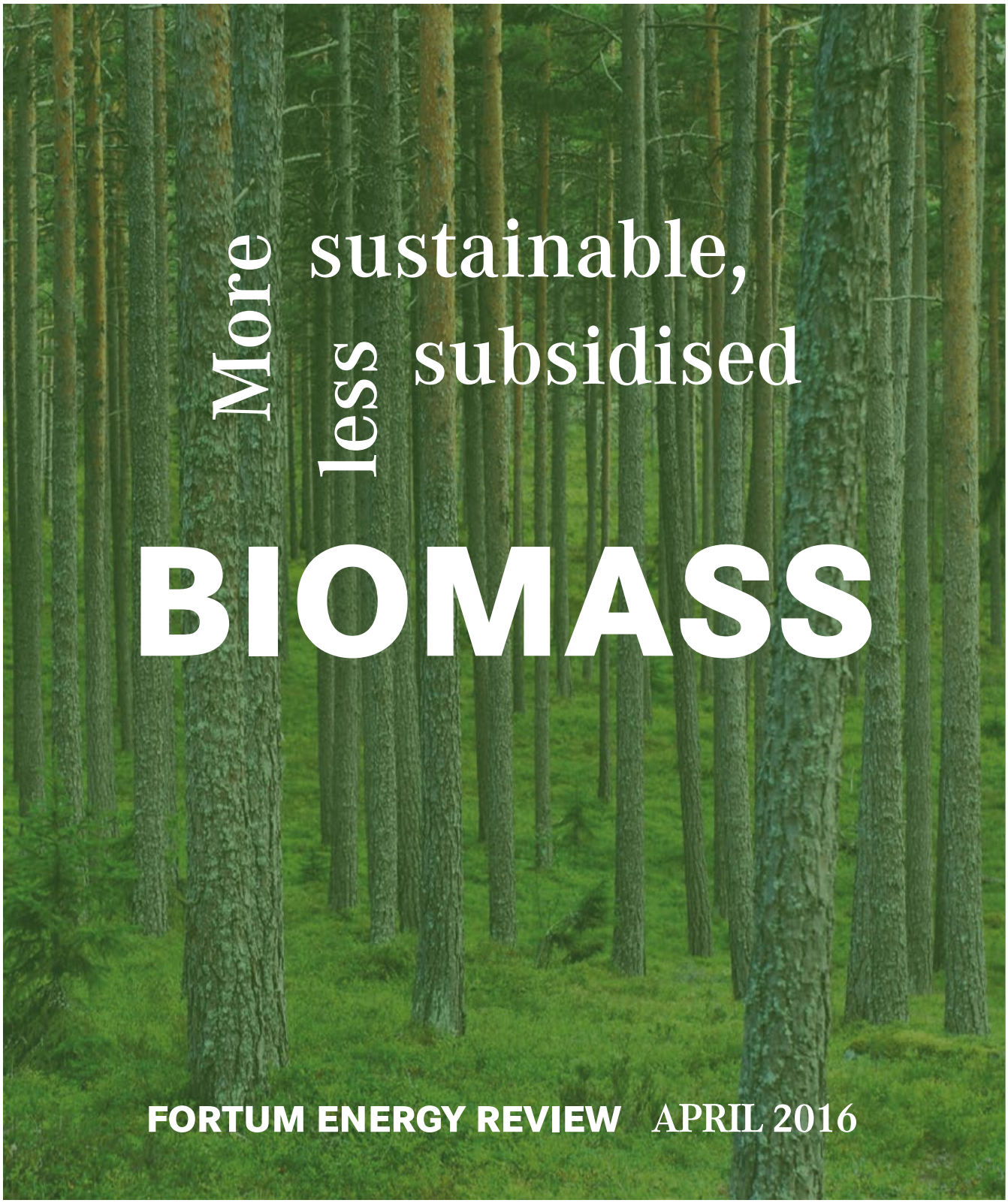


FORTUM ENERGY REVIEW APRIL 2016

Fortum

FOREWORD

Bioenergy – the leading renewable energy source

Bioenergy is the most common form of renewable energy in the EU. The biggest source for bioenergy is forest biomass, in particular wood and wood residues[1]. Biomass is the only renewable energy source that can replace every type of fossil fuel in all energy markets – heating, cooling, electricity, and transport. Biomass is responding to several EU policy objectives: It is instrumental in mitigating climate change and improving the security of energy supply. Furthermore, it enhances industrial competitiveness, economic growth and employment.

On the other hand, concerns have been raised about the sustainability of bioenergy, competition for resources and the security of energy supply. The EU Commission launched in February a public consultation on a sustainable bioenergy policy for the period after 2020 with a view to developing an EU policy framework for the sustainable biomass beyond 2020. Bioenergy will play a key role in the achievement of the EU renewable energy targets for 2020 and 2030. The Commission's recent proposal for the heating and cooling strategy also emphasises the use of biomass.

Biomass is a major energy source in the Nordic forested regions where the local fuel is available cost-efficiently. Fortum has long experience in utilising biomass for both electricity and heat production in Finland and Sweden. In recent years the use of biomass has increased also in our operations in the Baltic countries and Poland. Forest biomass accounts for about 31% of the fuel consumption in our heat production in Europe and about 2% in our electricity production. In line with our strategy, we believe that bioenergy will be an integral part of our sustainable solutions for cities and urban areas.

Fortum wants to bring its views and experience with the use of biomass into this topical discussion. As forest biomass is the main source of bioenergy for Fortum, this report focuses on forest biomass and its use in electricity and heat generation; biomass from agriculture and waste as well as biomass for transportation are referred to only briefly.

We hope that this Energy Review promotes an active discussion about forest biomass at the local, national and European level.

Fortum Corporation

Biomass is the only renewable energy source that can replace every type of fossil fuel in all energy markets – heating, cooling, electricity, and transport.

[1] European Commission SWD (2014) 259 final

Biomass in the EU's energy portfolio

WHAT IS BIOMASS?

Bioenergy represents 2/3 of the renewable energy and 10% of the total energy consumed in Europe[2], and its use is growing rapidly. Solid biomass is the largest source of renewable energy in the EU and is increasingly important in the EU energy system. It is used as much as natural gas and twice as much as oil.[3]

About 70%[4] of the total bioenergy feedstock originates from forests and forest residues, while the rest is based on waste and agriculture. Biomass can exist in three forms: solid, liquid and gaseous.

Bioenergy from agriculture is used mainly for transportation biofuels and biogas, but to some extent also for heat and electricity. Municipal waste can be incinerated for energy recovery and biogas can be produced from various sewage sludges.

Solid biomass is the largest source of renewable energy in the EU. 70% of biomass used as energy originates from forests.

DEFINITIONS

Biomass: the biodegradable fraction of products, wastes and residues from biological origin from agriculture (including vegetable and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste

Bioenergy: biomass, bioliquid and biogas for heat and electricity, biofuel for transport

Bioliquid: liquid fuel for energy purposes other than for transport, including electricity, heating and cooling, produced from biomass

Biofuel: liquid or gaseous fuel for transport, produced from biomass

Source: European Commission Directive 2009/28/EC

CONSUMPTION IN HEAT AND ELECTRICITY PRODUCTION

Biomass is a significant energy source in particular for cost- and energy-efficient combined heat and power (CHP) production and district heating. Solid biomass is the largest contributor to renewable heat production, representing some 90% of all renewable heating[5] and 16% of district heating[6]. Biomass accounts for 18% of all renewable electricity generated[7].

