ARTICLE IN PRESS

Biomass and Bioenergy xxx (2016) 1–9

Contents lists available at ScienceDirect

Biomass and Bioenergy

journal homepage: http://www.elsevier.com/locate/biombioe

Research paper

Waste and residue availability for advanced biofuel production in EU Member States

Stephanie Y. Searle [a,*], Christopher J. Malins [b]

[a] The International Council on Clean Transportation, 1225 I St NW Ste 900, Washington DC, 20005, USA
[b] The International Council on Clean Transportation, 11 Belgrave Road, London, SW1V 1RB, United Kingdom

ARTICLE INFO

Article history:
Received 20 August 2015
Received in revised form
8 January 2016
Accepted 18 January 2016
Available online xxx

Keywords:
Biomass
Advanced biofuel
Policy
Sustainability
Waste
Residue

ABSTRACT

The EU is adopting policy measures to promote the use of advanced biofuels for transport made from sustainable sources including wastes and residues. As Member States prepare to implement these policy changes, they will need to understand if they have sufficient resource to meet an advanced biofuel target. This study assesses the availability of agricultural residues, forestry residues, and biogenic wastes that could potentially be used for advanced biofuel production in EU Member States at the present and projected to 2020 and 2030. This analysis incorporates specific information on agricultural, forestry, and waste production, management practices, and environmental risks in each Member State in order to model the amounts of residues needed to preserve soil quality and that are utilized in other industries; we exclude these quantities in order to determine the sustainable biomass potential that can be achieved without significant adverse impacts on the environment or biomass markets. We find that most EU Member States are likely to have more than enough sustainably available feedstock to meet the advanced biofuel requirement, and a majority may have more than 10 times the necessary amount. While this study does not assess economic viability of advanced biofuel production, from a resource perspective, the target appears to be achievable in most Member States. Some countries, including Austria, Cyprus, Denmark, Estonia, Ireland, Luxembourg, Malta, and Slovenia, may need to import either feedstock or advanced biofuel from neighboring countries to meet the target.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

1.1. Policy relevance

Cellulosic biofuel provides environmental benefits, reduces petroleum consumption, and provides economic opportunities for rural communities. Importantly, advanced biofuels from cellulosic wastes and residues deliver much higher greenhouse gas reductions compared to first generation biofuels from rapeseed or wheat, which are associated with indirect land use change emissions [1–3].

This year a directive proposed by the European Commission to address indirect land use change (ILUC) of biofuels in the Renewable Energy Directive (RED; Directive 2009/28/EC)) [4] and the Fuel Quality Directive (FQD; Directive 2009/30/EC) [5] was finalized; this directive (the 'ILUC Directive'; PE-CONS 28/15) includes a cap of 7% on the contribution of crop-based biofuels (including energy crops) to the RED's 10% target of renewable energy in road transport and a 0.5% subtarget for advanced biofuels, including those made from cellulosic wastes and residues [6]. Italy has already adopted a ministerial decree requiring 0.6% blending of advanced biofuels from 2018 [7], and the UK appointed a 'Transport Energy Taskforce' that modeled achievement of a 0.5% target as an element of compliance with the UK's RED obligations [8].

All Member States must either implement the 0.5% advanced biofuel blending subtarget for transport by July, 2017, or else explain to the Commission why the subtarget is not achievable in that country. Each Member State will thus need to understand whether it has access to sufficient resources to produce this quantity of biofuel for transport.

1.2. Objective of this study

The purpose of this study is to assess the sustainable availability of cellulosic wastes and residues in each EU Member State at

* Corresponding author.
E-mail addresses: stephanie@theicct.org (S.Y. Searle), chris@theicct.org (C.J. Malins).

http://dx.doi.org/10.1016/j.biombioe.2016.01.008
0961-9534/© 2016 Elsevier Ltd. All rights reserved.

Please cite this article in press as: S.Y. Searle, C.J. Malins, Waste and residue availability for advanced biofuel production in EU Member States, Biomass and Bioenergy (2016), http://dx.doi.org/10.1016/j.biombioe.2016.01.008

present as well as projected to 2020 and 2030. Three types of feedstock are included in this analysis: agricultural residues, forestry residues, and wastes. Only the quantities of feedstock that can be harvested without undue adverse impacts on the environment or on existing uses are treated as available for biofuel production. The amount of biofuel for transport that could be produced from these resources is estimated and compared with the 0.5% blending subtarget in each Member State. This study also assesses the economic opportunity for jobs from constructing and operating the biorefineries that could be sustained on this resource base as well as the agricultural jobs involved in harvesting the feedstock.

2. Methods

The sustainable availability of agricultural and forestry residues and biogenic wastes is calculated by estimating total production of each resource in each EU Member State and subtracting estimated amounts that are already used (including for heat and power generation) and that should be left at the production site to preserve soil quality (for agricultural and forestry residues).

