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Learning Diary: Bioenergy Market and Policies

1. Background of Basic concepts in Bioenergy

Bioenergy, in its various forms, can eventually contribute to balancing the electricity grid as an effective, low carbon and low cost grid management and energy storage option. Seasonality, i.e. energy demand fluctuations in the winter and summer seasons, is one of the key challenges for future smart energy system management, which will have various consequences for optimization in various parts of Europe and globally. This represents a clear synergy in seasonal balancing between photovoltaics and biomass.

One approach gaining traction in recent years is generating bioenergy along with carbon capture and storage, known by the acronym. Although regarded as one of the most viable, cost-effective negative emissions technologies, there are still multiple major challenges to its widespread implementation. At its most basic, involves growing plant material, burning that material for energy, capturing the CO_2 emitted during combustion, and storing it underground. More advanced versions include gasifying easy-to-grow feedstocks, such as switchgrass, generating biofuels with algae, or even using municipal solid waste as a feedstock.

Currently, transportation fuels based on biomass (i.e., biofuels) are identified as first and second generation biofuels. First generation biofuels are produced from sugar, starch, vegetable oil, or animal fats using conventional technologies. The basic feedstocks are often seeds and grains such as wheat, corn, and rapeseed. The most common types of first generation biofuels are bioethanol, biodiesel, and starch-derived biogas, but also straight vegetable oils, biomethanol, and bioethers may be included in this category. The main advantages of first generation biofuels are due to the high sugar or oil content of the raw materials and their easy conversion into biofuel, while the disadvantage is the competition with food and feed industries for the use of biomass and agricultural land. Since climate change mitigation and energy security are the two most important driving forces for biorefinery development are GHG and energy balances.

2. The role of policy on bioenergy markets

The high-level horizontal strategies have enshrined the green economy concept, the main ones being the Europe 2020s flagship initiatives 'An industrial policy for the globalisation era' and 'Resource efficient Europe'. ´the Commission will work to promote the competitiveness of Europe's primary, manufacturing and service industries and help them seize the opportunities of globalisation and of the green economy´. The objective of the Resource efficient Europe flagship initiative is ´to support the shift towards a resource efficient and low-carbon economy that is efficient in the way it uses all resources. The aim is to decouple our economic growth from resource and energy use, reduce CO_2 emissions, enhance competitiveness and promote greater energy security´. In this sense, policies related to resource efficiency need to be seen as efforts for shifting towards a resource-efficient and low-carbon economy within the global context of green economy transition EC.

In the European Commission's approach, bioeconomy covers 'the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy', including both traditional and emerging sectors, i.e. 'agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries'. The Renewable Energy Directive (RED) also includes a set of provisions to facilitate the development of renewable energy, such as a legal requirement for the MS to prepare National Renewable Energy Action Plans (NREAPs) with detailed roadmaps to reach the RES targets and measures taken to reach these targets and develop energy infrastructure. Bioenergy is expected to provide almost 60% of the renewable energy in 2020. Bioenergy is expected to have an important role within the long-term goal to become a competitive low carbon economy according.

Biomass is expected to contribute to about half of the EU Renewable Energy target in 2020. Bioenergy at EU level is expected to remain the main RES contributor. Within this framework, it is necessary to ensure that these expected increases in biomass use take place within a sustainable framework and biomass sustainability is thus a key issue. A significant increase in the demand for biomass for bio-based materials, together with the predictable increase in biomass demand for bioenergy will increase the competition for natural resources.

3. Economic Instruments in energy policy

The term "economic instruments" mainly refers to taxes, tax allowances and relief, grants and charges. Electricity certificates and the EU emissions trading scheme, which are market-based systems, are described insofar as they interact with other economic instruments. International experiences in order to implement related environmental policy, especially economic policy such as environmentally-related taxation is important as instrument. Although carbon tax is only an economic policy at national level, the international coordination system in carbon tax cannot be missing. And governments have conducted a series of international cooperation in programs of responding to climate change, and several cooperation frameworks have been signed such as the "United Nations Framework Convention on Climate Change", the "Kyoto Protocol" and the "Bali Roadmap".

