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Scenarios for biofuel demands, biomass production and land use – The case of Denmark

Lars Ege Larsen [a,*], Martin Rudbeck Jepsen [b], Pia Frederiksen [c]

[a] Department of Development and Planning, Aalborg University, A.C. Meyers Vænge 15, 2450 København SV, Denmark

[b] Department of Geography and Geology, Copenhagen University, Denmark

[c] Department of Environmental Science, Aarhus University, Denmark

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ABSTRACT

The land potential for producing biomass for bioenergy purposes has been highly debated in recent years. The present paper analyses the possibilities and consequences for land use and agricultural production of biofuel production in Denmark based on domestic wheat and rape under specific scenario conditions for the period 2010–2030. The potential is assessed for a situation where policy targets for renewable energy carriers in the transport sector is reached using biofuels, and where second generation ethanol increasingly substitutes first generation ethanol.

Three scenarios are developed and evaluated: a baseline, an alternative scenario allowing continuous growth in the now dominant livestock branch and a biofuel scenario assuming that efforts to achieve self-sufficiency in biofuel displaces part of the domestic production of fodder.

Results show that the biofuel demand could be met in 2020; but only if current rape oil production is used to satisfy local bio-diesel demand. It would also imply that the Danish bio-diesel export currently supplying a minor part of the German fuel market would seize. In 2030, however, only about 60 percent of the biofuel demand would be covered by self-sufficiency. If biofuels were to displace animal production to make up for this, a reduction of the pig production between 10 and 20 percent would result. Efficiency increases across production branches would allow the animal production to continue un-affected if about half of the rape oil produced for other purposes is utilized.

1. Introduction

Combustion of fossil fuels has been a recurring topic for discussion for at least 40 years [1]. A major concern is the reliance of modern society on an exhaustible feedstock which is regionally concentrated in a few nation states across the globe.

Another concern is the environmental problems associated with emissions of particles and gasses from the combustion, notably the contribution to increasing atmospheric carbon dioxide levels, leading to global warming and global environmental change.

While these concerns have evoked public interest and scientific research into the potentials for renewable energy sources in general, recent surges in prices of liquid fuels have led to specific attention to growing biomass for biofuel production, hereafter referred to as biofuel crops.

Increased utilization of residues, another way of providing biomass for energy purposes, has also gained attention as

* *Corresponding author*. Tel.: +45 2063 3969.
E-mail address: ege@plan.aau.dk (L.E. Larsen).

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a feedstock for biofuel production. Among others European Union (EU) policy makers have adopted the focus on biofuel production and reacted by establishing binding targets for the replacement of fossil fuels by biomass and other renewable energy sources. In the EU this was specified in the 'biofuels directive' (2003/30/EC) [2], which has since then been replaced by the 'renewable energy directive' (2009/28/EC) [3]. The latter specifies that by 2020 energy from renewable sources has to make up a 20% share of the overall energy consumption in the EU. Within the same time frame each member state has to reach a 10% share of renewable energy in the energy consumed by the transport sector.

Since biofuels are more readily implemented in the existing transport structures than the other contenders, electricity and gaseous fuels, such mandatory requirements to member states will inevitably cause an increased demand for biomass for conversion to biofuels. Depending on the readiness of unexploited residues and matching conversion techniques there will be an increase in the demand for land on which the biofuel crops can be produced. Member states, or the EU as a whole, can respond to this increased demand by supporting domestic allocation of land areas for biofuel crop production or by easing the access to biofuels or biomass from across the globe. In both cases this new demand for land will very likely compete with alternative land uses (production of food and fibre, urbanisation, afforestation etc) making overall land availability a limiting factor for biofuel production [4]. This line of thinking holds important perspectives for as well the effect on global equality and the effect on the environment since land use changes to support biofuel demand will lessen the land resources available for life and ecosystem supporting services. Further, a global increase in cropping for biofuel feedstock may also affect the accessibility of water resources in some regions [5]. An often mentioned example of the possible counterproductive nature of biofuel use is the rise in demand for land leading to deforestation of rainforest areas releasing sequestered carbon dioxide to the atmosphere and thereby adding to the challenge of combating climate change. Hence the EU member countries share a challenge of finding a path to a sustainable use of biofuels.

At EU level a set of sustainability criteria have been adopted along with the renewable energy directive [6]. It is, however, up to the EU member countries to take steps to regulate the distribution and use of biofuels. A combination of regulation of biofuel products and certification of biofuel production is the most likely solution as it keeps the door open to the global market. Regulation and certification schemes are already in place in some member states [7]. Another or perhaps complementary solution could be to restrain from using 'hard to manage' global resources and instead focus on inland resources. While this is not in line with free trade perspectives, does not rule out indirect land use changes and is perhaps a socio-economically ill-fitted solution, it is an interesting perspective to investigate in a scientific inquiry since it expresses the balance between food, energy and life- and ecosystem supporting services at a more easily conceived scale. However, EU member countries are far from uniform in terms of their natural resources. The challenge from the demand on energy in the transport sector also varies from country to country.

Denmark has a noteworthy access to agricultural land suitable for cropping. The amount of arable land per capita is twice as large as the EU average and the world average respectively but only slightly larger than the overall European average when considering the large Russian and eastern European territories. The population density is, however, about the same as the EU average. The arable land makes up more than half of Denmark and 90% of the agricultural area. As a result of this, most of the potentially productive land in Denmark is accounted for in agricultural statistics [8].

Denmark makes an interesting case for assessing the feasibility of large scale introduction of cropping for biofuel feedstock because the potential is high and the productivity of the land is relatively well-documented. Denmark also stands out on the demand side with a final energy consumption per capita for road transport that is 30% above EU average (33.1 GJ–25.5 GJ in 2008) [9] due to a high degree of work force mobility [10,11] relying heavily on road transport and a high degree of recreational use of cars [12]. Meanwhile, Denmark is also one of the countries in Europe with the smallest shares of renewable energy in the transport sector. Hence, the Danish case represents an extreme in the recurring question of the significance of the scale of consumption in the debates on environmental and resource crisis (e.g. the European Commission's flagship initiative on resource efficiency, [13]).

In this paper we will investigate the case of Denmark and the Danish opportunities for meeting the EU biofuel demands based on domestic biofuel crop production and use of agricultural residues from cropping.

The analysis presented in this paper has been carried out as a part of REBECa (Renewable Energy in the transport sector using Biofuels as Energy Carriers), a large interdisciplinary project examining introduction of large scale domestic biofuel production of bio-ethanol and bio-diesel in Denmark.[1]

2. European and Danish scenario studies of biofuel production potentials

An abundance of studies have tried to estimate potential bioenergy production at various scales ranging from a regional to a global level. A few studies made on a European level have references to Danish biofuel production.

In an evaluation study, Baka and Roland-Holst [14] present two scenarios for biofuel production in EU-27, both keeping existing agricultural production levels and land use constant: An extreme scenario utilizing all suitable crops for biofuel production, including cereals and pulses presently used for food or fodder, and a more realistic scenario basing biofuel production on current (2004) surplus crop production. The first scenario estimates that approximately 26% of the fossil fuel used in the transport sector could be replaced by biofuels produced in Europe, while displacement of fossil fuels under the second scenario is around 5%. The corresponding figures for Denmark are reported by Baka and Roland-Holst [14] at approximately 46% and 6%. The extreme scenario in this study uses 59.1% (1,571,002 ha) of the Danish agricultural area for biofuel feedstock (using 2003 figures).

[1] REBECa: http://rebeca.dmu.dk.