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Educational requirements to support research and innovation in Bioenergy

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Abstract. Conversion of biomasses to energy, food, feed and chemical building blocks for further usage become increasingly important. Educations and research within biorefinery and especially bioenergy have become popular and are offered at most universities in Europe. Bioenergy is a very wide scientific area however, and we must educate students that possess the qualifications to bring the industry and research forward. We must not just educate students that know some general elements but students that really can go into the depth. Universities should specialise and seek partners to complement educations and research areas.

Key words: bioenergy, biorefinery, education.

Introduction

The World is facing major challenges looking at a population of 9 billion people within year 2050 and a doubling of the energy consumption. The fossil resources are becoming limited and we need to re-think the way of using energy. Most of all, we have to find sustainable alternatives that can ensure an ongoing industrial development, improved living standards and sufficient supply throughout the day. Much research is dedicated to wind energy developing on-shore and off-shore wind turbines. Today Denmark is receiving 20% of the electricity from wind and the goal is to have a 50% supply by year 2020. At the same time a development and installation of solar panels is taking place. Solar and wind energy are excellent examples of technologies that complement each other. When there is no wind the sun is shining and vice versa. However, when the wind is blowing strongly for a full week we will have a surplus of electricity that needs to be stored. Batteries will not possess such a capacity and there is a need for alternative systems to dampen the fluctuations.

Biomasses are already a major supplier of energy but will become increasingly important as wind and solar systems develop. Biomasses are today supplying 11% of the Worlds total energy of which most goes to heating of houses. Today the energy production from biomasses is larger than from wind and solar systems. However, we will need a major source to take up the fluctuations of energy output from wind and solar systems and that can act as major supplier of fuel for transportation. The main use of biomasses today are for feed and food and we need to be aware of this competition with production of energy since we have a limited arable area. There are potentials to double the biomass production in most parts of the World and smart use of the biomass will make it possible to provide the needed energy, food, feed, and chemical building blocks for alternative usage.

Increased production and intelligent use of the biomasses requires research, innovation and education of students. The potential products that can be developed and build from biomasses are enormous (Fig. 1). Consequently, the major challenge for universities is not general information about energy systems and their interaction but education of students that can solve specific challenges for the energy industry and the society as such.

Energy educations in Europe

The European Platform of Universities Engaged in Energy Research, Education and Training (EPUE) has carried out a survey on the universities research and education capacities within energy (Smith et al., 2012). There are more than 900 energy educations at the master level. Most universities got Bioenergy and the fewest Carbon Capture and Storage on their program. Smith et al. (2012) classified educations in the following groups according to popularity: BioEnergy, Concentrated Solar Power, Nuclear Energy, Wind and Ocean Energy, Photovoltaics, Energy Storage, Fuel Cells and Hydrogen, Energy Efficient Buildings, Energy Grids, Geothermal Energy, Carbon Capture and Storage.

With all the debate going on currently, it is obvious for students to start at an education in Sustainable Energy. But what will their competences be afterwards? Will they know about integration in the society, aspects of acceptability, life cycle assessment, production of biomasses, logistics, biogas fermentation, conversion of C5 sugars, catalytic reactors, storage systems, hydrothermal liquefaction, incineration or handling of waste materials? The good headings do attract students but it is difficult for the industry to figure out what the competences of the students from the individual educations are.

Fig. 1 illustrates the different pathways in biorefinery. Biorefinery includes chemical, thermo chemical, mechanical and physical processes. The input materials range from specialise plants to waste materials. The output covers different energy sources as heat, electricity, biogas, syngas, ethanol, methanol, biodiesel, and DME and other resources as food, animal feed, fertilizers, and chemical building blocks for further refinery. It is obvious that a candidate in Sustainable Energy cannot be a specialist on all the different technologies and pathways in such a system. As an example, the Danish company Inbicon converts straw to bioethanol (de Jong et al., 2010). The main pathway is pre-treatment of the wheat straw, hydrolysis, fermentation of C6 sugars, separation and distillation. Parallel to this there is a production of animal feed from C5 sugars and combustion of lignin for production of electricity and heat. This is just a small area of Fig. 1, but still it will require skills from microbiologists, biotechnologists, mechanical engineers and chemists with several different specialisations to build and make this factory run.

