needed. The slash can be chipped on the roadside by mobile chippers, or more commonly for larger plants, at or in proximity to the plant. The cut-to-length system is common in Northern Europe and typical machines preforming the operations include forwarders and harvesters.

Another system for felling is the **tree length** system, in which whole trees or stems are brought out from the forest. Hence, there is no additional step for collecting residues. This method is common in the Alps, where cable yarders often are used due to the steep terrain, and in other countries such as France and Germany where skidders are commonly used .

In conventional harvesting as described, sometimes there are lot of impurities and energy losses which are harmful and can be very costly later when used for bioenergy purposes. Whenever forest biomass is used for energy, the conventional harvesting systems should be modified so that the biomass quality obtained is very high for energy and it does not adversely affect the biomass supply chain.

Medium to small scale

Another form of harvesting and collection, that is very different from large-scale mechanized systems, is medium sized partly forest - owner based harvesting and collection of biomass for heating. The wood is harvested and collected usually as firewood for their own use in wood boilers/wood stoves or for sale. These forests are sustainably managed where harvesting is done usually by a mechanized handheld saw.

A final form of harvesting and collection which is prevelant in developing countries is the collection of biomass for residential heating and cooking which is done manually by cutting trees using axes etc. Such traditional use of biomass is already described in the WBA factsheet on Clean and Efficient Biomass Cookstoves.

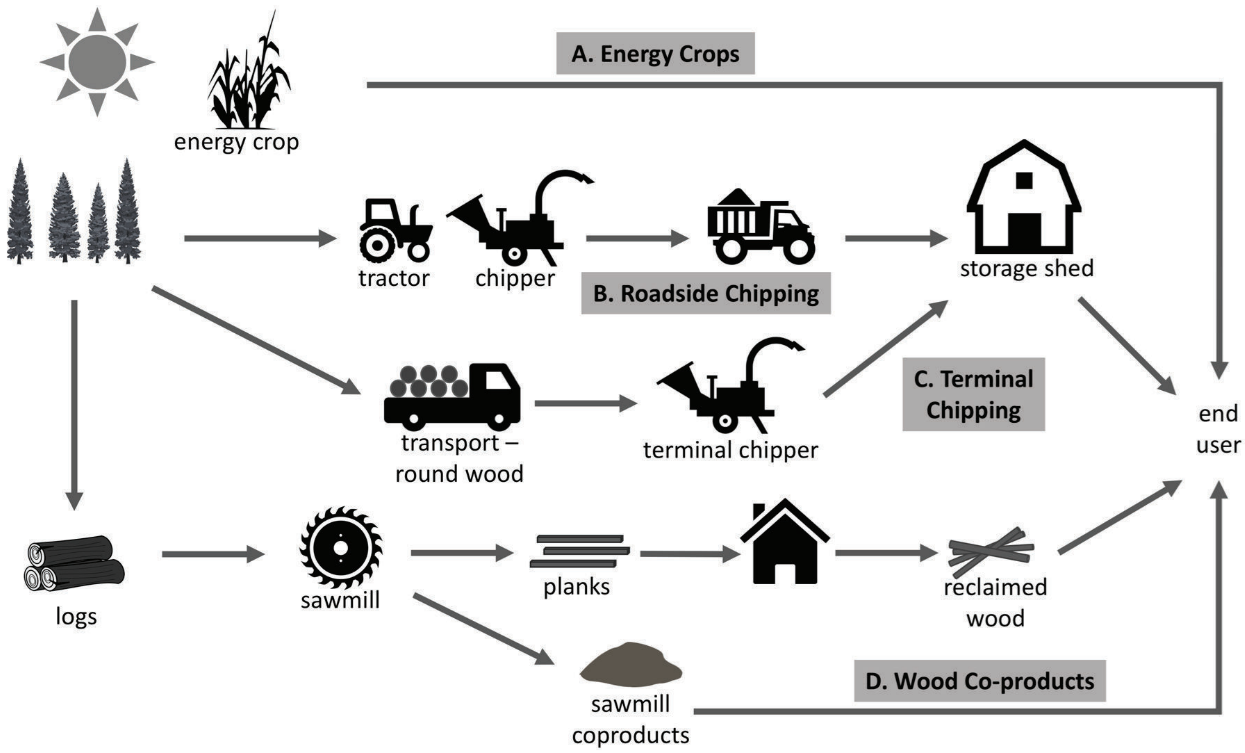

Figure 2. Example of different paths from forest feedstock to energy conversion. (Source: Based on Forestry Commission Scotland, 2016)

