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1. Introduction

Bioenergy is renewable energy made available from materials derived from biological sources (wikipedia). Bioenery was used as fuel in 1908 when Ford motor company release the Ford model T. This model could run on either gasoline or ethanol. There are several reasons why bioenergy has been increasingly over last century. The first significant event was the 1970 energy crisis since it leaded to the rising of the oil's price from 3 USD/barrel to 12 USD/barrel globally (wikipedia). There are three main sources of bioenergy: agriculture, forestry and waste. In term of forestry, this comes from merchantable stem wood [wood in the stems of trees greater than 5" diameter at breast height (dbh)], tops and branches of harvested trees, and understory trees (less than 5" dbh). It is described in the process bellow.

It is needed to utilize technology to release the energy directly from biomass, by burning its materials for heat, or transform it into other forms such as solid or liquid fuels. There are three types of conversion technologies currently available, each appropriate for specific biomass types and specific energy products: thermal, chemical and biochemical.

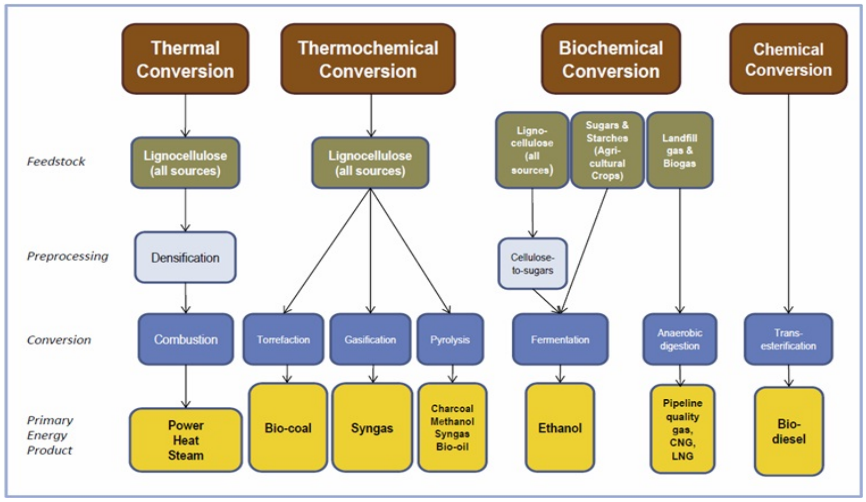

Figure 1: Bioenergy conversion technologies (CL Williams, after Baye, 2010)

Due to the technology development, it is enabling more efficient use of a wider variety of biomass types for these and other uses (figure 1). However, there are advantages and disadvantages to each scale of bioenergy production and use. Decision-makers must often balance trade-offs? between the benefits and the costs associated with bioenergy production and use at any particular scale.

Reference:

1. Baye, T. 2010. Managing the biomass value proposition: business planning, contracting, pricing and execution (presentation). University of Wisconsin Extension, Madison.

2. Wikipedia. Accessed link [https://en.wikipedia.org/wiki/Bioenergy]

3. Wikipedia. Accessed link [https://en.wikipedia.org/wiki/1973_oil_crisis].

2. The role of policy

European Governments are currently increasingly developing bioenergy for economic and environmental purposes. It was said to be 'carbon neutral', because, while trees and agricultural crops release carbon when they are burned, they also absorb carbon while they are growing (as opposed to fossil fuels, which release carbon that was removed from the atmosphere centuries or millennia ago) (Bente, 2016). The percentage of bioenergy has been contributing increasingly to the total energy consumption in the EU over last decades. From 1995 to 2013, this figure increased from 5% to 12% respectively. As resulted, bioenergy played an important role in the actual implementation of EU climate and energy policies. This focused on decreasing independency on imported oil, switch to fuels that were less environmentally damaging. To fulfil these targets, a wide range of solutions has introduced for renewable energy and subsidies for bioenergy production and consumption. These include:

- Direct subsidies for research;
- Tax-exemptions, based on the assumption of carbon neutrality of energy generated by burning biomass;
- Support programs for establishing 'bio-plants' (e.g. for biogas, biomass co-generation of heat and power, agrofuels) and for running these plants;
- A steady ow of research and development funds, for example through the EU ALTENER program or through national programs;
- Support programs for production of raw material for bioenergy in agriculture and forestry (e.g. through EU rural development programs).

