Energy Policy 122 (2018) 349–357

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Wheat straw availability for bioenergy in England

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ARTICLE INFO

Keywords:
Bioenergy
Wheat
Postal survey
Straw

ABSTRACT

In an effort to meet energy demands while reducing carbon emissions, crop residues, such as wheat straw, have been investigated for their use as feedstock for biofuel production. In order to identify the feasibility of utilising crop residues as bioenergy feedstock, a postal survey was conducted to determine current farm business wheat straw use, destination and potential future supply. The survey responses showed a bias towards larger, more commercially-minded farms, therefore capturing a large area of straw production. Results demonstrated a wide range of responses to both current straw use and potential for the supply of straw to different markets in the future. Interestingly, even for a very generous payment for straw, 28.5% of straw currently chopped and incorporated would not be sold, suggesting that straw supply for bioenergy feedstock is likely to be more limited than previously assumed. However, higher prices for straw would encourage farmers to explore ways of increasing straw yield.

1. Introduction

Second-generation biofuels derived from crop residues provide a potential means of reducing reliance on oil-based fuels in the transport sector (IEA, 2010). In the UK, and other northern European countries, wheat straw is one of the greatest potential sources of feedstock for these biofuels. Production of straw in the UK outweighs demand and a large proportion is chopped and incorporated into the soil after grain harvest (Copeland and Turley, 2008). However, the amount of straw that could be available for biofuel production is uncertain and estimates of straw availability vary depending upon methodological approaches adopted and study periods examined; given its low economic value relative to grain output, official data on straw production do not directly exist. Crucially, one of the most important aspects of developing a second-generation biofuel sector requiring investigation is the extent to which farmers are willing to supply feedstock (Thivolle-Cazat et al., 2013).

Willingness to supply straw as feedstock will vary greatly among farmers, with some unwilling to sell straw at any price (Tyndall et al., 2011). Glithero et al. (2013a), in surveying arable farmers in England, found a third would not supply wheat straw for bioenergy, and in a survey of farmers in Missouri and Illinois, Altman et al. (2013) found that 42% and 39% of farmers respectively, were not willing to make their hay, wheat straw or corn stover available to sell in a bioenergy market, though it is unclear if they were already using their crops/hay or residues for other uses. Giannoccaro et al. (2017) found 31% of survey participants in Apulia (Italy) were unwilling to supply straw to a bioenergy market.

There are many factors that influence a farmer's decision to supply straw, including: the price offered for the straw; the need to return crop residues to maintain soil health; timeliness considerations regarding fitting in baling operations around other farm operations; soil compaction from baling; access to markets; and contract terms (Glithero et al., 2013a).

Considerations about soil health are often incorporated in estimates of straw availability (e.g. Searle and Malins, 2016, factor in an average of 3.7 t ha^{-1} crop residue remaining on the field across EU countries). Returning crop residues to the soil is recognised as providing important services including reducing erosion, improving soil structure and providing nutrients (Searle and Bitnere, 2017); however, the amount that needs to be left on the field to maintain soil health is to some degree uncertain and will be affected by location, soil type, cropping system and existing soil organic matter levels. It is unclear whether straw remaining on the field as stubble is sufficient to meet those requirements or if farmers would need to leave additional straw on the field or alternate between harvesting straw and chopping and incorporating it in the crop rotation.

To some extent, straw availability estimates can take account of access to markets and the amount that must be incorporated to maintain soil health; however, beyond these there is difficulty in incorporating farmer willingness to sell into estimates of straw availability. Some studies assume that farmers will supply feedstock at the

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https://doi.org/10.1016/j.enpol.2018.07.053
Received 5 November 2017; Received in revised form 13 July 2018; Accepted 26 July 2018

breakeven production price (e.g. Gallagher et al., 2003) or for the breakeven price plus a percentage to cover risk, management and profit margin (e.g. a 15% margin in MAFRD, 2014). Others use arbitrary assumptions for farmer willingness to supply straw, such as Petrolia (2008) who assumes a 50% farm participation in feedstock supply. Due to simplified assumptions such as these, it is possible that previous biomass feedstock availability has been overestimated (Tyndall et al., 2011). However, as considerable policy and research investment is based on estimates of energy potential from biomass sources, and in particular from by- or co- products from agricultural production, accurate estimation of biomass supply is vital in order to accurately inform the bioenergy debate. For example, resource availability, which included feedstock availability, was one of the dominant sources of uncertainty in entrepreneurial decision making with regards to an emerging renewable energy technology (biomass gasification projects in the Netherlands; Meijera et al., 2007). A greater understanding of farmer decision making in general, in particular to understand non-economic influences on decision making, is of great interest to policy makers in government (Edward-Jones, 2006); being able to better predict straw availability through improved understanding of farmer willingness to sell feedstock could significantly influence policy decisions, industry investment and associated impacts on biofuel availability.