CONVERSION OF BIOMASS UNITS

1 solid m^3 = 2.5 loose m^3
1 solid m^3 = 2 MWh
1 loose m^3 = 0.8 MWh

[2] Aebiom Statistical Report, 2015

[3] Aebiom Statistical Report, 2015

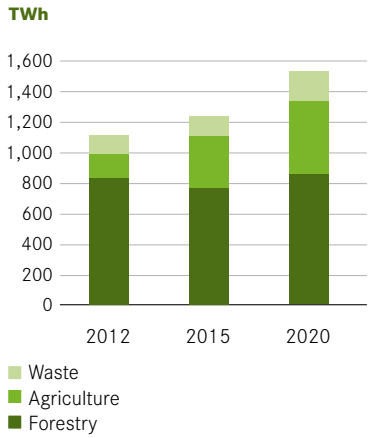
[4] Aebiom Statistical Report, 2015

[5] European Commission COM (2015) 293 final

[6] European Commission COM (2016) 51 final

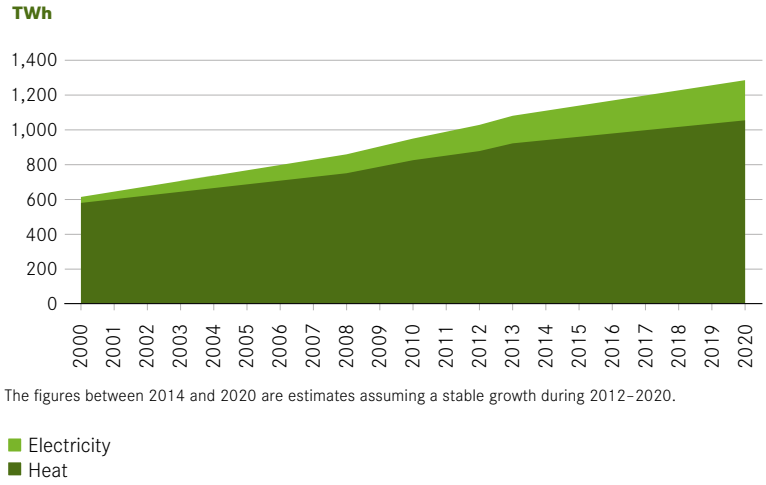
[7] European Commission COM (2015) 293 final

EU biomass supply for electricity, heating and cooling in 2012–2020



Source: European Commission SWD (2014) 259 final

Forestry and agriculture biomass consumption for heat and electricity in the EU in 2000–2020



The figures between 2014 and 2020 are estimates assuming a stable growth during 2012–2020.

Source: AEBIOM Statistical Report, 2015

Biomass consumption in the heat and power sectors is expected to increase by 2020 and to increase even further by 2050. According to the national renewable energy action plans (NREAP) of the EU member states, the consumption is expected to increase to 1,285 TWh by 2020 from the current 1,047 TWh[8]. Heat is expected to remain the leading market for bioenergy. In addition, the EU's circular economy action plan[9] will promote the increasing use of non-recyclable, biodegradable waste for energy production, though no specific forecast is yet available.

The role of bioenergy varies significantly among member states. In relative terms, Finland, Sweden and Latvia have the highest shares of bioenergy in final energy consumption.[10] In absolute terms, Germany, France and Sweden are the largest producers of bioenergy, followed by Finland and Italy.[11]

BIOMASS FROM FORESTS

Forests cover about 45% of the EU land area. The EU forest area has increased by approximately 2% over the last decade and forest expansion is expected to continue[12]. Over 75% of the land area in Finland and Sweden is covered by forests.

[8] European Commission SWD (2014) 259 final

[9] European Commission COM (2015) 614 final

[10] Aebiom Statistical Report, 2015

[11] European Commission SWD (2014) 259 final

[12] European Commission SWD (2014) 259 final

Forest biomass accounts for about half of Europe's renewable energy consumption. In some countries, such as Finland and Poland, forest biomass meets more than 80% of renewable energy demand[13].

The energy use of forest biomass in the EU is closely linked to the forestry and wood processing industries. It is largely based on processing and harvesting residues produced as a complementary co-product of wood materials and fibre products. The wood can be industry residues, such as saw dust, bark and wood chips, or it can come directly from the forest from thinnings (small diameter wood) and harvesting residues (branches, tops, stumps). Dedicated harvesting of stem wood only for bioenergy purposes plays a marginal role.

In addition to the increase of forest area in the EU, the stock of wood is increasing significantly. This means more possibilities for increasing the

Currently, 60–70% of annual forest growth in the EU is harvested. There is potential to increase the harvesting rate and consequently the residues available for bioenergy production.

Heat and electricity production from biomass in 2014 and its share of total primary energy consumption in Fortum's countries of operation in the EU

Country	Heat produced from biomass (TWh)	Electricity produced from biomass (TWh)	Total primary energy consumption of biomass (TWh)	Share of biomass in total primary energy consumption (%)
Finland	19.4	11.3	100.7	25.0
Sweden	27.5	9.1	116.1	20.7
Estonia	2.1	0.8	9.4	12.0
Latvia	2.4	0.4	16.6	32.1
Lithuania	4.2	0.7	13.6	17.4
Poland	4.0	10.0	89.2	8.1

Source: Eurostat

[13] Aebiom Statistical Report, 2015

use of biomass in energy production. Currently, about 60 – 70% of annual EU forest growth in areas available for wood supply is harvested[14]. The amount of bioenergy generated from forest biomass could still be increased. Based on Eurostat statistics[15], the annual increment in forest available for wood supply amounts to almost 780,000 m^3. A higher harvesting rate would lead to more residues available for bioenergy production both from the forest directly and from the forest industry.

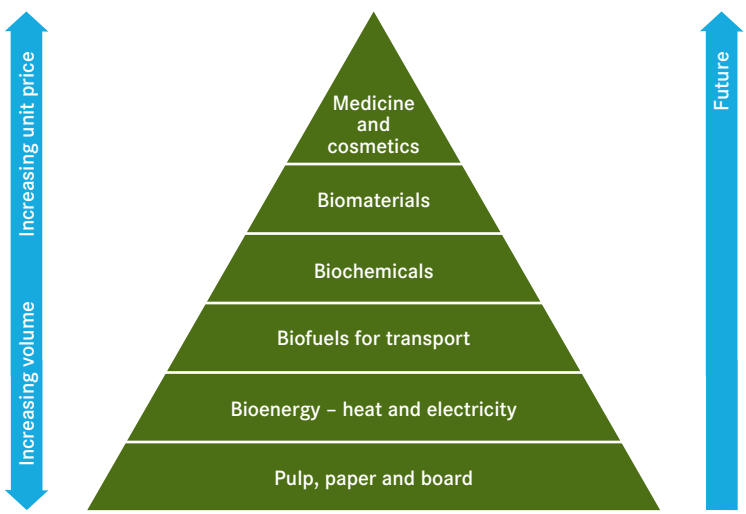
COMPETING USES OF BIOMASS

Due to its versatility, biomass is a desired raw material. The energy industry is competing both locally and globally for the biomass resources with wood product and construction industries, the pulp and paper industry, and, increasingly, with the biochemical, pharmaceutical and textile industries.

Recently, the principle of cascading biomass use has entered into the debate. The principle implies that the same biomass should be used more than once, starting with material use. Energy conversion would typically be the last step in the hierarchy. However, in many markets energy conversion may be the only economically viable or available option for the use of biomass resources. Instead of cascading biomass use, the resource efficiency in energy production should be considered.

A level playing field and fair competition between the various uses of biomass resources is needed.

Various uses of wood biomass



Source: Fortum

[14] Aebiom Statistical Report, 2015 and European Commission SWD (2014) 259 final

[15] Aebiom Statistical Report, 2015

Biomass markets should be open and progressively integrated across the EU. There is no contradiction between the energy and industrial uses of biomass, as most solutions benefit both of them. Markets and economic operators – not politicians – should decide on how biomass is used to various purposes.