International climate cooperation, and insists in bearing common but differentiated responsibilities. We should stress issues of international coordination and cooperation in tax, as well as handling well the relation between tax and three flexible systems, especially relation between tax and clean development mechanism. As a highly dynamic environmental and economic policy, Green Credit has become a key market lever for promoting energy efficiency and emission reduction. It has received widespread attention and emphasis from the environmental protection and financial sectors and from the broader society, within internationally. The potential synergies created by various economic instruments in Sweden in relation to one or more environmental quality objectives are to be taken into account, as are any counter-effects. The analysis should therefore be linked to the three action strategies: (i) More efficient energy use and transport; (ii) Non-toxic and resource-efficient cyclical systems; and (iii) Management of land, water and the built environment.

The new market-based instruments systems, i.e. electricity certificates and the EU emissions trading scheme, mainly act in concert with other economic instruments to achieve the Reduced Climate Impact objective. These instruments are aimed at actors in the energy production sector and in energy-intensive industries. The market-based instruments affect the behavior of actors and the scope for introducing other instruments that should be used in combination with these systems.

4. Adoption dynamics in bioenergy markets

Over the past century, socio-technological innovations and the abundance and reasonably low cost of fossil energy sources have significantly changed the quality and way of life in many countries. At the same time, it has also led to a number of environmental problems, such as global warming, ozone layer depletion, air and water pollution, and the deposition of hazardous waste. A number of options, including sustainable use of renewable resources, replacement of non-renewable resources and dematerialization have been suggested as means of mitigating these problems. Sustainable use of forest resources can mitigate greenhouse gas as (GHG) mitigation. Forest resources can be used to replace fossil fuels directly, as well as indirectly by materials substitution, for example in building construction, packaging, etc. One option is to replace fossil fuels with forest resources for space heating of detached houses by using wood pellet heating systems (boilers, burners, or stoves).

Wood pellets are homogeneous densified wood fuels of a standardized size of typically 6–12 mm in diameter and 25–50 mm in length. They are produced from wood residues under high pressure, with or without the use of organic binders, and have a relatively high average energy content of about 18 MJ/kg. Pellets can be burned at low pollutant emission levels in fully automated small-scale heating systems that require only a modest level of maintenance. Apart from GHG mitigation, the use of pellets for heating purposes can improve fuel supply security by reducing dependence on oil imports, and stimulate local and regional job creation and economic development. Finally, the development of a strong domestic market also enhances the opportunities for technology export.

Swedish energy policy is aimed at phasing out oil and electric heating on the one hand, and at increasing energy efficiency and the use of renewable energy resources in the residential and commercial premises sectors on the other hand. In Sweden, around 50% of the 1.6 million detached houses have electric or oil-based heating systems, i.e. electric boilers, electric resistance heaters, or oil boilers. These systems could be replaced by pellet heating systems, but also by biomass-based district heating, heat pumps or logwood boiler systems, among others. System analysis of small-sized heating systems has revealed that pellet boilers, on a life cycle basis, emit significantly less GHGs than electricity or oil-based heating systems.

5. Biomass Markets: model behavior

The level and location of energy crop demand is available from the set of operating plants and supply from the set of farmer agents. However, supply and demand must be matched, to allow calculation of the transportation costs, to know how much supply a plant has been allocated, or to identify farms that have unused supply. To match supply and demand, farmer agents were selected at random; each choosing to supply the nearest plant with demand, to minimize transportation costs. This selection process continued until all demand was met or all supply was allocated. If the market is in over-supply, then farmers who have unallocated biomass hold this for potential allocation at a future time period. Alternatively when the market is in under-supply, power plants with unfulfilled demand operate at less than maximum capacity. This reduces their profitability, which is reviewed by the agent's learning mechanisms.

Their main resource is the land that they farm, which is spatially specific to account for soil and climate variability, resulting in variation in crop yields. In aggregate, the farmer agents control the supply side of the market. A single delivered market price exists for each energy crop, and is adjusted over time based on market conditions. After each time-step, agents learn from their own experiences and that of their neighbours, and this influences their future decision-making. Figure shows the main agents and their interactions.