In addition to understanding farmers' willingness to supply straw from current production levels, farmers may also adjust their straw production practices in response to potentially higher straw prices resulting from changes in the straw market. Given that modern plant breeding and agronomic practice has led to production of shorter straw in cereal crops, Townsend et al. (2015) reviewed the concept of a dual-purpose wheat cultivar that was optimised for grain for feed or food markets and straw for the biofuel market. Management practices that could influence straw yield were identified; however, given the lack of scientific focus towards increased straw production, there is little research to support these practices. Hence, although potential means of increasing straw yield per area exist, it is uncertain if farmers would adopt these practices, especially given the relative grain-straw market prices, which favours techniques that partition biomass to the grain at the expense of the straw. Glithero et al. (2013a) found that farmers were more interested in contracts that specified straw supply based on area rather than by weight, which might influence decisions about whether it is in the farmers' interest to increase straw yields. It is unclear the terms of contracts currently available to farmers for straw for bioenergy in the UK as publicly available information on straw contracts for energy is not something readily available, suggesting these might be bespoke. Nevertheless, in the presence of enhanced market opportunities for straw flowing from demand for second generation biofuels, farm-level adaptation strategies are likely to include changes to the amount of straw baled and sold, and agronomic or management changes favouring increased straw yield, or straw harvested, per unit area. Knowledge of farm-level adaptations, capturing these production and market changes, represent key policy questions. Consequently, the objectives of the study were to better understand farmers' intentions regarding current and future straw supply, drawing upon a structured postal survey methodology.

2. Methodology

2.1. Survey questionnaire

The postal survey questionnaire followed Dillman's tailored design survey protocols (Dillman et al., 2008). Pilot work took place during the development of the questionnaire involving discussions with farmers and individuals with prior experience of conducting farmer surveys. A pre-paid addressed envelope was provided for respondents to return the survey questionnaire. The survey questionnaire was sent out in December 2012[1]; this time of year was chosen to maximise response rate as it is a less busy period for arable farming operations.

The survey population was focused on the eastern side of England as this region accounts for the largest area of arable production in England, and is additionally where the greatest straw surpluses are found (Copeland and Turley, 2008); this region is, therefore, the most likely site for a biorefinery (Glithero et al., 2013b). All counties within the North East, Yorkshire, East of England, East Midlands, and South East of England Government Office Regions (GORs) were surveyed. The survey frame was based on addresses from business directories (Yellow Pages and the Thomson Directory). A total of 2000 questionnaires were sent out; 1245 addresses were collected from the Thomson Directory with the Business Activity class 'Farming – Crops' and 755 addresses from the Yellow Pages with the Business Activity class 'Farmers'. The addresses available were limited for these farms with only 36,877 addresses for the UK when the Yellow Pages classification "Farming" was selected against an estimated 105,449 holdings in England alone in 2010 (Defra, 2011). The sample of 2000 farmers represents approximately 4% of the farms in these regions (Defra, 2011). Due to the limited information on the farmers contained in these directories, not all farms would be wheat producers, thus limiting the potential responses. The returned surveys purposefully did not require contact details or details about finances from respondents to be provided in order to minimise barriers to survey completion and return; however, this meant it was not possible to identify non-respondents and this prevented unreturned responses from being followed up. The implication of these choices when constructing the questionnaire will be explored in the discussion.

2.2. Survey questions

The relevant questions from the questionnaire are presented in supplementary material (Supplementary 1). The survey questionnaire asked about the county where the farm was located, the age of the farmer and the size of the farm. The respondent was asked to provide information on the crops grown for harvest in 2012 and the livestock held on the farm that year. They were asked whether they had any other enterprises on farm though this was not given financial quantification preventing in-depth analysis. The questionnaire had a Likert-scale rating question for the importance placed on farming objectives.

Respondents were asked about their uses of the wheat straw from the 2012 harvest. They stated the area of land given to each wheat straw use. This means straw use was based on area harvested rather than actual straw yields; this is a more practical way of comparing use as yield would not have been quantified for straw being chopped and incorporated, and not necessarily for straw being baled and sold. It is acknowledged that when straw is baled that there will still be straw remaining on the field (i.e. stubble, leaf material and chaff) that will be returned to the soil.

Some assumptions had to be made to analyse the straw-use data. Some answers were incomplete for the question about wheat straw from the 2012 harvest and hence straw uses had to be approximated from other data. For example, when the proportions of straw used did not sum to one, unproportioned use was allocated to 'straw chopped and incorporated'. This was because it was assumed that the farmers would have a much clearer idea of the amount of straw they had baled than they had incorporated. When residues from other cereals (e.g. barley, oats) were included and it was unclear what each straw type was used for, the same proportions of total residue for each use were assumed for the wheat straw.

Three questions examined potential future straw supply:

[1] Since the survey was conducted there have been no structural changes in crop or input prices, suggesting that the responses would not be significantly different if the survey was conducted in 2018.