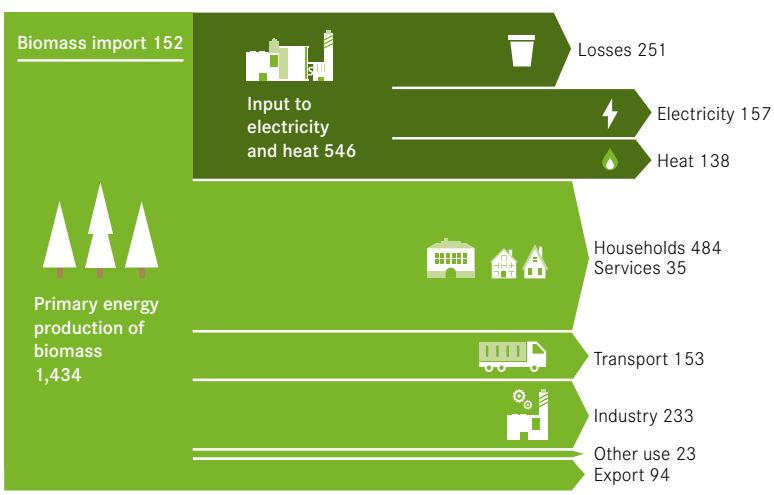
TRADING OF BIOMASS

Biomass is mainly a domestic energy resource in the EU with imports accounting for less than 3% of its total solid biomass consumption. The imports are mainly from Russia and North America. Solid biomass is predominantly imported to Europe as wood pellets[16].

Also in the future, the EU demand for solid biomass for bioenergy production is expected to be largely met with domestic raw material, though biomass imports are estimated to triple between 2010 and 2020[17].

There is no contradiction between the energy and industrial uses of biomass. Markets and economic operators – not politicians – should decide on how biomass is used to various purposes.

Use of biomass in EU28 for different purposes in 2013, TWh



Source: AEBIOM Statistical Report, 2015, Fortum, VTT

The EU bioenergy balance in 2013 indicates that biomass is mainly a domestic energy resource in the EU with imports accounting for less than 3% of its total solid biomass consumption. Circa equal amounts of biomass are consumed by households and services (35%) and electricity and heat sector (37%). About 16% of bioenergy is used in industry and 10% in transport.

[16] Eurelectric 2011, Biomass 2020: Opportunities, Challenges and Solutions

[17] European Commission SWD (2014) 259 final

From forest to boiler – biomass logistics

Forest biomass has traditionally been and still is mainly a local energy resource. However, as the biomass market is increasingly global, long-distance transport is becoming more general. Typically, forest biomass for energy production is still sourced from a relatively small procurement area, preferably within a 100-kilometre radius, although sometimes up to 150 kilometres. Within the logistics chain many small companies supply biomass in thousands of batches to one large customer.

FOREST BIOMASS CATEGORIES

The primary resources for forest biomass and wood chips for energy from forests can be divided into four main categories:

- Harvesting residues, including branches and tree-tops
- Stumps and root wood from clear cuts
- Round wood typically not suitable for industrial use
- Small-diameter wood or small whole-wood from thinnings.

Harvesting residues are the most significant resource for wood chips. The amount of accessible residues depends on, e.g., the wood species, wood quantity, and amount of branches. For instance, in the final fellings, spruce generates more than twice the amount of residues compared to pine or birch forests.

Round wood chips are usually produced from small-diameter trees, and mostly from unmarketable wood. They are mainly used in boilers that are more sensitive to fuel quality, particularly in terms of moisture content and particle size. As round wood is suitable for over-season storing, round wood chips are valued reserve fuel and primary fuel also for large boilers in peak-load periods.

Stumps and root wood are in some cases collected from the final fellings. While stumps can be stored over long periods of time and their caloric value is high, issues related to forest ecology and the efficient processing of stumps make their use challenging.

INDUSTRIAL BY-PRODUCTS

Solid, chemically untreated industrial wood residues such as bark and other by-products, e.g. sawdust, wood shavings, sides (slabs) of plank wood, constitute another important resource for wood chips for heat and power production. Except bark, they can also be used in industrial processes, such as pulp or pellet mills.

A typical forest biomass logistic chain

Forest biomass is typically produced from harvesting residues. Within in the logistics chain, many, usually small contractors with harvesters, forwarders, chippers and trucks are needed to supply biomass to one large customer. The logistics chains of forest-based biomass are mainly determined by the position of comminution (cutting/crushing the wood into small pieces) processes in the chain and the way and form the raw material is transported. Within the logistics chain many small companies supply biomass in thousands of batches to one large customer.

STORING, CHIPPING AND TRANSPORTATION

Before utilisation for energy, different forest-based wood stocks are first dried in logging areas, then in roadside storages, intermediate storages or terminals. They are then processed to suitable form and particle size by chipping or by crushing. The main technical properties for wood chips or biomass are moisture content, particle sizes, net calorific value, ash content, and loose density. The transportation system typically consists of special trucks or rail wagons, depending on the material type and destination. At harvesting sites, the residues, small-diameter wood and stumps are transported to the roadside (or intermediate storages) by forwarders with a wider cargo space and grapples designed specifically for these materials. Wood chips are typically transported from the roadside or intermediate storages to the power plants by large-volume chip trucks. Bulk cargo vessels are used in the transportation of wood chips or wood pellets from one country to another by sea.

Securing forest biomass for energy production

While the use of biomass in energy production is expected to increase, there are several challenges and potential bottlenecks that might affect the utilisation of forest biomass in the EU: the availability of necessary labour and machinery for supply chains; the willingness of forest owners to sell wood to the market; the commercial harvesting volumes of the forest industry; the competitiveness of forest biomass; as well as sustainability and environmental issues.

A sufficient supply of forest biomass will require both skilled labour and significant investments in forest and processing machinery and transportation capacity. Eurelectric[18] estimates that investments of nearly 10 billion euros will be needed to secure the growing demand in the EU without increasing the share of imports.

STABLE BUSINESS ENVIRONMENT IS ESSENTIAL

Many of the operators in the supply chain are small- and medium-sized companies that have a few machines or trucks. To make the necessary investments, they want assurance of a stable business environment with a constant demand for biomass.

Forest owners also play a major role in securing the future supply of forest biomass. They decide if and when the wood is sold and harvested, if the residues are used in energy production or left in the logging areas, if and by whom the thinnings of young stands are carried out, etc. Greater awareness of the value of biomass can motivate forest owners to consider the active and sustainable management of their forests.

Moreover, the ongoing transformation of the EU forest industry impacts the volume of timber harvesting; and with declining volumes of harvesting, the needed residues can become difficult to source.

Political decisions on issues like excise duties and subsidies on energy production play a key role in the establishment of a stable and predictable business environment for the end-users of energy wood, (see more on this topic on page 18).

The availability of wood for all end-use purposes should be increased and its mobilisation from the forest should be made easier. Practical means could include enhancing the improvement fellings in young forests, maintaining and improving the proper infrastructure (forest truck roads, etc.) and enabling an increase of forest estates and smooth arrangements for the transfer of land to the next generation.

[18] Eurelectric 2011, Biomass 2020: Opportunities, Challenges and Solutions

Case: Värtan – A biomass giant in Sweden

The world's largest biomass-fired CHP plant, Värtan CHP8, co-owned by Fortum and the City of Stockholm, started its operation in early 2016. This biomass giant is located in the middle of Stockholm with its population of 1.4 million people, making the fuel logistics and handling a challenge.

FLEXIBLE FUEL USE AND LOGISTICS

The new CHP plant can flexibly use a wide range of biomass materials. The main fuel types are forest residues and wood waste, such as saw dust, bark and logging residues. Fuel flexibility enables also the use of new fuels from the developing bioenergy market.