Agricultural crop residues

In comparison to biomass from forests, harvesting of agricultural residues is often done in easily accessible areas and integrated with harvesting processes for conventional agricultural products, which in many cases are highly mechanized. However, the harvesting process in most cases has to be done within a very limited timeframe, greatly dependent on weather conditions. In Figure 3, different machines used for harvesting of agricultural residues are shown, with the biomass resulting from the chosen feedstock and harvesting technology.

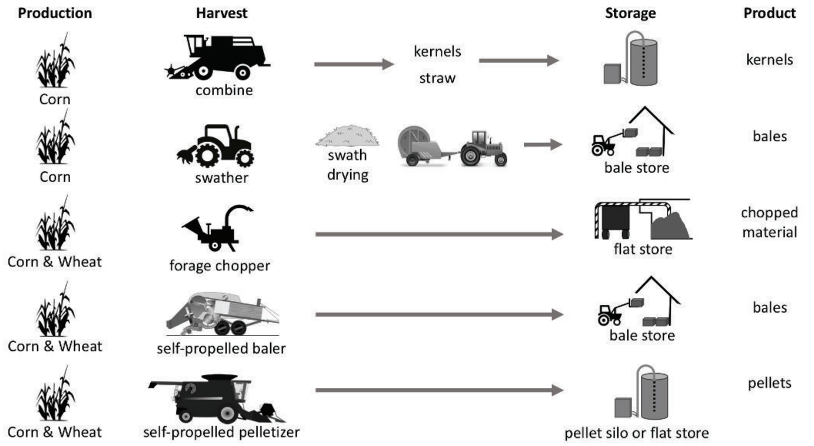

Figure 3. Harvesting options for biomass from agricultural crops.
(Source: Based on Handbook of biomass combustion and co-firing)

Balers

A common method for collection of agricultural residues is in the form of bales. If the main product of the harvest is grain, this is harvested first, leaving the rest of the plant on the field. These are thereafter collected in rows by a machine called windrower. Thereafter, the residues are formed into bales with a machine called baler. Bales can have different shapes and sizes; square, rectangular or round, depending on the type of baler used. While round bales are usually less expensive to produce, square bales are generally more dense and easier to handle and transport. Dedicated energy crops are also frequently collected as bales. In this case, it is possible to do the cutting and the windrowing at the same time. If the moisture content is low, the biomass might not have to be dried on the field before baling, and the baling can be done in the same integrated process.

Forage harvesters

Another alternative for harvesting of whole plants is using forage harvesters. With this technology, standing plants are collected and loaded directly on trucks. In the process, the feedstock is often reduced in size, which can eliminate size reduction steps such as grinding later in the supply chain. However, this method does not allow natural drying in the field.

Mobile Pelletizers

A further option for harvesting, that is not as widespread as balers and forage harvesters is mobile pelletizers. They can either operate as moving pelletizers, eliminating the need of standard harvesting machines, or as mobile pellet plants that are carried around on the field by tractors or trucks and can be loaded with bales, reducing cost by not having to move the bales to the pellet plant.

Figure 4: Pécs is one of several cities in Europe making use of 100% local, renewable resources for its heating needs. Source: iStock

CITY OF PÉCS, HUNGARY

Pécs with 160,000 inhabitants is described as the first green city in Hungary. Veolia operates two electricity & heat production plants in Pécs: a 35 MW power & 72 MW heat plant fueled by straw and a 50 MW power & 190 MW heat plant fueled by wood waste.

Long-term contracts to supply the two power plants have been established with farmers and forestry and sawmill operators in the region.
The farmers deliver 240,000 tonnes of straw a year. In addition, 450 000 tonnes of wood biomass are delivered annually, 60 percent low-grade biomass from forest fires and 40 percent by-products from sawmills.