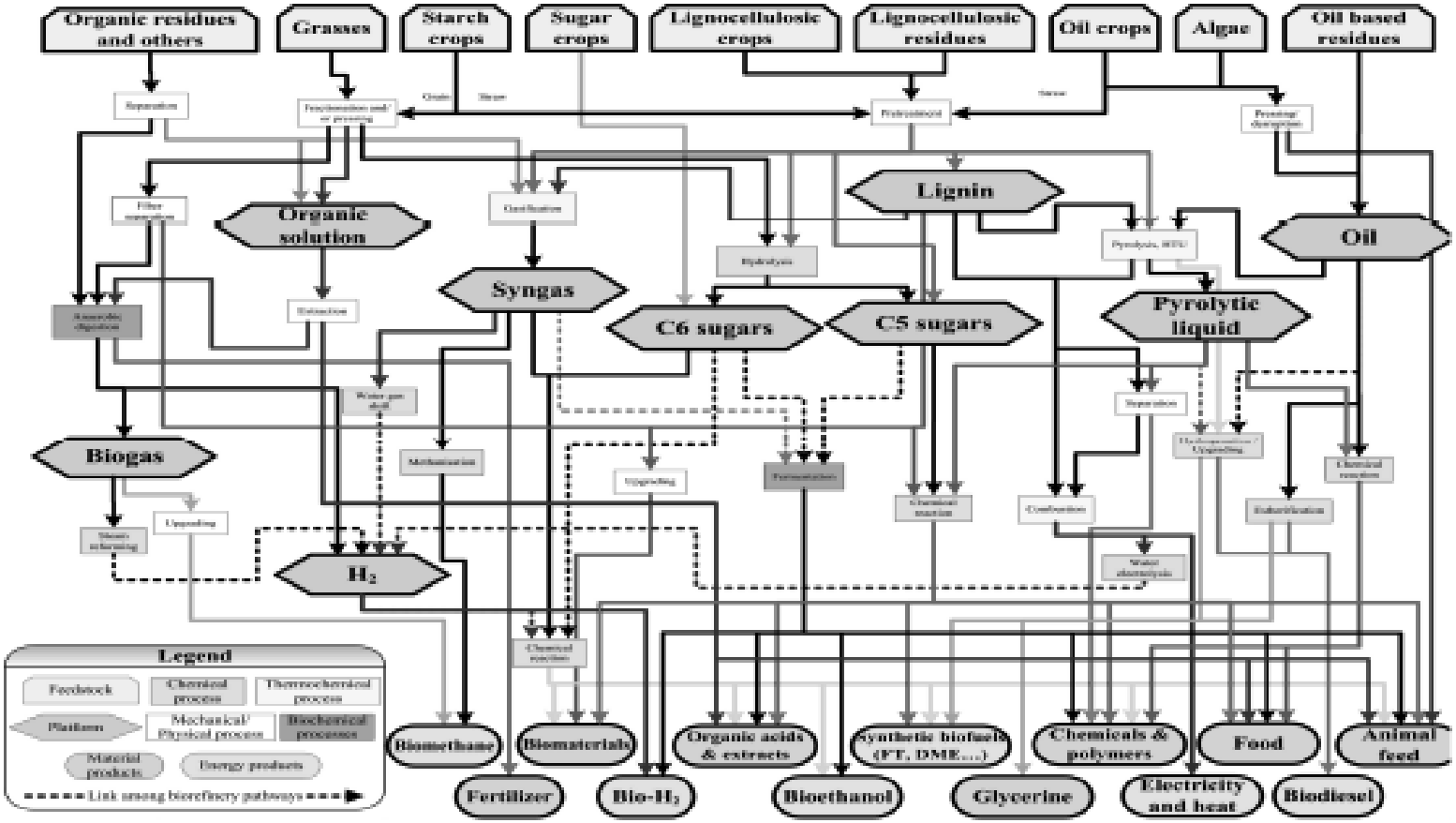

Fig. 1. Biorefinery classification system (Cherubini et al., 2009).