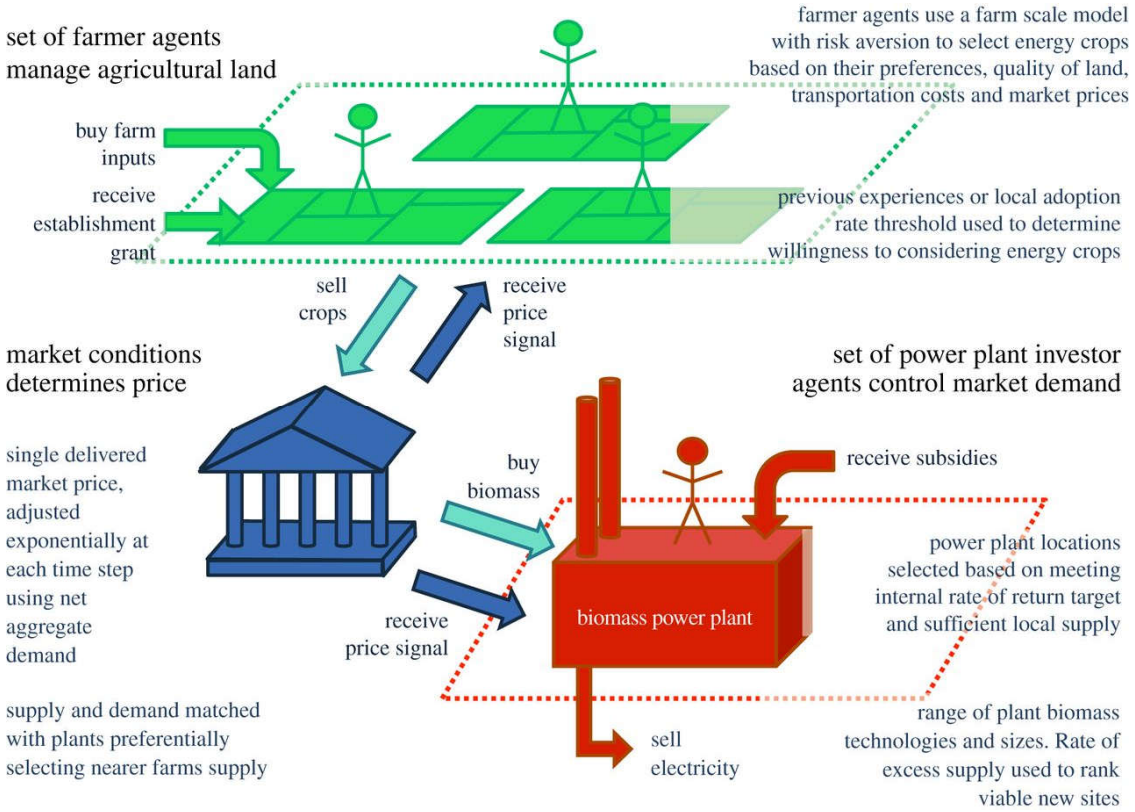

Figure 1: Schematic of the main agent processes and interactions within the perennial energy crop market model

6. Concepts and approaches to bioenergy governance

GHG mitigation potentials, cost characteristics and wider environmental and socioeconomic impacts of bioenergy pathways are influenced by a variety of allocation decisions taken along heterogeneous and transregional value chains. At the production, conversion and utilisation stages, actors' decisions are not only influenced by political and economic framework conditions, but also by technological constraints specific sectoral applications demand specific bioenergy technologies, which again determine what types of biomass can be used. As a result, the problem of optimizing bioenergy production and use is characterized by a high degree of complexity. For each step of the value chain, several distinct allocative problems can be identified.