This solution ensures the city's energy independence and provides heating for 31,000 houses and 450 public buildings, while avoiding the emission of 400,000 metric tons of CO_2 per year.
More than 170 jobs have been created in the plant's straw supply chain and more than 100 jobs in its timber supply chain.

PRETREATMENT & UPGRADING

Some feedstock can be directly combusted or gasified in order to generate heat or electricity, while others are pre-treated to facilitate the energy conversion process and increase the energy density as well as comply with potential specifications on volume, moisture content and standards.

Drying

Drying is an important step in most solid biomass supply chains, taking place at one or several stages. Managing the moisture content is essential both to comply with specifications of the energy conversion technology used and to facilitate transportation and storage.

About moisture content

Efficient modern combustion systems are designed to operate within a specific range of fuel moisture content in order to meet efficiency and emission specifications. Some combustion systems do not require particularly low moisture content in order to function, but can utilize newly harvested ("green") wood chips. State of the art boilers for flue gas condensing are frequently in use in Northern Europe (Scandinavia) reducing the need to dry the feedstock. These systems however make use of a portion of the heat from the combustion process in order to dry the fuel right before entering the process. Gasifiers are typically designed to operate on a fuel with very low moisture content, in the range of 10-20 %, requiring substantial drying.

Biomass with lower moisture content can furthermore be transported and stored more efficiently. Higher moisture content results in a lower energy density due to the added weight and volume of the water. Biomass with higher moisture content can moreover be problematic in the storage stage due to higher risk of composting, mold and buildup of high temperatures that constitute a fire hazard.

Drying process

The drying process can either be passive or active. Passive drying, drying without an external energy source, such as storing feedstock in forests or on fields, is the cheapest option and requires little additional equipment. In this case, it is important to have material to cover the feedstock and protect it from precipitation etc. However, it is a slow process potentially requiring large storage areas. The drying time depends on a variety of conditions both regarding the material, such as shape, size and density as well as the surrounding conditions, including method of storing and stacking, air flow, temperature and humidity.

For combustion systems, passive drying is in many cases sufficient. Nevertheless, lower moisture content can contribute to higher efficiency and reduced emissions. For gasification, pyrolysis systems and pellet manufacturing, active drying is generally required in order to comply with the specifications on moisture content. For active drying, energy input from an external source is used. Heat can be provided in the form of excess heat from the energy or fuel conversion processes or from a separate heating unit.

Examples of technologies for active drying are: perforated floor bin dryers, rotary dryers, conveyor dryers, cascade dryers, flash dryers, pnuematic dryers and superheated steam dryers. The function of dryers is quite simple as using hot gases from burners to passthrough perforated floor with good mixing ability of feedstock to superheatd steam dryers in closed loop systems.

Bulk and Energy Density of Feedstock

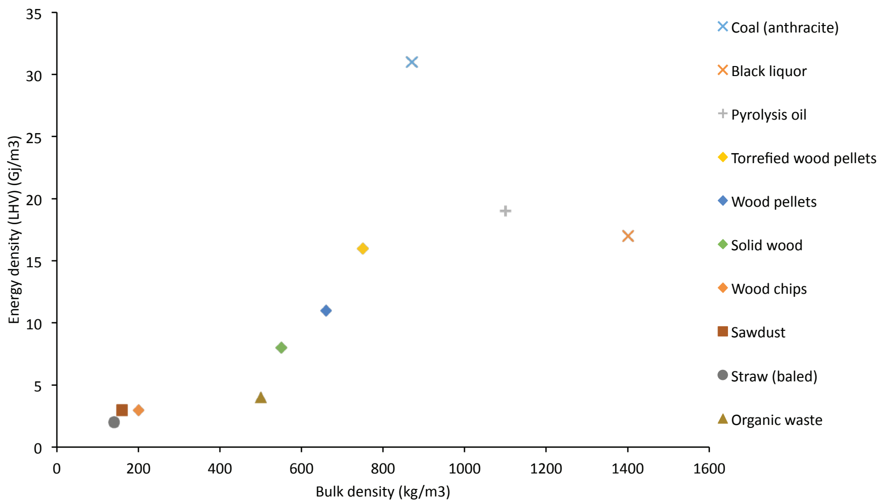

Figure 5. Bulk and energy density of different biomass feedstocks and coal. (IEA, 2012)