Scientific and academic skills

Students should have the wide perspectives of what they are doing and where they support the development, but they must also be able to go in depth with specific skills. It is my believe that we should attract students to the universities by telling about the application areas, inform them about the demands, and provide them with the competences needed for giving them a direct link to a job in the industry. One of the most important skills that students should acquire at the university is the ability to obtain new knowledge. Students must learn the basics behind their subject and possess the ability to go fully in depth. These are skills that should be trained right from their start at the university. Teachers should select their examples and exercises carefully to train the basic skills along with provision of application areas that encourage the overall perspectives of their education.

Secondly, students must possess the ability to put their knowledge into a perspective and analyse the situation. It is expected that university candidates are able to analyse and reflect on challenges and concurrently initiate and organise the work and groups that may solve the problem. Such academic skills must be build into their educations through the organisation of the lectures and exercises. Students at the bachelor level should be able to solve given problems whereas students at the master level must be able to analyse the situation and define the tasks. Written documentation of their work as well as precise oral presentations are additional academic skills that companies will expect of university candidates.

Research and talent development

Smith et al. (2012) discovered 1551 specific research topics within the energy field in their survey of the European universities. This shows how wide a span that energy research covers and it is obvious that one research group, department or even university will not be able to cover all fields. If we try to cover the full range just within bioenergy we will become generalists and not be able to dive fully into depth within specific areas. Universities must apply research programs within dedicated areas of energy research and then seek partners that can complement their skills (Fig. 2). This is especially true when applying for EU funding, but it also applies to national cooperation and matching with companies. We take a risk by specialisation within rather specific areas but without we are not able to solve the problems. This also set demands on our ability to cooperate and share our knowledge.

Our highest level of talent, the PhD-students, must learn to work in teams, share knowledge and be aware of additional required skills that can solve the coming challenges within biorefinery. Only the best research groups will be able to attract funding, but as projects become larger and more complicated, cooperation between strong groups are needed to meet the requirements. We cannot cover all areas and therefore we need to specialise and become the World best within a dedicated area.

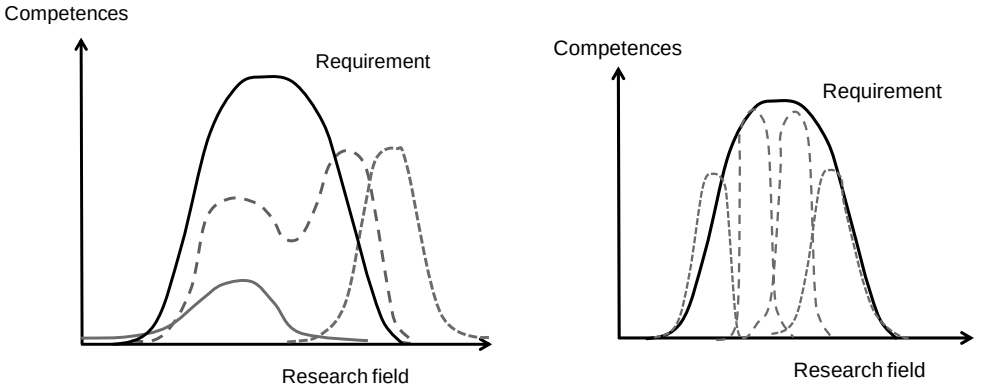

Fig. 2. Competences from different universities, institutions and companies must complement each other in order to meet the requirements.

Reflections

Bioenergy is a very wide scientific area and we must educate students that possess the qualifications to bring the industry and research forward. We must not just educate students that know some general elements but students that really can go into the depth. Chemistry, material science, biotechnology and microbiology will become the most important science and engineering disciplines. Universities should seek partners that will complement their educations and research areas because without specialisation we will not be able to solve the challenges in interchanging fossil fuel with bioenergy in a sustainable, economic and environmental way that meets the demands of the society of tomorrow.

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