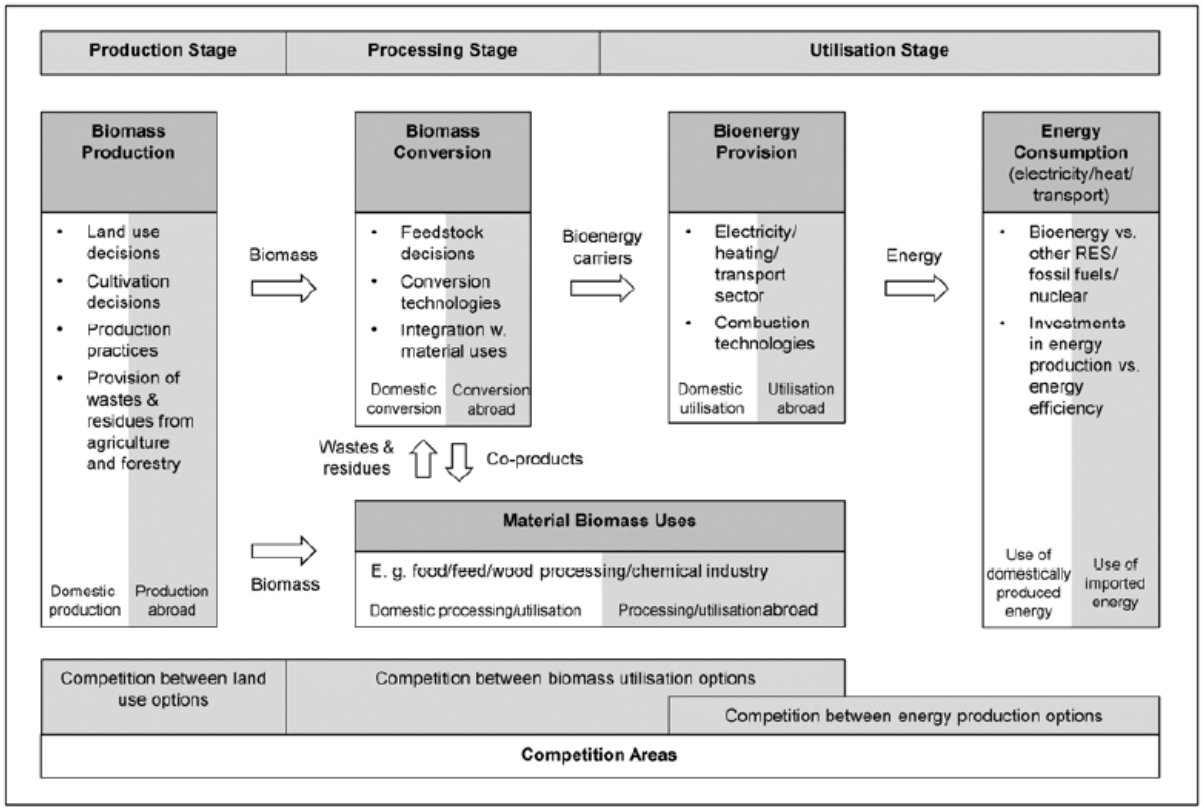

Figure 2: Allocation decisions and areas of competition along a bioenergy value chain

Processors decide whether to source raw materials regionally, domestically or import them. In all cases, different degrees of integration between value chain components are possible, with trade on commodity markets, supply contracts with producers, foreign direct investment and on-farm processing representing some of the options. In a market context, biomass is directed towards the applications with the highest value creation, while technology and sourcing decisions are determined by costs. But once again, price signals do not reflect the external costs and benefits of different utilisation options, and innovative technologies are undersupplied due to knowledge spillovers.

7. International bioenergy markets

In the past decade, international bioenergy trade of both solid and liquid biofuels has shown high growth rates the total trade volume of major bioenergy commodities such bioethanol (used for fuel), biodiesel and wood pellets have all increased by a factor of 10 or more between 2000 and 2010. Total international trade volumes of liquid biofuels exceeded 200 PJ in 2010; the trade of solid biomass trade exceeded 300 PJ. This increasing demand has triggered a debate on the sustainable production of biomass. However, international bioenergy trade if done right can have important benefits in terms of: Socio-economic development, and Sustainable management and the rational use of natural resources. Bioenergy markets are about to change. The current increasing demand for biomass is creating opportunities for exporting regions of traditional fuels, such as Brazil (ethanol), Argentina, Malaysia and Indonesia (biodiesel and vegetable oils) and Canada, the US and Russia (wood pellets). It is clear that major supply and demand regions are geographically separated, which means that global bioenergy trade will play a major role to match supply and demand.