One of stronger EU legislation was put in place in 2009: The Renewable Energy Directive (RED) introduced binding targets in the transport, heating and electricity sectors across the EU with 2 significant targets:

• An overall goal of generating 20% of energy from renewable resources by 2020
• A binding target of 10% of energy consumed in the transport sector to come from renewable sources by 2020 (with up to 7% allowed from first-generation agrofuels based on food crops).

Reference:

1. Bente Hessellund Andersen. 2016. Bioenergy in EU

3. Policy instruments

There are different policy-based instruments that can affect markets in order to fulfilled objectives. The justification of this interventions is based on the role that different externalities play in the market development of these commodities. In the case of bioenergy, this is a fundamental topic that largely affects its implementation. There are different tools, from more aggressive approaches such as quotas and restrictions, to subtler as promotion campaigns, green labeling or even research grants. Two commonly used instruments have been subsidies and taxes.

In term of taxes, the tax incentives for biomass energy production generally could promote markets and increase demand for forest products. This also involves exemption from taxes and/or value-added tax. In additio, since 1997 (the entry into force of the Kyoto Protocol), countries such as the UK, France, Germany, Spain, Norway, Finland, the Czech Republic and Sweden, have increased taxes on oil and oil products. Denmark introduced a taxon carbon dioxide emissions before 1997. But, paradoxically, in some European countries, taxes on oil and oil products have increased significantly in accordance with the requirements of the Kyoto Protocol but coal taxes (much more "dirty" energy source) does not increased at all (Ayodele, 2016).

Regarding subsidies, this is a tool used for the expansion of the bioenergy sector. However, subsidies directed to one sector may harm the other sectors and can also increase the costs of mitigating climate change. For example, bioenergy can only reduce emissions if it is used to replace fossil fuels. Replacing wind, solar, hydro or nuclear energy with bioenergy will always lead to more emissions. Subsidies encourage the use of biomass in the power and heating sector, which reduces its availability for other uses, outside the ETS. For instance, biomass can be used to replace petroleum-based plastics and other materials, or refined into transportation fuels to replace oil, or used as a feedstock in the chemical industry. In all these applications, biomass would replace fossil fuels.

Reference:

1. Ayodele O. Ogunlanaa, Nataliya N. Goryunova. 2016. Tax Incentives for Renewable Energy: The European Experience

4. Adoption dynamics in bioenergy markets

After the oil crisis, many European countries implemented policies in order to decreased oil dependence. These policies were later reinforced with growing environmental concerns, and dedicated to the promotion of renewable energy. One example of such a promotion was the development and establishment of energy crops as a source of biomass for energy purposes. Sweden was among the countries considering this options from the beginning, particularly focusing on fast growing willow plantations.

Sweden issued policies to encourage this cultivation. he first subsidies for willow planting in Sweden, during 1991 and 1996, were as high as 1,200 ECU/ha and 480 ECU/ ha for fencing. In later years, willow growers in Sweden could receive approximately 515 Euro/ha (LSFRI Silava 2005). Harvesting cost of short routine willow cultivation in Sweden is approx. 400 Euro/ha or 9.8 Euro per 1 oven dry ton (odt-1) of wood (LSFRI Silava, 2005).

Regarding taxes, in 1991 Sweden's energy tax system was modified, with the introduction of a CO2 tax, a reduction in the general energy tax, a tax on sulphur emissions and various value-added taxes on electricity and fuels. These policies have both environmental and fiscal purposes, but in recent years focus has been a strengthening of the environmental aspects. The present tax structure comprises three elements: an energy tax, a CO2 tax and a sulphur tax. CO2 tax has been raised in stages over the years, from SEK 0.25/kg CO2 to SEK 1.20/kg CO2 in 2015, but this rate is reduced for the manufacturing, agriculture, forestry and aquaculture sectors (IEA, 2017).
The sulphur tax is applied to emissions where these are measured, or the sulphur content of oil used. In both cases, the tax is uniform across all users. For oil and diesel, the tax is charged per 0.1% of sulphur content by weight. For coke, coal and peat it is charged per kg of sulphur content. The sulphur tax is applied on heavy fuel oils, coal and peat. If sulphur is removed from the exhaust gases the tax is refunded at the same rate for each kg of sulphur removed.