2.1. Estimating agricultural residue availability

Residue availability is estimated for the 12 crops with the highest production in the EU: barley, maize, oats, olives, rapeseed, rice, rye, soybeans, sunflower, triticale, wheat, and sugar beet. Total above-ground residue production is calculated by multiplying production of the main commodity crop by a residue ratio, which represents the amount of crop residue per unit commodity crop (e.g. straw:wheat). Both field residues (such as wheat straw) and process residues (such as olive pits) are included. Crop production and yield data is obtained from FAOSTAT [9] and averaged over the period 2009–2013. Residue ratios are taken from Refs. [10–12], except for sugar beet, which was estimated from data in Refs. [13,14]. The residue ratios for crops included in Ref. [10] were calculated separately for each country based on that country's crop yields; these ratios include both field and processing residues. Residue production is adjusted for moisture content and all estimates here are presented in oven dry tonnes. Projections to 2020 and 2030 are based on projections of production of major categories of commodity crops in Ref. [15]. For crops included in Refs. [10], we have estimated changes in the residue ratio based on the expected crop yield changes, consistent with historical changes in residue ratios as a result of selective breeding [16].

Some amount of agricultural and forestry residues should be left in place to prevent unacceptable levels of erosion and soil carbon and nutrient loss [17–20]. A linear model was constructed to estimate the necessary amount of residues left in the field in tonnes per hectare in each EU Member State based on that country's erosion rates and tillage practices (data from EUROSTAT [21]) and soil carbon concentration [22]. In this model, a default residue retention rate was set at 3.6 t ha^{-1} based on [3]. Each country's retention rate is modeled based on how the above parameters compare to the US average. More detail on this model is given in the Supporting Online Material (SOM). The average retention rate for all EU countries, weighted by total residue production, is 3.7 t ha^{-1}. The quantity of field residue production per hectare in excess of each country's modeled residue retention rate is determined to be available. There are limitations on the amount of agricultural residue that can feasibly be collected with modern machinery; we therefore apply a cap on collection of 65% of total residues produced, even if theoretically more material could be used without negative impacts on soil. The residues that cannot be feasibly harvested contribute towards meeting the minimum retention requirement for soil protection.

Agricultural residues already used in other industries are treated as unavailable for biofuel. The other uses identified and accounted for are: livestock bedding; mushroom cultivation; horticulture; and the generation of heat, power, and biogas. Residue consumption for livestock is estimated based on the per animal rates from Ref. [10] multiplied by the number of cattle, pigs, sheep, and equines (horses, mules, etc.) in each country from EUROSTAT. The total amount of crop residues consumed by livestock in the UK is taken from Ref. [23]. Usage of residues for mushroom cultivation is estimated based on each country's mushroom production rate [24] multiplied by a typical ratio for straw of 1.8 tonnes per tonne mushroom produced [25,26]. The amount of residues used in horticulture is assumed to be equivalent to that used for mushrooms. EUROSTAT reports a category “other vegetal materials and residues” as a feedstock in total primary production of energy. We assume that half of this category represents agricultural residues used for heat, electricity, and biogas [21]. All uses of crop residues for Denmark are taken from that country's national statistics (detail in SOM). The major uses of agricultural residues are included here, but some residues have industrial or other uses for which data is not available. This analysis may thus underestimate other uses of agricultural residues.

Residue retention requirements for soil quality and residue use for livestock, mushrooms, and horticulture are assumed to remain constant to 2030. The rate of change in the usage of residues for heat, power, and biogas from the present to 2030 is extrapolated linearly from each Member State's planned usage of “agricultural residues and by-products” from its National Renewable Energy Action Plan (NREAP) [27].

2.2. Estimating forestry residue availability

Forestry residue availability is estimated using a method similar to that for agricultural residues. Forestry residue production is calculated by multiplying production of total underbark roundwood (timber that is left in small logs, not sawn or chipped for fuel) in each Member State (data from FAOSTAT) by a residue ratio. Here, forestry residues include the unused portions of felled trees, including tops and limbs, but exclude the below-ground parts of stumps. It is assumed that leaves fall off of limbs and tops and constitute part of the fraction of residues that remain on the soil surface.

Residue production is calculated as follows. First, bark volume is used to convert under-bark volumes as reported by FAOSTAT to over-bark volumes; this is estimated based on bark ratios from Ref. [28] using national values where available or else European average values. Residue ratios are then estimated separately for hardwood and softwood. Countries are split into ‘Nordic’ or ‘other European’, as Finnish data [29] show that Nordic softwoods (largely spruce) have a higher residue ratio than hardwoods, while this relationship is opposite for temperate regions. The Finnish data are adjusted to exclude the below-ground portion of stumps. Residue ratios for ‘other European’ countries are estimated from US data on residue and roundwood production [30–38]. The residue:roundwood ratios are: 0.47 for Nordic softwoods; 0.31 for Nordic hardwoods; 0.17 for other European softwoods; and 0.34 for other European hardwoods. The estimated residue ratio is then multiplied by each country's total hardwood and softwood production to estimate total residue production in cubic meters. This is converted to oven dry tonnes using density values from Ref. [28].

Total production of roundwood and forestry residues is assumed to remain constant to 2030. Declining paper production could reduce roundwood harvests in future, while other factors such as renewable energy policy could increase it; overall there is no clear indication that roundwood production will change over time.

Please cite this article in press as: S.Y. Searle, C.J. Malins, Waste and residue availability for advanced biofuel production in EU Member States, Biomass and Bioenergy (2016), http://dx.doi.org/10.1016/j.biombioe.2016.01.008

Download English Version:

https://daneshyari.com/en/article/7063276

Download Persian Version:

https://daneshyari.com/article/7063276

Daneshyari.com