In Finland the wood pellet production started in 1998, when the first pellet plant was built in Vörå, Ostrobothnia. The consumption of wood pellets has a stable growth Figure. At present, approximately 25 wood pellet mills are in operation in Finland. The main wood pellet production plants are located mainly in the southern half of the country, where the greatest concentration of forest industry facilities is located.

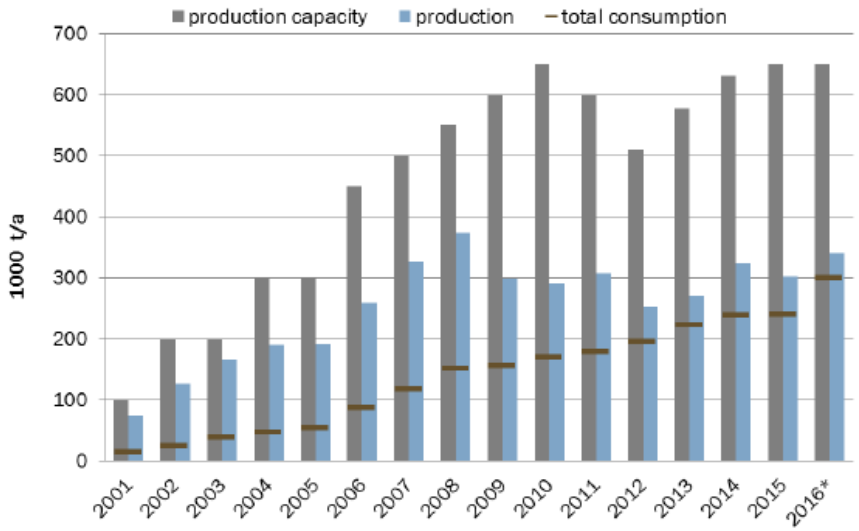

Figure 3: Wood pellet market development in Finland from 2001 to 2016

The Finnish Pellet Energy Association has set a target number of domestic pellet consumers of nearly 80,000 (75,000 single family houses and 4,000 industrial users) and a domestic pellet consumption target of approximately 1.5 Mt/a by 2020. The consumption target of Pellet Energy Association is much higher than the government's target indicates in NREAP (0.4 Mt/a).

8. Bioenergy Regions

The National Biomass Action Plan (nBAP) sets out the potential for the use of biomass in Germany, quantifies the biomass share in meeting current demand and identifies available reserves. It also describes the Federal Government's strategies towards promoting bioenergy use in the heating, electricity and fuel sectors, and the measures it intends to take in implementing them. The aim of the nBAP is to provide a holistic concept to significantly increase the bioenergy share in Germany's energy supply while adhering to sustainability criteria. Greater use of biomass must be achieved in an efficient and sustainable manner. The following criteria apply: Contribution to reducing GHG; Contribution to other environment policy goals, e.g. biodiversity conservation, soil fertility and preventing water and air pollution; Protection of valuabe landscapes like the Natura 2000 sites (in Europe), High Conservation Areas (international) and areas which enjoy protected status, particularly those that function as major carbon sinks; Contribution to securing energy supply.

To increase the efficiency of forestry associations, in 2007 in the frame of the Joint Task of Improvement of Agricultural Structures and Coastal Protection (GAK) a performance bonus (so-called mobilisation premium) was introduced for the independent industry-wide marketing of wood supply through a forestry association. Furthermore, training measures were implemented for further professionalization of the management in forestry associations. When mobilising reserves of wood, requirements of soil protection and nature conservation (sufficient amount of dead wood, protection of the habitats of endangered species, conservation of biodiversity) are to be given equal weight to economic demands and interests based on sustainability.

Germany has realised a national ban on landfilling of untreated and biodegradable waste by June 2007 and surpassed the targets of the EU Landfill Directive already. Around 50 mechanical biological treatment plants with 5.5 million tons of treatment capacity stabilize the organic part of the residual municipal solid waste (after separate collection of bio-waste) so it meets the German acceptance and storage criteria for landfills. Under its High-Tech Strategy, in 2008 the Federal Ministry for Education and Research (BMBF) launched the programme BioEnergie 2021. In the frame of the promotional scheme Basic Research 2020+ and the 6th Energy Framework Research Programme of the Federal Government in 2011 BMBF launched a new programme BioProFi – Bioenergy – Process-oriented Research and Innovation.