Flexibility is a key in fuel logistics. The aim is to ensure the security of supply and access to a wide geographic biomass market over time. The Värtan site is well located for efficient logistics: it has full access to road, rail and sea transportation. Most of the biomass is supplied by rail and by vessels. Trucks are used only temporarily.

FUEL HANDLING IN URBAN SURROUNDINGS

The entire power plant is fully adapted to the urban surroundings and requirements. Already in the design phase, the prerequisites were set by the limited space and the demand for closed fuel systems to avoid dust emissions and noise. An old rock cavern, previously an oil storage, has been converted into an enormous underground wood chip storage with a capacity of 60,000 m^3, i.e. about five days' fuel demand.

A new 200-meter pier was constructed in the harbour area to accommodate vessels up to Panamax size. The pier can hold two vessels at a time, and the new crane has a discharge capacity of 2,000–3,000 tonnes/hour. The grab itself holds about 50 m^3. On average, the plant requires 3–4 shipments per week to meets its fuel demand.

FACTS ABOUT THE VÄRTAN CHP8 PLANT

Capacity: 130 MW electricity, 280 MW heat

Heat and electricity for 190,000 households

Fuel consumption: 2.4 TWh/a (1 million m^3/a) or 12,000 m^3 per day

Investment cost: EUR 480 million

Constructed: 2012–2015

Emissions reduction: 126,000 tonnes CO_2/a (=12% of the annual emissions from the area's transport sector)

In addition, five trains per week transport biomass. The capacity of each train is some 4,600 m^3.

Fuel unloading and processing is done indoors within a closed and fully automatic system. All fuel is processed before its delivery to the power plant.

BIOMASS FROM THE BALTIC SEA REGION

Biomass for Värtan CHP8 will be supplied from local and regional sources around the Baltic Sea. The current fuel procurement plan is based on 40% of the fuel by rail from Nordic biomass suppliers and another 60% by ship from the Baltic Sea region and Russia.

All the logistics are controlled and coordinated in-house to optimise the logistics system and the supply chain as a whole and to control supply risks.

SUSTAINABILITY SYSTEM

Since 2005, Fortum Värme has been working in close cooperation with WWF Sweden as a member of the Global Forest and Trade Network to define and develop the sustainability aspects of the biomass supply chain.

In 2015, Fortum Värme was the first energy company in Europe and the second worldwide to receive FSC chain of custody certification for its biomass fuel. From 2016 onward, all forest biomass will be under third-party control in compliance with the FSC Controlled Wood standards.

Sustainability of biomass

Sustainable bioenergy production and use are topics of increasing global debate. In the EU, the sustainability and traceability concerns are primarily related to biomass imports from other continents. The use of agricultural biomass in energy production and competition with food production are also subject to discussion. The future EU sustainability policy for biomass should apply to both biomass produced within the EU and biomass imported from other areas.

CURRENT SITUATION IN THE EU

The current EU sustainability criteria as specified in the Renewable Energy Directive are applicable only to biofuels and bioliquids. Solid and gaseous bioenergy are regulated by a spectrum of national and voluntary sustainability criteria.

The lack of uniform criteria for all bioenergy hinders investments in bioenergy. Divergent national sustainability rules become a barrier to biomass trading and make it more difficult and costly to meet the increasing demand for biomass use in electricity and heat production.

The Commission is now reviewing the sustainability of all bioenergy sources and final uses. It launched a public consultation on bioenergy sustainability in February 2016, and a policy initiative on bioenergy sustainability is expected before the end of the year.

The identified sustainability risks under examination include, among others: lifecycle greenhouse gas emissions from bioenergy production and use; impacts on the carbon stock of forests and other ecosystems; impacts on biodiversity, soil, water and emissions to the air; indirect impacts caused by land use changes; and competition for the use of biomass between different sectors (energy, industrial uses, food).

Harmonised sustainability criteria for all bioenergy would increase the predictability and stability of the operating environment, ensure proper functioning and transparency of the biomass markets, increase the use of sustainable biomass in energy production, and promote the transition from fossil fuels to renewable and carbon-neutral biomass fuels.

PRACTICAL APPROACH TO PROVING SUSTAINABILITY

The forest biomass sector has thousands of players: from small and medium enterprises and hundreds of thousands of private forest owners to large forest companies and institutional forest owners, such as corporations and states.

The sustainability criteria should meet the needs of all these stakeholders. It should enable increased use of biomass while minimising administrative burdens or related costs. The new criteria should not decrease the competitiveness of biomass: in many cases, biomass competes with fossil fuels, which generally have no requirements to demonstrate sustainability.

Optimally, the criteria should be practical, applicable and transparent. In terms of governance and cost efficiency,

EU sustainability criteria for bioenergy should be legally binding and focus on the origin of biomass. They should apply to all types of bioenergy, regardless of whether being used in industry, energy production or transport.

the criteria should apply to energy production plants that are included in the EU emissions trading scheme (plants exceeding a capacity of 20 MWth).

Until uniform criteria are established, it is important to widely recognise the various current sustainability schemes to facilitate the market of biomass-based products. Today, country-specific sustainability systems are not automatically recognised elsewhere – not even between the EU member states – even if they are based on the RES Directive. This adds a level of bureaucracy, as the sustainability of an exported product must be approved in each country separately.

SUSTAINABLE FOREST MANAGEMENT AS THE BASIS

The EU and member states have profound legislation and established practices in forestry and sustainable forest management. These take also into account the national characteristics. In addition, there are many voluntary international standards/systems that can be utilised in the verification of sustainability. Going forward, the existing legislation and practices should be used as the foundation, and overlapping regulation should be avoided in setting the sustainability criteria for solid biomass.

Optimally, it should be enough if forest biomass meets all relevant legislation at the member state and EU level. No additional requirements to demonstrate sustainable biomass production should be set.

If new procedures to assess and prove the sustainability of solid biomass are needed, a risk assessment approach on a national or regional level and audited by a third party would be the most appropriate. This approach is already used in the EU Timber Regulation and by several voluntary sustainability certification schemes. If a country is classified as a low-risk country, sourcing of forest biomass should be allowed without further requirements.

Biomass users should have flexibility in choosing the appropriate tool to prove the compliance with the sustainability criteria e.g. by applying sustainable forest management certifications and practices. Voluntary sustainability schemes (e.g. PEFC, FSC, SBP) that tackle the risks mentioned above should be recognised also by the EU authorities.

CARBON DEBT AND EMISSIONS FROM ENERGY USE TAKEN INTO ACCOUNT IN LAND-USE SECTOR

The majority of biomass used for heat and power production results in significant reductions in greenhouse gas (GHG) emissions in the short, medium and long term compared to fossil fuel. For example, the current bioenergy plants achieve GHG savings of at least 70% compared to fossil fuel.[19]

FORTUM'S POSITION

- All bioenergy (solid, liquid, gaseous) needs common sustainability criteria in order to create a level playing field for competition
- Sustainability criteria should apply to the origin of all bioenergy regardless of end-use: industry, energy production or transport
- Forest and agriculture biomass require separate criteria
- Sustainability criteria should be legally binding
- The target should be global sustainability criteria, but, at minimum, common EU requirements with mutual recognition
- Sustainable forest management should establish the basis for the sustainable production of forest biomass
- Instead of the cascading use of biomass, resource efficiency should be an indicator of the preferred use of biomass
- Sustainability criteria should be applicable to energy production plants exceeding 20 MWth

[19] European Commission SWD (2014) 259 final

The sustainability criteria should set a GHG emissions reduction threshold for all types of biomass, irrespective of the final energy use. The threshold would allow to prove emission savings and ensure a minimum savings level. An appropriate level of the threshold could be a 60–70% reduction. GHG emissions should be calculated according to the existing methodology recommended by the Commission.