Densifying

Besides managing the moisture content, additional increasing of the energy density and reduction of the volume is often desired in order to facilitate transportation and storage, as well as create a more homogenous fuel complying with standards appropriate for the chosen heat and power generation technology. Bulk and energy density for some processed and unprocessed biomass are presented in Figure 5. It is clear that liquid fuels such as black liquor and pyrolysis oil have a clear advantage in term of bulk density, and torrefied as well as regular wood pellets have both a higher energy and bulk density compared to solid wood, wood chips and sawdust.

Some processes for upgrading biomass to a more densified fuel include:

Pelletisation and briquetting: Widely commercially available and comparatively simple technology to mechanically compress bulky biomass, for example sawdust and agricultural residues. Under very high pressure, the lignin in woody raw material is released, binding pellets and briquettes together with a high density . The moisture content of the feedstock has to be relatively low, in the range 6-16%.

Torrefaction: In the torrefaction process, biomass is heated in the absence of oxygen to 200°C - 300°C, turning it into char. Torrefied wood is usually compressed into pellets, with a bulk density 25-30% higher than of conventional wood pellets.

Pyrolysis and hydrothermal upgrading: A process in which the biomass is heated to 400-600°C in the absence of oxygen, producing liquid pyrolysis oil, solid charcoal and a product gas. The energy density of pyrolysis oil is approximately twice that of wood pellets, making it appropriate for long-distance transportation, as discussed later in the chapter about international trade and transportation.

STORAGE & HANDLING

In most cases, biomass and biofuels have to be stored, between different stages of the supply chain and during shorter or longer periods before being used for heat or power generation. In some regions, the demand for heat and electricity varies greatly between seasons, while the forest industry is active all year around. The harvesting seasons for agricultural crops are often short, and in order to enable a stable supply of biomass, meeting the demand at all times, storage solutions are of great importance.

Keeping the solid fuel and feedstock dry, protecting it from both rain and groundwater, is often the main concern. Different storage solutions include structures, above or below ground, designed for the specific setting and purpose, adapted units such as silos and shipping containers as well as prefabricated units designed for a specific fuel such as pellets.

Storage size

The size of the storage is important to optimize. A larger storage unit is often preferred since it allows purchasing larger quantities at one occasion, resulting in a lower unit price. It furthermore allows greater flexibility in delivery scheduling and serves as a backup in case of delayed delivery.

Ventilation

Another important aspect when considering dry biomass is ensuring sufficient ventilation, in order to avoid condensation and prevent mold, of which spores can be a serious health hazard if inhaled, as well as to allow additional drying and minimize decomposition of biomass, which can lead to loss of energy content. Proper ventilation is furthermore vital in order to prevent high temperatures creating a fire hazard. Another hazard that can be prevented through sufficient ventilation is the formation of carbon monoxide. The toxic gas is produced from natural components in biomass stored in an environment lacking a sufficient supply of oxygen, and has led to strict safety rules and regulations.

Drainage

Drainage furthermore has to be incorporated in case water somehow gets into the storage area, and so that the area can be cleaned if necessary. Sufficient ventilation and drainage are harder to ensure for below ground solutions, that are often costlier to construct than above ground solutions. However, below ground solutions have the benefit of facilitating delivery from tipper type vehicles and reducing the space required above ground.

Wet biomass

Wet biomass such as animal slurries and liquid biofuels are stored in tanks, and can be pumped in pipelines in the same way as traditional liquid fossil fuels. It is important to consider the time biomass can be stored without affecting its quality, which is also the case for liquid biofuels, such as biodiesel, of which long-term storage might result in biological degradation and loss of energy content.

Figure 6. Chipper-truck. A system that combines chipping and transportation of forest fuel.
Photo: Lars Eliasson, Skogforsk

Figure 7. Loading of a 74 tonnes chipper truck. Photo: Henrik von Hofsten, Skogforsk.