9. Policies and Modeling of Energy Systems for Reaching European Bioenergy Targets

Basically one expects carbon-energy taxes to provide incentives in two directions; a demand effect whereby the demand for energy is reduced as a result of the price increase caused by the tax; and a substitution effect whereby carbon fuels are substituted by low-carbon or carbon-neutral fuels that are taxed at lower rates. As reduced energy demand may reflect either a lowering of output or actual energy savings it is often more appropriate to monitor energy intensity. In other words we would expect to see changes in energy intensity as well as carbon intensity as a result of carbon pricing.

While some analysts have suggested that a global carbon price will need to be increased to a level of 30-40 euro/ton CO_2 by 2020 to stabilise atmospheric concentrations, the price at which CO_2 is traded under the cap in the European ETS is presently about 15 euro/ton. Unilaterally applied carbon-energy taxes in individual EU member states have been more modest and for industries range generally from a low, to some extent symbolic level (for the most energy-intensive industries) up to approximately 25 euro/ton in the case of Sweden and Finland. Denmark is exceptional with a tax on energy consumed for heating purposes (including for industries) at an effective rate of about 80 euro/ton CO_2.

In evaluating the impact of carbon-energy taxes on CO_2 emissions a complicating factor is that in some cases they have replaced pre-existing energy taxes, and now come under a different name and with a modified tax base according to carbon content rather than energy content. Sweden, for instance, has had taxes on industrial energy consumption in place already since 1974, which then were modified in 1990 towards a CO_2 tax base. Whereas in Germany and UK carbon-energy taxes were introduced only from the end of the 1990s, the four Nordic countries and the Netherlands, with time series of more than a decade, generally provide the firmest basis for ex-post assessment. Slovenia has a longer timeline too, but as a country in transition, one associated with data and conversion difficulties. According to the estimations six countries show a reduction in fuel demand that results from the environmental tax reform (ETR).

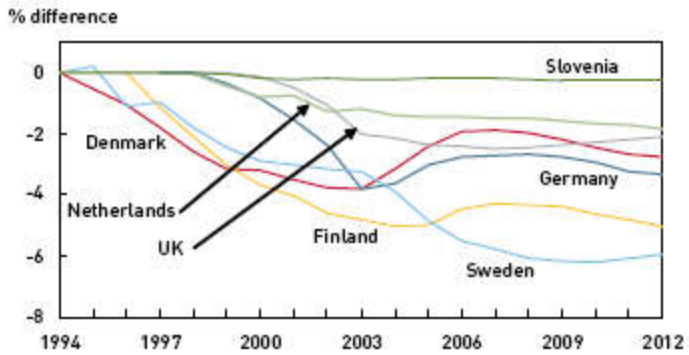

Figure 4: The effect of ETR on total fuel demand
Note: % difference between the base case and the counterfactual reference case

10. Bioenergy Policies for EU & Nordic regions

Finland's long-term objective is to become a carbon-neutral society. Within the next 10 years, Finland wants be a pioneer in bioeconomy, circular economy and cleantech. In the energy system wood fuels are already the largest energy source, and it is planned that their use will increase by 35 % by 2030. Many new biofuel and energy plants are planned. The use of biomass for energy is increasing, but the development has not been steady nor even for different bioenergy sectors. Electricity and fossil fuel prices are currently low, which has become a barrier for wider use of energy-efficient combined heat and power production with biomass in some of the Nordic countries. Sustainability of biomass is also a hot topic with direct impacts on the market. According to the recent Communication on low emission mobility by the EU Commission, advanced 2nd and 3rd generation biofuels will play a key role in a transition from fossil fuels towards low emission transport. In this session, industry specialists will provide updates on latest developments in the biofuels market.

The 2030 climate and energy framework sets three key targets for the year 2030:

- At least 40% cuts in **greenhouse gas emissions** (from 1990 levels)
- At least 27% share for **renewable energy**
- At least 27% improvement in **energy efficiency**

The framework was adopted by EU leaders in October 2014. It builds on the 2020 climate and energy package. It is also in line with the longer term perspective set out in the Roadmap for moving to a competitive low carbon economy in 2050, the Energy Roadmap 2050 and the Transport White Paper.