Biomass should continue to have a zero emissions factor in the EU emissions trading scheme. According to international rules, forestry carbon emissions are currently taken into account in the land-use sector. In this approach, the carbon contained in biomass used for energy is reported as an emission in the land-use sector in the year and at the point of harvest (when biomass is removed from the forest). To avoid a double-calculation, emissions from biomass combustion should continue to be calculated as zero.

As a whole, the climate impact of forest biomass used in energy production is exceptionally complex and differs between the short, medium and long-term perspectives. However, emissions from the energy use of forest biomass becomes quite irrelevant as long as they are covered by the land-use sector calculation.

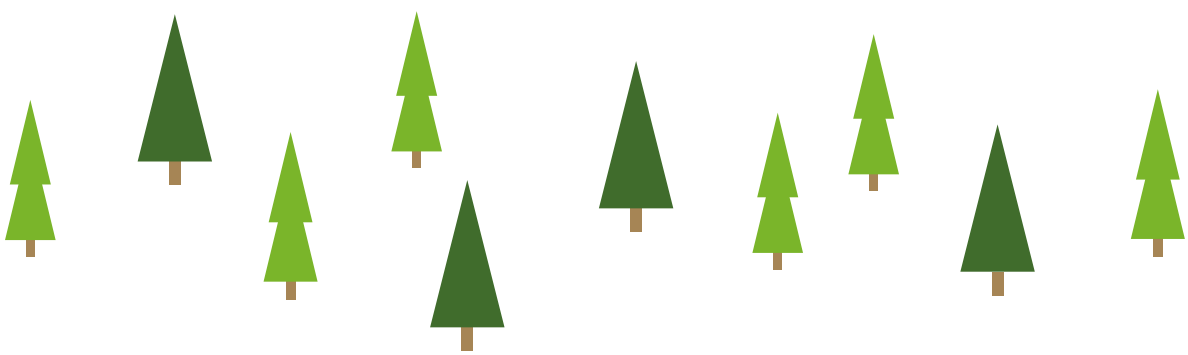
RESOURCE EFFICIENCY TO STEER THE BIOMASS UTILISATION

As there is increasing competition for the use of biomass, it is important to ensure that it is used as efficiently as possible. Instead of defining the cascading use of biomass (see page 7), the resource efficiency could be an indicator of the preferred use of biomass.

There are substantial benefits to the use of biomass for combined heat and power production (CHP). The overall efficiency of CHP is typically 70–90%, compared to an average of 30–40% in dedicated biomass plants for electricity only. Total efficiency can be further increased in advanced solutions where e.g. biofuel or bioliquid production is integrated into a CHP plant. In such processes, the by-products of the production process can be fully utilised in heat and power production and the excess thermal energy can be utilised as district heating or cooling.

BIODIVERSITY MEASURES AN ESSENTIAL PART OF SUSTAINABLE FOREST MANAGEMENT

The use of biomass should not compromise the biodiversity of forest ecosystems. For example, stumps and deadwood are important in maintaining the biodiversity. The risks related to further deforestation due to increased biomass use are minimal, as forest biomass is currently largely produced as a complementary by-product of wood material and fibre products in Europe. Furthermore, biodiversity measures are taken into account in sustainable forest management practices, and legislation should prevent the sourcing of raw material from areas with a high biodiversity value.



Case: Joensuu – Bio-oil from wood in Finland

Fortum's CHP plant in Joensuu is an excellent example of advanced solutions to utilise biomass. The CHP plant's traditional products, electricity and heat, are complemented with Fortum Otso® bio-oil. The bio-oil production plant is the first of its kind in the world on an industrial scale.

Fortum Otso® is produced by a thermal treatment of wood-based raw materials, such as forest residues, wood chips or sawdust, in the absence of oxygen. Pyrolysis is a well-known method to produce tar, but during the last few years a fast pyrolysis technology has also met today's technical requirements.

INTEGRATED FAST PYROLYSIS PROCESS

Bio-oil production is based on the commercialisation of new technology in which a pyrolysis reactor is connected to the CHP plant's boiler. The fast pyrolysis process involves fast thermal treatment of biomass in an inert atmosphere to produce bio-oil, gases and char. Non-condensible gases together with wood char are fed back to the CHP boiler to be utilised as a fuel for district heat and electricity. Consequently, all wood particles can be utilised without any waste.

Bio-oil is bioenergy in a very compact form. The energy density (calorific value) can be significantly increased as solid biomass is converted into liquid. Bio-oil is also easy to handle and can be used in current boilers with some modifications.

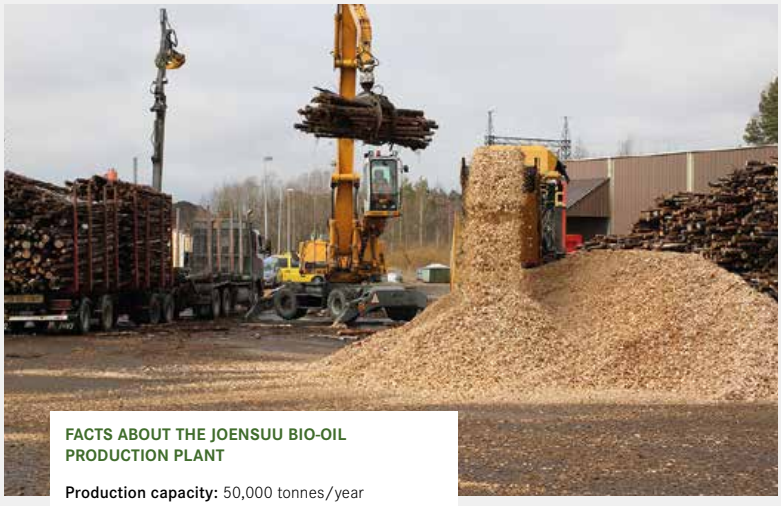
SUSTAINABILITY SYSTEM

The sustainability criteria for biofuels and bioliquids as specified in the EU Renewable Energy Directive is applied to the biomass used in the bio-oil production, whereas the biomass used at the CHP plant itself is not currently within the sphere of the sustainability criteria.

Fortum has developed the Fortum Otso® sustainability system, covering the whole value chain from forest to bio-oil production and finally to the end customer. The CO_2 footprint of the whole production chain is calculated and compared to fossil fuel. The Fortum Otso® sustainability system is approved by the Finnish Energy Authority and audited annually by an independent auditor.

LOCAL WELLBEING

The bio-oil production plant is also generating jobs and contributing to the local wellbeing. The raw material generates revenues for forest owners and local harvesting contractors. At the plant itself, new jobs have been generated in raw material procurement, production and logistics. In total, the employment effect in the Joensuu region is estimated to be around 60–70 man-years.



FACTS ABOUT THE JOENSUU BIO-OIL PRODUCTION PLANT

Production capacity: 50,000 tonnes/year (210 GWh), i.e. equivalent to the heating needs of more than 10,000 single-family homes

Biomass consumption: 225,000 m^3/year (350 GWh/a)

Bio-oil applications: district heating, process industry, first product batches delivered to customers in 2015

Investment cost: EUR 30 million

Constructed: 2012–2013

Emissions reduction: 60,000 tonnes CO_2 and 320 tonnes SO_2 when replacing heavy fuel oil

Benefits to the local economy

Forest biomass is inherently a local energy source, as about 95% is consumed within the borders of the country of origin. Biomass is typically sourced within a 100–150 km radius of the plant. Consequently, bioenergy production generates local economic benefits, growth opportunities for local business, new job opportunities and wellbeing for the rural economy.

BIOMASS BRINGS LOCAL JOBS

In 2012, the European bio heat and electricity sectors employed about 375,000 people[20]. The supply and delivery of biomass have the largest contribution to employment, but also the construction and operation of biomass-fired plants provide job opportunities. In total, electricity production from biomass requires 3 to 6 times more labour across the supply chain than required for fossil fuels[21].