TRANSPORTATION & HANDLING

Biomass feedstock is often harvested from a relatively large area, not always in close proximity to a power plant or upgrading facility. As clear from Figure 1, there are several steps in the supply chains between which transportation is likely to be required, both of untreated feedstock and upgraded fuel. In its primary form, biomass often has relatively low energy density and irregular shape, adding complexity and costs to the transportation stage. However, the feedstock is often processed, for example in the shape of wood chips or pellets, in order to facilitate transportation, handling and storage, as discussed in the previous section.

There are many different options for transporting biomass and biofuel, and the most appropriate mode of transportation depends on the type, stage in the supply chain, distance of transportation as well as geographic and infrastructure conditions. Different transportation options include:

Tipper trailer or truck: A common option used for a variety of biomass worldwide, including wood chips, pellets, and agricultural and forestry byproducts. The design simplifies offloading since the load can be discharged directly into the storage and additional handling and equipment might not be required.

Flatbed trailer: Also, a widely-used option, suitable for palletized bags of pellets, straw bales and large logs etc.

Tanker, grain or animal feed vehicle: Specifically, designed vehicles with enclosed tanks can transport liquid biofuels and slurries as well as wood pellets. It is possible to connect the tanks with pipes at the delivery site, resulting in a clean and convenient delivery system.

Timber haulage wagon: Special lorries for timber haulage, typically including a crane for loading and unloading, are commonly used for delivery of saw logs for the timber industry. Sometimes, longer and heavier trains are also specially designed to deliver roundwood.

Container and container lorry: Containers and container lorries can be suitable for biomass transportation as well as storage.

Walking floor trailer: Specially designed enclosed trailers for delivery of wood chips in bulk. They can be directly filled from chippers with high throughput in only a couple of minutes, which reduces the need of additional handling related to loading.

Chipper-truck: A system that combines chipping and transportation with the same vehicle. Commonly used for forest fuel handling.

Rail: In areas with sufficient railway infrastructure, transportation by rail is suitable for larger quantities of biomass, to designated delivery points, such as large-scale power plants with biomass combustion or co-firing.

Inland waterway: Slower option that can be suitable for non-time-sensitive delivery. Carbon emissions are generally low.

Ship: Suitable for long distance, non-time-sensitive transportation of large scale bulks. Carbon emissions of long distance shipping are around one tenth of the emissions per kilometers of road transportation.

EMISSIONS FROM TRANSPORTATION

An example of emissions from transportation of chipped forest fuels in Sweden as shown in Figure 8. The level of emissions depends on many parameters such as fuel, average transport distance and truck size. The diagram compares trucks with a maximum weight of 60 and 74 ton, fueled by ether diesel or RME (Rapeseed Methyl Ester). The straight line represents a long-distance transport, 450 km by train, reloaded and completed with 20 km of truck transportation by a 74-ton truck driven on RME-fuel. It is important to notice that the train transport example concerns an electric train powered by a renewable energy mix, hence the emissions from the train haul is negligible. (Enström & Hofsten 2015).