Greenhouse emissions – a cut of at least 40%

The framework contains a **binding target** to cut emissions in EU territory by **at least 40%** below 1990 levels by 2030.

This will enable the EU to:

- take cost-effective steps towards its long-term objective of cutting emissions by 80-95% by 2050 in the context of necessary reductions by developed countries as a group,
- make a fair and ambitious contribution to the Paris Agreement.

To achieve the at least 40% target:

- EU emissions trading system (ETS) sectors would have to cut emissions by **43%**(compared to 2005) – to this end, the ETS is to be reformed and strengthened
- non-ETS sectors would need to cut emissions by **30%** (compared to 2005) – this needs to be translated into individual binding targets for Member States.

11. Recent and future trends in (bio)energy

Biomass currently provides around 1100 Mtoe (50 EJ) of primary energy per year

- 190 Mtoe (8 EJ)/yr of commercial heat and power and 40 Mtoe (1.7 EJ)/yr of liquid transport fuels
- Traditional biomass accounts for over 800 Mtoe (35 EJ) /yr

In BLUE Map scenario biomass use increases to around 3400 Mtoe (145EJ)/yr in 2050.

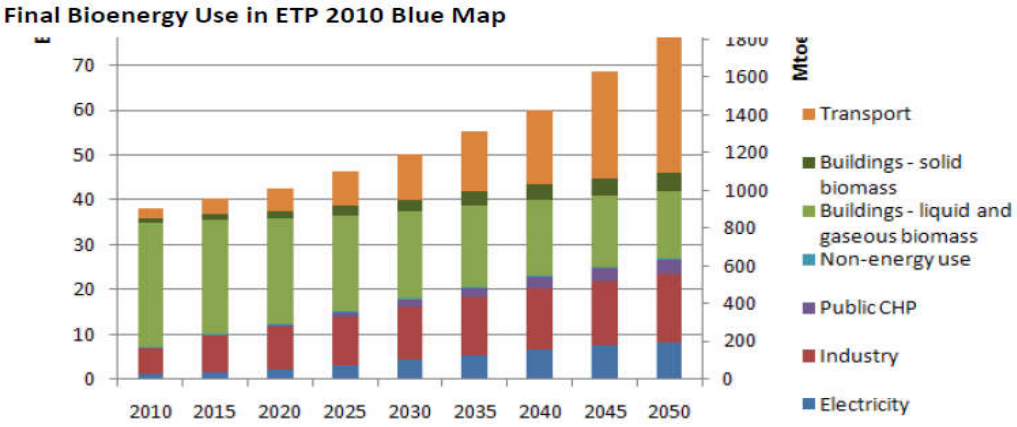

Figure 5: Bioenergy Use in ETP 2010 Blue Map

IEA Roadmaps - Bioenergy

Roadmaps are intended to: Highlight pathway(s) to reach large scale use of low-carbon technologies, consistent with Energy Technology Perspectives 2010

Focus on the key steps over the next 5-10 years, as well as long-term milestones, including:

- Identify barriers and obstacles and how to overcome these
- Identify key conversion pathways
- Key RD&D gaps and how to fill them while ensuring sustainability
- Identify market requirements and policy needs
- Define international collaboration needs

Baseline Scenario – business as usual; no adoption of new energy and climate policies
BLUE Map Scenario – energy related CO_2 emissions halved by 2050 through CO_2 price and strong support policies

- ✓ Serves as basis for all IEA Technology Roadmaps
- ✓ 23% of global emission savings occur in the transport sector