Bioenergy production employs especially small- and medium-sized enterprises. In various Finnish studies, the employment effect from the use of forest chips has been estimated at 180–250 man-years/1 TWh biomass[22].

ECONOMIC BENEFITS SPREAD BROADLY

Biomass use yields several economic benefits: revenues for forest owners, taxes from sales of timber, income for harvesting and transportation enterprises, taxes from enterprises and employees, and the manufacturing and maintenance of machinery and equipment.

Especially the forest owners benefit from the additional income from harvesting residues and thinnings. They benefit indirectly from increased and accelerated wood growth as a result of the thinnings.

The value added in the solid biomass industry is estimated at EUR 36 billion[23].

LOCAL BIOMASS CONTRIBUTES TO ENERGY SECURITY

Biomass can be stored during times of low demand and used when needed. Depending on the type of the conversion plant, biomass can thus play an important role in balancing the increasing share of variable renewable electricity from wind and solar in the electricity system.

Bioenergy production generates local economic benefits, improves employment and creates wellbeing for the rural economy. The bioenergy business is important, especially for small- and medium-sized enterprises.

As the majority of the biomass used in the EU area is domestic, it also improves the EU energy security and the diversification of energy supply, and it reduces dependency on imported fossil fuels. This has direct and indirect effects on GDP and the trade balance.

[20] European Commission SWD (2014) 259 final

[21] Aebiom Statistical Report, 2015

[22] Metsäteho Oy and Pöyry Oy 2009, TEM 2010, VTT 2003

[23] Aebiom Statistical Report, 2015

Case: Częstochowa – Biomass from orchards co-fired with coal in Poland

In 2010, Fortum commissioned a CHP plant in the southern Poland city of Częstochowa. This was the first cogeneration plant built on a greenfield site in Poland by Fortum. The plant with a circulating fluidised bed boiler (CFB) uses biomass and hard coal. The new CHP plant replaced coal-fired heat-only boilers that currently are used only as peak-load boilers. The CHP plant provides over 86% of the heat used in the city's district heating system.

FACTS ABOUT THE CZĘSTOCHOWA CHP PLANT

Capacity: 68.4 MW electricity and 129.1 MW heat

Electricity production: 430 GWh/a

Heat production: 500 GWh/a

Fuel consumption: 1,380 GWh/a

Gross efficiency: 90%

Investment cost: EUR 95 million

Constructed: 2008–2010

CO-COMBUSTION OF BIOMASS AND COAL

Initially, biomass accounted for 20% of the fuel. Currently, its share can reach 35%, and tests have been made even with 100% biomass. However, the Polish regulatory environment impacting the biomass market is unstable, which limits increasing the share of biomass. The new Polish Renewable Energy Law under preparation may put a cap on the amount of green certificates (green certificates are a market-based system to promote renewable energy) received for electricity produced from biomass, thus violating the principle of technology neutrality with regard to subsidies. The cap would be based on the average amount of green electricity produced in 2011–2013. For the Częstochowa CHP plant, this would correspond to a 25% share of biomass, consequently reducing the incentive to increase the share of biomass.

New regulations also define plants dedicated to the combustion or co-combustion of biomass and, based on that, differentiate the numbers of green certificates. A dedicated plant is entitled to twice as many certificates per unit of biomass-generated energy than a non-dedicated one. This is essential for the profitability of production, as biomass is more than twice as expensive as coal (per GJ). Fortum CHP in Częstochowa is one of 12 plants in Poland officially certified as plants dedicated to the combustion or co-combustion of biomass.

AGRICULTURAL BIOMASS AS THE MAIN ENERGY SOURCE

In 2015, the plant incinerated more than 147,000 tonnes of biomass, including 28,000 tonnes of forestry biomass. The majority, 119,000 tonnes, originated from agriculture: 90% from orchard removals or trimmings and the rest was energy willow. Most of the biomass was purchased from local suppliers, who source biomass from orchards in southern and central Poland. Some agricultural biomass was imported from Belarus.

Fortum regularly audits its biomass suppliers and visits orchards to make sure its standards are met.

BENEFITS FOR THE REGION

The employment effect during construction was over 250 man-years. The Częstochowa CHP plant employs 31 people in the operation of the plant and dozens more have jobs in biomass production and transportation. For example, the biggest fuel supplier employs over a hundred people.

The new CHP plant has increased energy efficiency considerably compared with the heat-only boilers operated earlier. The use of biomass has reduced annual CO_2 emissions by 130,000 tonnes (28%) and SO_2 emissions by 600 tonnes (64%) since 2011. The emissions reductions have improved the local air quality.

Co-combustion of biomass together with hard coal is a simple and economically viable way to replace fossil fuels. Co-combustion in a high-efficiency CHP plant means utilisation of biomass with a higher thermal efficiency than what otherwise was possible. The co-combustion of biomass and coal represents a low-risk, low-cost, sustainable and renewable energy option that results in reductions in CO_2, SO_2 and NOx emissions, and increases in a number of societal benefits.

Support schemes for renewable energy sources – a never ending story?

The EU member states are applying various support schemes to promote renewable energy sources (RES), including biomass, in energy production.

The table on page 19 indicates the variety of schemes in Fortum's operating countries. The complexity of schemes in these EU member states alone is large, but it is much worse in the EU as a whole.

CURRENT SUBSIDY POLICIES ARE VERY FRAGMENTED

Subsidies have facilitated meeting the renewables targets, but at the same time they have created a myriad of different schemes in the EU. Biomass support is also often tailored to and focused on a particular type of biomass. The level of subsidies and the biomass fractions entitled to subsidies differ significantly in various member states, and electricity and heat are usually treated differently. CHP, which has a pivotal role in bioenergy production, faces rather divergent treatment in various member states in terms of heat price regulation, subsidies and taxation.

The support schemes are also constantly (and even retrospectively) changing, which reduces the investment willingness, especially among smaller enterprises.

CHALLENGES FOR ENERGY AND BIOMASS MARKETS

The different subsidy levels applied by countries prompt the unnecessary

FORTUM'S POSITION

- The current situation regarding subsidies for renewable energy, including biomass, is unsustainable. Different national subsidy schemes are fragmenting the EU internal biomass market and prompting the unnecessary transport of biomass in pursuit of the highest subsidies. They encourage concentrating investments to member states with the highest bioenergy support schemes.
- A market-based approach for the promotion of renewables with regional or EU-wide harmonised support schemes would bring more biomass to the EU energy system and increase predictability for investments in bioenergy. The EU emissions trading scheme (ETS) should be the main instrument in steering investments in biomass and fuel choice in existing plants.
- Subsidies for all mature renewable energy technologies, including biomass in the sectors covered by the ETS, should be gradually phased out in order to fully integrate renewable energy generation into the energy market. An appropriate transitional period to move towards a market-based approach may be necessary until the 2020's.
- As long as subsidies exist, they should be technology-neutral and harmonised. Harmonisation of subsidy schemes would enable the most efficient and economical use of biomass. Harmonisation could start at the regional level.
- Subsidies should focus on bioenergy innovations and R&D activities, in particular on the commercialisation of new bioenergy technologies and bringing them to the markets.
- Development of renewables, including biomass, may require additional incentives in non-ETS sectors. Primarily, any additional measures to promote biomass should focus on sectors remaining outside the ETS.