Reference:

1. LSFRI Silava] Latvian State Forest Research Institute "Sila- va". 2005. A handbook on the establishment and management of willow plantations.

2. International Energ Agency. 2017. Energy, Carbon Dioxide and Sulphur Taxation. Available at [https://www.iea.org/policiesandmeasures/pams/sweden/name-21011-en.php]

5. Bioenergy market behaviour

Market economics follows certain rules concerning price, supply and demand. Development of sustainable advanced biofuels is part of the Strategy for a Sustainable European Bioeconomy proposed by the European Commission in February 2012 to shift the European economy towards greater and more sustainable use of renewable resources and processes (for food, feed, energy and industry).

In 2009 the EU bioeconomy had a turnover of nearly €2 trillion (2012) and employed more than 22 million people, 9% of total employment in the EU (ETIP). The statistic included agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries. Each euro invested in EU-funded bioeconomy research and innovation was estimated to trigger €10 of value added in bioeconomy sectors by 2025.

In recent years, market development of biofuels in Europe has been driven by binding targets set in the Renewable Energy Directive for 10% of renewables in transport energy use by 2020. Public concerns over land use issues have led to the amendment of the Renewable Energy Directive in 2015 (EU/2015/1513) which caps the use of conventional biofuels derived from crop plants at 7%. At the same time, it obliges Member States to implement a target for biofuels from non-food feedstock of at least 0,5% in transport energy in 2020. As a further incentive the amendment rules the double-counting of the energy contents of advanced biofuels towards the renewable energy target of 10%. Hence the future expansion of biofuels markets in Europe is dependent on the commercial deployment of advanced biofuels that use wastes, residues and energy crops (grown on marginal land) as feedstocks. In addition, electricity from renewable resources for rail transport is counted 2,5 times and for road transport 5 times the energy content.

Reference:

1. European Technology and Innovation Platfom . 2016. European Biofuels market. Available at [http://www.etipbioenergy.eu/?option=com_content&view=article&id=297]

6. Concepts and approaches to bioenergy governance

Governance covers: (i) the activity or process of governing; (ii) those people charged with the duty of governing: and (iii) the manner, method and system by which a particular society is governed. It has international, national and local dimensions.

EU and Member State policies in support of alternative energy sources can be traced back to the 'oil crisis' in the 1970s and concerns over acid rain related to coal burning in the 1980s. These policies were later reinforced with growing environmental concerns, and dedicated to the promotion of renewable energy. In the 1990s, reducing CO2 emissions by promoting the development of renewable energy sources became the central stated goal. Policies introduced in this context were aimed at stabilizing carbon dioxide emissions at 1990 levels by the year 2000, a target the EU adopted when signing the Kyoto Protocol under the UN Framework Convention on Climate Change (UNFCCC) in 1997. The policy documents defined renewable energies as 'non-depletable forms of energy, including, in particular, hydropower, wind and solar energy (both thermal and photovoltaic), biomass and geothermal energy. Mutiprinicipal and other organic waste, although depletable, is normally also classi ed as renewable sources of energy.

The expected targets of EU anf member state could meet these demand as follow (Bente, 2016):

• Help increase self-sufficiency and reduce dependency on imported fossil fuels;

• Have a positive impact on regional development and employment;

• Help to improve the overall competitiveness of European companies;

• Contribute to achieving the overall strategy for sustainable development;

• Help reduce greenhouse gases emissions.

Referene:

1. Bente Hessellund Andersen. 2016. Bioenergy in EU

7. International biomass trade

In 2015, wood pellet consumption was around 20.3 million tonnes in EU-28, account for 6% of the total solid biomass used in Europe (AEBIOM,2016). While there was a fluctuation in the pellet consumption in other regions, this figure for EU has been gradually increasing. Nevertheless, the producing capacity of EU is only 14.1 million tonnes of pellet, covering around 70% of its demand. Therefore, EU and member states have to import these from overseas, mainly North America.