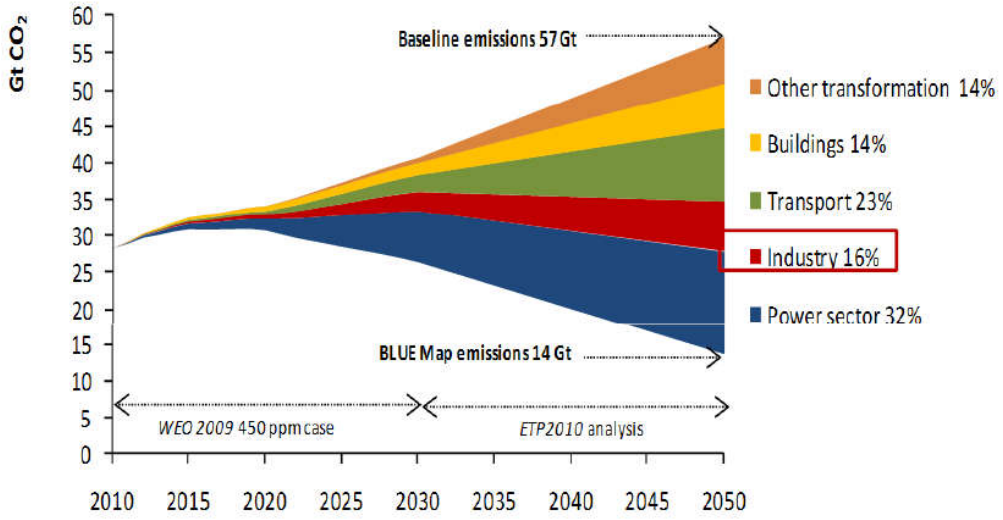

Figure 6: The IEA Blue Map Scenario – Towards a Low Carbon Future

IEA Biofuel Roadmap: Vision

Global biofuel supply grows from 2.5 EJ in 2010 to 32 EJ in 2050

- ✓ Biofuels share in total transport fuel increases from 2% today, to 27% in 2050
- ✓ Diesel/kerosene-type biofuels become particularly important to decarbonise heavy transport modes
- ✓ Biofuels could reduce global transport emissions by 2.1 Gt CO_2-eq. in 2050
- ✓ Large-scale deployment of advanced biofuels will be vital to meet the roadmap targets

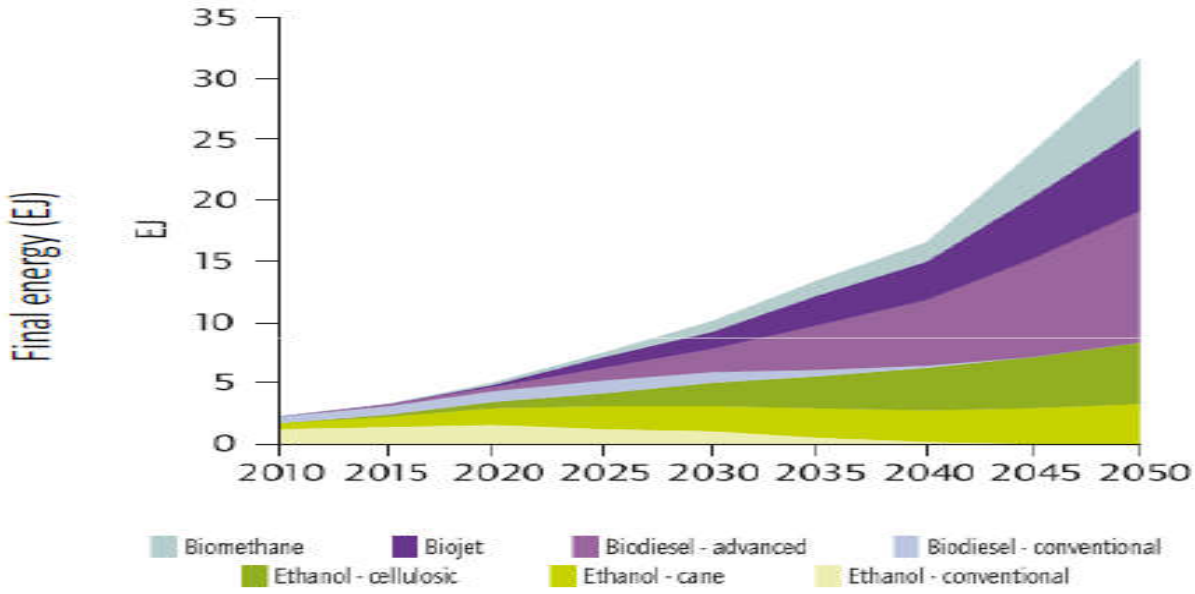

Figure 7: Global biofuel supply

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