Biomass support schemes in Fortum's operating countries in the EU[1]

Country	**Biomass projects** (energy production, DH infrastructure, new technology, buildings)	**Operative support** (electricity and heat production)					**Investment support** (biomass projects)		**Other**
		Feed-in-tariff (FiT) for RES-E	Feed-in-premium (FiP) for RES-E	Certificate system (GC) for RES-E	Capacity remuneration (CR) for RES-E	Heat premium for RES-E	Investment grants	Loan guarantees or support	
Estonia	• Heat-only boilers (new/reconstruction) • CHP projects (new) • DH infrastructure linked with biomass use		 X 				X X X		
Finland	• Small heat-only boilers < 10 MW (RES> 50%) • Small CHP production < 8 MW • Biomass production projects (new technology) • New technology demonstration • DH infrastructure (RES plant connection)		 X 			 X 	10–15% 20–40% X X		Investment support for farmers Taxation of fuels for heat production including CO_2 tax
Latvia	• Heat-only boilers • CHP plants[2] • DH infrastructure • New buildings/ deep renovations		 X 		 (X) 		X X X X		Net metering Reduced VAT RES obligation for buildings
Lithuania	• Heat-only boilers (new) • Biomass- and bio-waste CHP • New buildings/ deep renovations	 X 					X X X	X X	Tax exemptions RES obligation for buildings
Poland	• Conversion of heat-only boilers • New CHP plants • New building/ deep renovations			 X 			X X X	X	Tax exemptions RES obligation for buildings
Sweden	• New heat-only boilers • New CHP projects			 X			X X		Taxation of fuels for heat production including CO_2 tax

Sources: AEBIOM 2015, www.res-legal.eu, national ministries, CEER, KPMG Fortum analysis

[1] We have not verified this data with national ministries. Thus the presented data is tentative.

[2] CR not valid for new facilities

transport of biomass to countries with the highest bioenergy support schemes. This, in turn, may distort biomass markets and dilutes the overall efficiency of pursuing the RES targets: renewable energy sources should be utilised in areas where each source is the most cost-competitive and makes the most sense economically. A functioning market and level playing field for biomass is a necessity to keep its use cost-optimal for society.

Subsidies also inflate the impact of the EU emissions trading scheme (ETS), which should be the main instrument in steering investments in renewables in the sectors covered by the scheme. A well-functioning ETS with a meaningful price signal could remarkably contribute to attracting further investments in biomass and hence deliver the planned increases in bioenergy production both at a national and EU level.

Sectors remaining outside the ETS would require other incentives. Currently, a minority of the heating sector emissions are included in the EU ETS, but a variety of excise duties and taxes are applied to biomass used in heating in non-ETS sectors. Current tax rates for the heating fuels in the member states are mostly above the EU allowance price and thus already provide more incentives to reduce emissions. However, given the large differences – and in some cases low levels – in excise taxes on heating fuels across member states and fuel types, there is likely room for improving cost efficiency. The inclusion of the whole heating sector in the EU ETS could be a future opportunity to be investigated.

Going forward, RES subsidies, including those for bioenergy, should focus on innovations and R&D activities. A specific emphasis should be set on the commercialisation of new technologies and bringing them to the markets. This should be taken into account in the review of the EU Renewable Energy Directive and the reform of EU state-aid guidelines.

DEVELOPING A REGIONAL APPROACH

Similar subsidy schemes in larger geographical areas – initially regionally and later throughout the EU – would limit the transportation of biomass in pursuit of the highest subsidies. This, in turn, would increase the overall efficiency of RES policies in the EU.

Boosting the switch from fossil fuelled district heating capacity to biomass could be promoted by investment subsidies when heat market conditions, i.e. environmental taxation, do not otherwise give sufficient incentives. As the economy of biomass-fired CHP depends both on the regional electricity market and merit order in local heat markets, the support should primarily come by ensuring heat load. Environmental taxes can be a significant cost factor for heat, so taxation and support schemes should be considered en bloc.

There is a choice to be made between market-based and subsidy-driven renewable energy policies. The first option would reinforce the EU internal energy market with renewables, including biomass, at its apex, while the latter goes down the road of further fragmentation of the EU internal energy market with the less cost-effective utilisation of bioenergy. A market-based approach or an intermediate policy model for the promotion of renewables with regional or EU-wide harmonised support schemes would best serve the purpose of bringing more biomass to the EU energy system.

Fragmented and constantly changing biomass subsidy schemes in the EU distort the functioning of the energy and biomass markets, prompt unnecessary transport of biomass, reduce investment willingness and diminish the overall efficiency of pursuing the renewable energy targets.

Fortum's biomass use

Fortum utilises both forest and agricultural biomass as well as biomass from waste in the production of electricity, heat, cooling energy and liquid bio-oil. About 80% of the biomass is forest biomass. Agricultural biomass accounts for about 13% of total use. The rest of the biomass is bio-based municipal waste and industrial waste. In 2015, total biomass use, including Fortum Värme, which is a joint venture with the city of Stockholm, was 5.1 TWh, equivalent to 2.6 million m^3.

Bioenergy accounts for about 3% of Fortum's energy sources. In our European heat production, the share is 31% and in the European electricity generation 2%.

Forest biomass is sourced from Finland, Sweden, the Baltic countries, Poland and Russia. The biomass consists of wood chips, industrial wood residues and wood pellets.

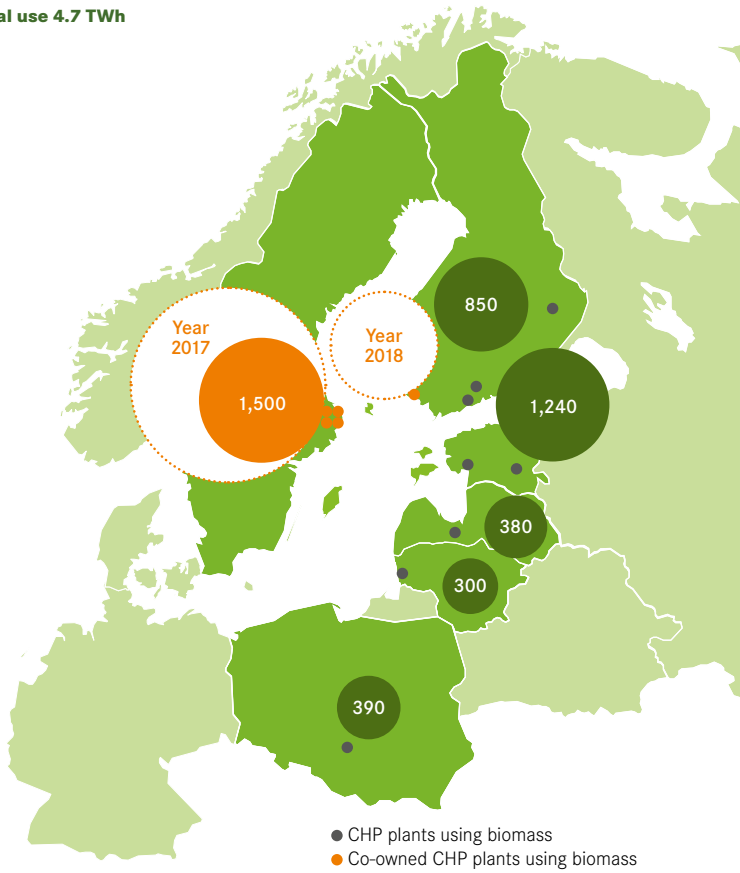
BIOMASS CONSUMPTION TO INCREASE BY 50%

During the next few years, the annual use of biomass will increase by more than 2 TWh and 1 million m^3 as a consequence of the commissioning of two large-scale CHP plants: Värtan CHP8 in Stockholm, Sweden, in the first quarter of 2016 (see page 11), and Naantali CHP4 in Naantali, Finland, in 2017.