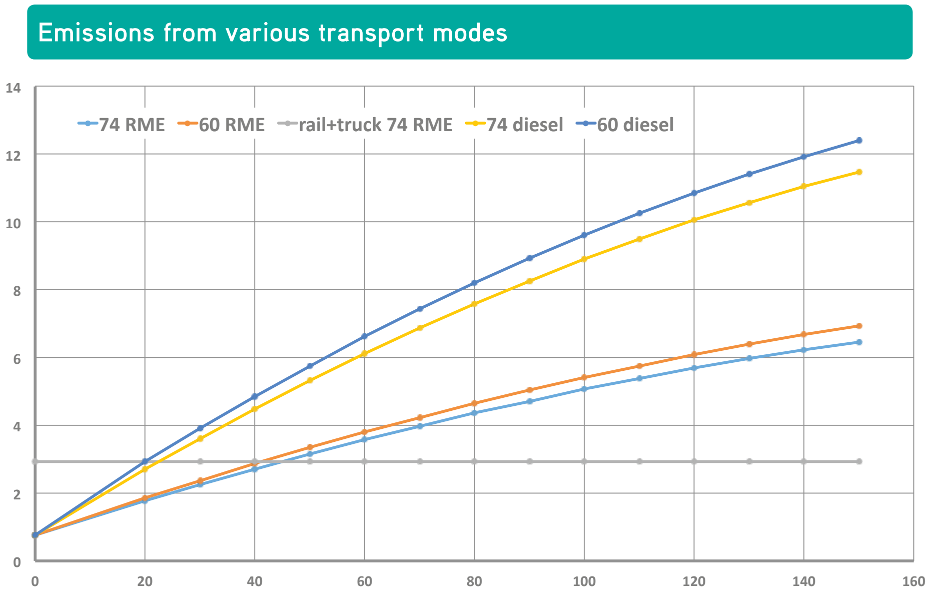

Figure 8. Emissions from various transport modes (kgCO_2e per transported ton chipped biofuel)

Figure 9. Optimizing the transportation of round wood is increasingly important. Innofreight designed their own stanchion system. It is a modular concept – a combination of stanchions structure and corresponding Innowagons – and is especially important and successful in the Scandinavian Region. Through the use of very wide and tall stanchion systems, the block train payload increased up to 25%. It is also possible to load pile sizes upto 34 tons (previously only 22 tons) thereby increasing cargo load and decreasing logistics costs. Other advantages include weather resistant, lower maintenance costs, faster & safer loading and unloading of wagons. Source: Innofreght

MANAGEMENT

The management of supply chains varies usually with the logistics of local – local, regional or long distance transportation. Each specific supply chain has its own management structure. For example, in local transportation, mutual interdependence of supply chains should be considered. In long distance transport, the most important part is securing the supply chain with long term contracts. One important aspect of the learning curve in managing supply chains is the issue of default values.

Usually, efficiencies of supply chains improve over time. Continuous supply of biomass ensures that the costs are lowered and default values are lower enabling the reduction in overall cost of operation. This shows improved efficiency of the supply chain. It is important to consider such efficiencies in the decisions and to ensure that the learning curve is included in the calculations.

One EU founded initiative with the aim of addressing the problem with fragmented and unorganized local biomass markets, is the project BLTC (Biomass Logistic and Trade Centers). 40 BLTCs are already set up in for instance Austria, Italy and Germany, and support is given to set up 40 new centers in countries including Spain, Greece, Croatia and Slovenia.

VÄRTAN IN STOCKHOLM, SWEDEN

Logistics are of critical importance to Stockholm Exergi. The biomass in the form of wood chips will mostly arrive by sea and rail to the new CHP plant, Värtan in Stockholm. The operations started in May 2016 and a unique supply logistics including balancing storage needed to be created, as the plant is basically located in the middle of the city.

The plant produces 2.5 TWh of heat and electricity for the residents of Stockholm, Sweden.

The plant is being supplied with wood chips in XXXL containers from Innofreight by the train operator 6 days a week and 3 to 4 ships deliver wood chips to the connected harbour every week. Each day 12 000 m^3 of wood chips are being converted into heat and electricity. In order to manage demand and supply, the storage is enclosing 50 000 m^3 of wood chips in a large underground cavern, previously used for storing oil for the preceding fossil fuelled plant. An advanced ventilation system is installed as well as a system that monitors and handles temperature changes, significantly reducing fire and health hazards.

Figure 10. A stationary unloading machine in Värtan, Sweden. Source: Innofreght

IGELSTAVERKET IN SÖDERTÄLJE, SWEDEN

The total supply of 1 million tonnes of biomass which counts for approx. 3 TWh per year is coming by ship, train and truck to the Igelstaverket owned by Söderenergi from 40 different suppliers in Sweden and North Europe. Half of the biomass (dry volume) is delivered by ships/vessels (200 vessels per year) and 10% is supplied from a biomass terminal in Nykvarn. The train operator Green Cargo delivers biomass with the new XXXL containers from Innofreight to the terminal. The load volume of these Innofreight XXXL containers is 58 m^3 per container which means an increased payload upto 25% compared to standard containers.