The wood pellet sector contributes significantly to the local and regional economies, especially job opportunities for local peole. That was why the wood pellet production is following an upward trend, increasing by 4.7% from 2014 to 2015. Germany is the biggest producer of wood pellets, producting 2 million tonnes, followed by Sweden, Latvia, Estonia and Austria.

The majority of the consumption was for heat production which represented 63,9%. Pellet consumption for heat can be further divided into three markets – residential heating (42,2%), commercial heating (15,7%) and heat generated from CHP (6%). The remaining 36,1% of wood pellets were used for power production. It should be noted that the technologies for producing energy out of pellets for heat, electricity or both, are mature, offering efficient and reliable processes.

Among the top 5 pellet consuming Member States, the proportion of wood pellet use varies. In Italy, Germany and France, the majority of wood pellet use goes to the residential heating market, representing 92%, 58% and 95% respectively. In Denmark, 56% of wood pellets are used in CHP plants for heating production and in Sweden, 60% of pellets go to heating installations for commercial purposes. Among all the heating market segments, commercial heating is often seen as the one offering the highest potential. Unfortunately, there is a clear lack of awareness about the potential to use pellets in sectors such as industry or services (hotels, swimming pools or public buildings).

Reference:

1. European Biomass Association. 2016. A focus on the pellet market

8. Bioenergy Regions in Germany & an example from Norway

The model project, Bioenergy Regions“ (Bioenergie-Regionen) was developed as a nationwide contest/competition for regions. The main objective of the contest is the development of functioning bio-energy-networks on a regional level in order to increase regional added value and contribute to employment creation through utilization of existing biomass potentials. The Agency for Renewable Resources (FNR) has been entrusted by the German Federal Ministry for Food, Agriculture and Consumer Protection (BMELV) with the co-ordination of the project.

The selection of the 25 winner regions was carried out in a two-tier process. The first tier asked all regions to hand in a first conceptual application according to a specified structure. From a total of 210 applications. Fachagentur Nachwachsende Rohstoffe as the coordination unit assessed the first drafts corresponding to an evaluation pattern and selected the regions for the second tier. The selection of the winner regions was based on the development and submission of comprehensive regional development plans (RDP). The implementation of the RDPs of the 25 selected winner regions is in the focus of the contest. Based on an expenditure and financing plan each of the winner regions can be supported with grants amounting up to 400,000 € for the implementation of their regional RDP over three years (Michael Krug, 2012).

The grants can be spent on travelling, staff and material expenses directly connected to the activities of the RDP.

Amongst others, the regions are encouraged to finance:

- the establishment of network and management units;

- measures for the build-up of network- and co-operation-structures;

- public relation activities;

- workshops, moderated meetings etc.

- co-operation with other projects, regions, networks etc.;

- know-how transfer and qualification of stakeholders;

- studies, concepts and evaluations.

Reference:

1. Michael Krug, Aino Matikainen. 2012. Country policy assessment report on bioenrgy - Germany

9. Models for Energy Systems

The objective of a carbon tax is to reduce the harmful and unfavorable levels of carbon dioxide emissions, thereby decelerating climate change and its negative effects on the environment and human health (wikipedia). Carbon taxes are in place in 14 countries in Europe. Nordic countries pioneered carbon taxes 25 years ago, while France and Portugal most recently did so.

Carbon taxes help reduce emissions in two different ways; 1) by increasing costs of energy they help to curb overall demand for energy, while 2) by increasing costs of carbon-intensive fuels (coal, oil)relatively more than of low-carbon fuels (gas; renewables) they help switch demand towards low-carbon fuels. When a carbon tax is levied strictly according to the properties of fuels, renewables will gain aproportional competitive advantage (Andersen, 2016).

BeWhere is a spatially explicit optimization model that is used to determine the location and size of biomass conversion plants, taking into consideration the demand as well as supply side. The output from the model includes the location of a set of plants, the flows of feedstock and biofuel between different regions, and the costs and CO2 emissions of the supply chain (Sylvain Leduc, 2012).

The research shown that CHP plants are preferred over biofuel production plants at high carbon costs (over 50 EUR/tCO2) and low biofuel support (below 10 EUR/GJ), whereas more biofuel production plants would be set up at high biofuel support (over 15 EUR/GJ), irrespective of the carbon cost. Regarding the CO2 emission substitution potential, the highest potential can be reached at a high carbon cost and low biofuel support. It is concluded that there is a potential conflict of interest between policies promoting increased use of biofuels, and policies aiming at decreased CO2 emissions.