Fortum is participating in the Naantali CHP4 project through its associated company Turun Seudun Energiantuotanto Oy (TSE). Fortum has a 49.5% interest in TSE. The new multi-fuel power plant can use biomass, coal and high-quality recycled waste. The biomass will consist of mainly locally sourced wood chips transported from within a 100–150-kilometre radius of the plant. The annual wood chip consumption will eventually be as much as 1.0 million solid cubic meters or more than 2.5 million loose cubic meters. Sourcing of the domestic biomass will create well over 200 permanent jobs. Additionally, the peak of the construction phase will provide jobs for about 600 people. Upon completion, the plant will produce 900 GWh electricity and 1,700 GWh heat annually. The plant's production capacity is about 140 MW electricity and about 250 MW heat.

Fortum's biomass use by country in 2015, TWh including forest and agriculture biomass

Total use 4.7 TWh



FORTUM'S BIOMASS PURCHASING

Fortum recognises the challenges related to the origin and sustainability of bioenergy. In the purchasing of biomass, Fortum is developing several actions in order to verify the traceability and sustainability of fuels.

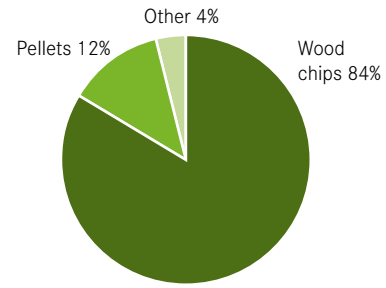
As sourcing and use of bioenergy is guided by a spectrum of national regulatory and voluntary sustainability criteria and certifying schemes, defining a common approach is a challenge. The origin of bioenergy is monitored and reported in Fortum's sustainability reporting.

In 2016, Fortum will strengthen and harmonise the agreement requirements related to the origins of wood-based biomass. We also aim to set a target for the use of wood-based biomass from certified sources.

Furthermore, we are participating in several international organisations promoting the sustainable use of bioenergy.

Fortum's forest biomass use by fuel category in 2015

Total use 4.0 TWh



Includes the jointly owned company AB Fortum Värme samägdt med Stockholms stad

Conclusions and recommendations

BIOMASS - AN INTEGRAL PART OF THE ENERGY SYSTEM

Biomass is an important renewable, local and carbon neutral energy source which contributes to several EU level policy targets: mitigating climate change, improving security of energy supply, providing local jobs and meeting the renewable energy targets.

At regional and local levels, biomass production and consumption generate growth opportunities and new job opportunities for local business.

POLITICAL UNCERTAINTY A KEY RISK

The political framework for the use of biomass is increasingly uncertain in the EU. The stop-and-go economic and political trends make biomass markets unstable and reduce the investment willingness. Divergent national sustainability rules and fragmented support schemes become a barrier to biomass trading and make it more difficult and costly to meet the increasing demand for biomass use in electricity and heat production.

MORE SUSTAINABLE BIOENERGY FROM FOREST

70% of biomass used as energy in the EU originates from forests. Harvesting residues and industrial wood residues constitute the most significant resources for biomass used in energy production. Currently, 60–70% of annual forest growth is harvested; there is potential to increase sustainable harvesting which, in turn, would provide more residues for bioenergy production.

SUPPLY OF BIOMASS TO BE BOOSTED

Future challenges and potential bottlenecks for forest biomass utilisation in the EU are related to the availability of sufficient labour and machinery, willingness of forest owners to sell wood to the market and commercial harvesting volumes of the forest industry as well as necessary infrastructure like roads.

Due to its versatility, biomass is a desired raw material. A level playing field and fair competition between the various uses of biomass is needed. Biomass markets should be open and progressively integrated across the EU. Markets should not be subject to any political interference to restrict sales of biomass to one national market or preferred industrial sectors.

A majority of the biomass for future demand can be produced within the EU. In order to release this potential and to secure long-term availability, supply-side incentives and a policy

framework for sustainable and market based biomass production are needed. The growth in biomass use will require significant investments in biomass supply chains. To ensure investments in supply chains and a skilled workforce, a stable and predictable investment framework is needed.

Furthermore, forest owners need incentives to enhance continuous supply of wood for energy use. Management of young, overdense stands should be enhanced on national level and improved collection of forest residues should be encouraged.

SUSTAINABILITY CRITERIA FOR SOLID BIOMASS REQUIRED

All bioenergy – whether in solid, liquid or gaseous form – needs one set of sustainability criteria to create a level playing field for competition. The criteria should be legally binding and focus on the origin of biomass, regardless of whether being used in any industry, energy production or transport. The sustainability criteria should take into account existing national forest legislation (e.g. national forestry rules in the Nordic countries) which in many cases already guarantees a good level of sustainability. The criteria should be practical, applicable and transparent and avoid unnecessary administrative burden. At the same time, differences between agricultural and forest biomass and between regions should be taken into consideration.

There are substantial benefits to the use of biomass in combined heat and power production (CHP). The overall efficiency of CHP is typically 70–90% and can be further increased in advanced solutions where e.g. biofuel or bioliquid production is integrated into a CHP plant.

Sustainable biomass should continue to have a zero emissions factor in the EU emissions trading scheme. According to international rules, forestry carbon emissions are currently taken into account in the land-use sector and double-counting must be prevented.

SUBSIDIES TO BE REMOVED

Subsidies have widely been used to meet the EU renewables targets, resulting in a myriad of different subsidy schemes. This has, for example, prompted unnecessary transport of biomass between countries, distorted the biomass markets and inflated the functioning of the EU emissions trading scheme (ETS).

Going forward, the utilisation of indigenously produced biomass in close proximity to its source of origin should be encouraged. Furthermore, a market-based approach or intermediate regionally harmonised support schemes would best bring more biomass to the EU energy system and increase predictability for investments in bioenergy.

A well-functioning EU emissions trading scheme (ETS) with a meaningful price signal should be the main instrument in steering investments in renewables such as biomass and in choice of fuel for existing plants in the sectors covered by the scheme. Subsidies for all mature renewable energy technologies, including biomass in the ETS sectors, should be gradually phased out in order to fully integrate renewable energy generation into the energy market. An appropriate transitional period to move towards market-based approach may be necessary until 2020's. As long as subsidies exist, they should be technology-neutral and harmonised.

Innovations and R&D activities for the promotion of biomass will need support also in the future. A specific emphasis should be set on the commercialisation of new technologies and bringing them to the markets.

FORTUM ENERGY REVIEW ON BIOMASS, APRIL 2016

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The energy sector is in the middle of a transition. Megatrends, such as climate change, emerging new technologies, changes in consumer behaviour, and questions regarding resource efficiency, have a major impact on the energy sector globally. Our intention is to actively participate in the market transition and to be part of the solution.

The Fortum Energy Review series highlights the challenges and opportunities we see in the energy sector and outlines our solutions to them. We want the Fortum Energy Review to engage our stakeholders in a dialogue about the future direction. In our view, energy should improve life for present and future generations.

BIOMASS – Fortum's key messages

- Biomass is a crucial part of a sustainable energy system: renewable, carbon-neutral, mainly local and domestic energy – the only renewable energy form replacing fossil fuels in the production of electricity, heat, cooling and traffic fuels.
- EU-wide harmonised and binding sustainability criteria for all bioenergy and targeting the origin of bioenergy, regardless of its end use, is required. In proving the sustainability of forest biomass, a practical and transparent approach based on sustainable forest management is a necessity.
- Due to its versatility, biomass is a desired raw material for many purposes. A well-functioning biomass market and a level playing field for competition between the various uses of biomass has to be enabled.
- Resource efficiency has to be a key criterion steering the use of biomass between the different end uses. In energy production, biomass is most efficiently utilised in advanced CHP plants in connection with district heat production or in other CHP-integrated processes.
- Subsidies for mature renewable energy technologies, including biomass, have to be gradually phased out and the EU ETS alone has to steer further investments in biomass and fuel choice in existing plants. Should subsidy policies continue, they have to be technology-neutral and preferably regionally harmonised.