The containers are unloaded from train for further transport to Igelstaverket via truck. The improved containers have increased capacity of the train by 75% compared to initial transport. The total volume holds 4500 m3/train that include double locomotive, 27 wagons and 81 containers (100 train-sets/year). From the terminal trucks transport the biomass. A new type of truck with a gross weight of 74 tonnes is tested from Scania that runs on biodiesel. The rest of the biomass to the plant comes with 23000 trucks per year.

Figure 11. XXXL Containers Green Cargo. Source: Innofreght

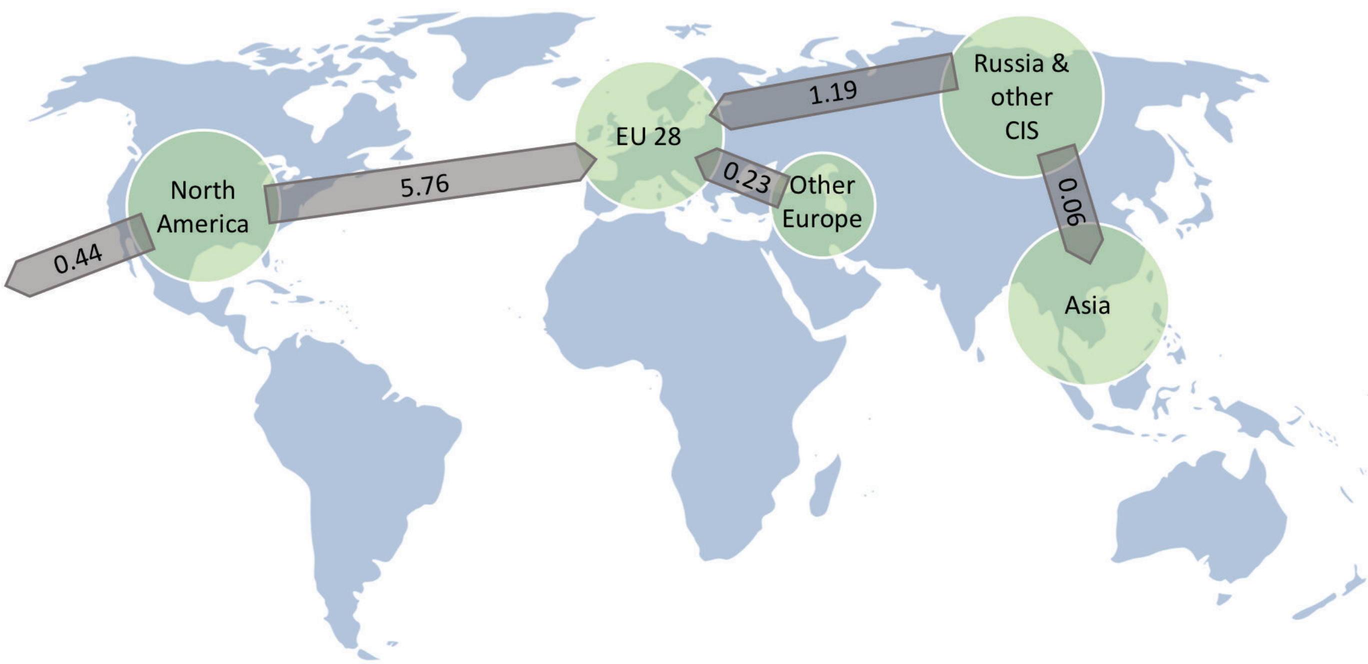

Figure 12. Wood pellet trade flows in million tonnes in 2015 (Source: AEBIOM)

INTERNATIONAL TRADE & TRANSPORTATION

Many counties in the world are now including targets for increased utilization of bioenergy in their policy for reducing greenhouse gas emissions. International trade and long distance transportation play an increasingly important role in many biomass supply chains, supporting countries without sufficiently developed national or regional markets for biomass. In order to economically transport biomass over longer distances, increased volumetric and energy density of the biomass feedstock are desired.