Reference:

1. Wikipedia. 2018. Carbon tax. Accessed link [https://en.wikipedia.org/wiki/Carbon_tax]

2. Mikael Skou Andersen. 2016. An Introductory Note on Carbon Taxation in Europe A Vermont Briefing

3. Sylvain Leduca, Elisabeth Wetterlunda, Erik Dotzauerc, Georg Kindermanna. 2012. CHP or biofuel production in Europe?

10. Bioenergy EU policies

Currently, the policies in EU have focusing on:

• Mandates with sustainability requirements or regulations: these mandates facilitate the utilization of bioenergy in the form of electricity generation, transportation fuels, and heating by establishing compulsory use to some degree. For example, biofuel mandates set a minimum volume or share biofuels to be blended with traditional fossil-based fuels for transport in order to secure a market for these fuels.

For example: Obligation to distribute biofuels to the transport market in Finland. E8 and blend mandate in Colombia (gasoline blend of 8% ethanol and 92% fossil gasoline)

• National standards for certification. Standards that set sustainability requirements that address the environmental sustainability of bioenergy production, and especially its climate change mitigation potential.

"In order to reduce these risks and ensure that national standards for certification contribute to fostering the international competitiveness of the domestic bioenergy sector (rather than hindering it), it is key that these standards are recognized by the main importing markets, as foreseen, for instance, under the EU RED"

• Financial incentives: these are payments, investments of fiscal benefits that governments provide in order to stimulate sustainable bioenergy production. They can be provided to different market actors along the biofuel supply chain, from feedstock production to fuel consumption. Examples:

Tax relief for all fuels used for electricity generation (tax incentive). Feed-in tariff for wood fuel based small-scale CHP (operational subsidy).

• Capacity building: The lack of financial, institutional and technical capacity can be an impediment and a non-economic barrier for the development of bioenergy. Strategies and programs to generate and share information, technology and develop certification schemes especially in developing countries with high potential for bioenergy production but with low capacity building, are part of policy instruments to expand the certified global market of bioenergy. Capacity building programs involves information sharing and dissemination, education and research, and trainings within a country or within a cooperation framework among countries.

11. Futue trends

The future of bioenergy is uncertain. The many constraints it faces suggest it could see very little growth. The EU is currently considering how to meet its 2030 renewable energy target, and the European Commission is expected to propose new policies for renewable energy and sustainable biomass early in 2017.

The new EU policies for renewable energy should recognise that there is not enough wood available for a sharp increase in the use of biomass; and that using woody biomass does not necessarily reduce carbon emissions. The EU should therefore not allow subsidies for the use of forest biomass after 2020.

Due to the A1 scenario of the Intergovernmental Panel on Climate Change (IPCC), which assumes steady economic growth, total EU wood demand is expected to grow by 75% between 2010 and 2030 to almost 1400 million. However, it projected growth can largely be attributed to bioenergy demand, which is expected to grow by 117%. Hence, in 2030, 56% of total wood use would be for energy: more than twice the amount used today in absolute terms (Fern, 2015).

The EU has committed to contribute to halting global forest loss by 2030 and reducing tropical deforestation by 2020 by at least 50%. It has also stated it will step up the EU's contribution to averting global biodiversity loss.Demand for wood (energy and material use combined) is expected to exceed domestic supply before 2020, leading to an increase in imports. For bioenergy, the share of imported biomass is expected to have reached 15%–27% of the total supply by 2020. This means that EU bioenergy demands are putting more pressure on global land use and forests.

By promoting wood as a renewable energy source, the EU is setting a bad example. Land and forests are scarce resources and should be used to meet local demands first, e.g. for food and energy production. With a growing population and increasing demand for natural resources (e.g. food, feed and fibre), the potential for land and forests to provide biomass is severely limited. The World Resources Institute has indicated that if a 20% bioenergy target is pursued globally, by 2050 demand for bioenergy alone will be equal to the entire human plant harvest in the year 2000.

Reference:

1. FERN. 2015. Briefing note in bioenergy in EU