Wood pellets trade

Wood pellets are one of the biomass product that are commercially viable today to be traded in substantial volumes internationally. Wood pellets have been traded internationally for over 20 years and the supply chain is mature. Figure 12 shows the net importers and exporters of pellets for industrial and residential usage in 2015 as well as the flows between different regions.

Regulations

An important regulation affecting the international trade of wood and wood products is the phytosanitary regulations. When plants and plant products are traded, there is a risk that new plant pests come with them, such as insects, nematodes, bacteria and virus. The regulation aims to prevent the spread of pests and destructive organisms, thus restricting the trade in raw wood products and instead providing support for trade in processed wood products such as pellets.

Transport dominating cost

Despite varying cost structures of different bioenergy projects, when involving transportation over longer distances, transport related costs are commonly the dominating costs in the supply chain. For wood pellets, the logistics costs are often in the range 34-77% of the total cost for the end user, as seen in Table 1, making economies of scale critical. The cost of ocean shipping in larger vessels such as Panamax and Handymax is considerably lower than in smaller ships.

High energy density reduces cost

As mentioned, wood pellets are the biomass for energy that is commercially traded in the global market today but also round wood especially of high density, e.g. eucalyptus. Nevertheless, there are other densified products that have potential to reduce long distance transportation costs with a higher energy density, for instance agricultural pellets such as sunflower husk pellets and straw pellets. Torrefied pellets, as mentioned earlier, also have great potential with about 50 % higher energy density than conventional wood pellets. However, the technology is only commercial on a small scale as of today.

Another fuel with higher energy density is pyrolysis oil, which has been produced commercially for over 20 years, but in small quantities only. With an energy density, more than twice as large as for wood pellets, it is expected to become a common alternative for long distance transportation in the future. Pyrolysis oil can be transported in tanks on ships similarly to petroleum oil.

TABLE 1: IMPORTANCE OF LOGISTICS RELATED COSTS

COST ITEM	COST IN % of PRICE FOR END USER	% OF COSTS ALLOCATED TO LOGISTICS
Feedstock	1 - 25	1 (if mill residue) 10 - 25 (if road side or standing)
Mill	8 - 15	
Finance	6 - 10	
Transport to Port	5 - 10	5 - 10
Storage, Load/Unload	5 - 12	5 - 12
Ocean Shipping	12 - 20x	12 - 20x
Transport to end user	2 - 10	2 - 10
Risk and Profit	20 +	
Total	**59 - 122**	**34 - 77**

* The ocean shipping costs are presently considerably lower

POSITION OF WBA

Bioenergy is the largest renewable energy source globally contributing 10% of the overall energy supply. To meet the international energy and climate goals, bioenergy has to contribute further. Estimates suggest that the supply of biomass can be tripled from the current 55 EJ to almost 150 EJ within the next 20 years in a sustainable way without impacting land use, biodiversity etc. WBA only promotes the management of the supply chains in a sustainable way which preserves and protects the socio, economic and environmental considerations of the particular region.

One of the critical hurdle in the rapid uptake of the technology is the cost of the feedstock which is directly dependent on the supply chains. Therefore, a careful analysis on the current supply chain pathways and researching ways to improve the efficiency goes a long way in greater acceptance of the technology as a solution of the future.

As shown in the factsheet, numerous technologies already exist to meet the needs of all components of the supply chains including harvesting, collection, pre treatment, upgrading, storage and transport of the feedstock. Countries especially in Europe - are pioneers in efficient use of machinery for harvesting and collection of biomass, clean and efficient conversion of biomass to processed products (e.g. pellets) & efficient use of road, rail and marine transportation of biomass from short and long distances.

On a global level, to mobilize the biomass in such a large scale, WBA urges for a concerted effort from all stakeholders in the biomass supply chain. This factsheet will form a basis for these stakeholders to understand the various technologies and processes already existing worldwide and to implement the lessons learned from successful case studies. WBA believes that supply chains from forestry and agriculture sectors in the future will enable cities, provinces and countries to meet their energy goals through the use bioenergy and leading to energy security, efficient resource utilization and economic development. ■

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Mission: Promote the increasing utilization of bioenergy globally in an efficient and sustainable way and to support the business environment for bioenergy.

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