Neglected Intermediaries in Bioenergy Straw Supply Chains: Understanding the Roles of Merchants, Contractors and Agronomists in the England

Abstract

Outside of Denmark, straw-based bioenergy has seen uneven success across Europe. In the UK, straw-based bioenergy has been positioned as making a potentially important contribution to the UK government's energy and environmental objectives. However, growth of the sector has been modest and supply shortages have been experienced despite straw being anticipated as being readily available in the UK and surplus to existing market requirements. This paper explores a previously under theorised and neglected aspect of this story, the role played by agricultural intermediaries, merchants, contractors and advisors.

Drawing on interviews with farmers, bioenergy industry representatives, agronomists, straw merchants and contractors from three case study areas, it finds that intermediaries undertake key roles providing physical and social labour required to maintain straw supply chains. They provide baling equipment, maintain informal and formal agreements with producers and users, build and maintain trust, influence on-farm management of straw and increase supply chain resilience to market shocks. However, there is tension between agronomists who advise straw incorporation and the aims of straw merchants and bioenergy policy which seeks to incentivise baling. If policy makers are committed to developing a straw-based bioenergy industry, then policy frameworks need to

engage in a multi-actor approach that enables the development of committed and well-resourced intermediaries.

Highlights

- Straw market intermediaries are crucial to farmer's straw use decision making
- They provide key on-farm services such as soil health advice, machinery and labour
- Intermediaries exert multi-directional influence on each other and other actors
- Currently informal arrangements and actor-actor trust heavily influence the market
- A consistent long-term policy framework should encompass intermediaries

Keywords

Cereal straw, Bioenergy policy, Agricultural intermediaries, Farmer decision making

1 Introduction

Agricultural residues such as straw, the dry stalks of cereal and oilseed crops, have consistently been identified in UK and EU bioenergy policy and technical assessments as a substantial potential feedstock for future bioenergy production (European Commission, 2005; Department for Environment, Food & Rural Affairs (DEFRA), et al., 2007; Department for Energy & Climate Change (DECC), et al., 2012; Harrisons, et al., 2014; Nakada, et al., 2014; PricewaterhouseCoopers, 2017; European Union, 2018; Committee on Climate Change, 2018). Straw is attractive because of its estimated abundance, with nearly all states in the European Union being modelled as having surplus recoverable agricultural residues potentially available for energy use (Scarlat, et al., 2010). Additionally, straw based power has been demonstrated as a politically, commercially and technically viable prospect. Denmark in particular has an established straw-based energy industry which spans small scale straw-fired boilers on farms, to large scale combined heat and power (CHP) and centralised power plants (Voytenko & Peck, 2012).

However, outside of Denmark the picture of straw-based bioenergy development is far more mixed, particularly for medium and large-scale straw-based heat and power production. Straw-based energy production remains marginal in France and Germany (Weiser, et al., 2014; Williams, 2018), the two EU countries estimated to have the largest availability of recoverable crop residues for energy (Scarlat, et al., 2010). Whereas the UK and Sweden have only established a small number of medium and large-scale power and CHP plants, respectively (DEFRA, 2019; Voytenko & Peck, 2012), despite both providing support mechanisms for straw-based bioenergy since the 1990s.

To understand the prospects for establishing a straw-based bioenergy sector, policy and research focuses on farmers as the crucial actors. In particular, the willingness of farmers to produce and sell straw at a rate viable for bioenergy or biofuel production under different policy and market conditions (Giannoccaroa, et al., 2017; Meyer, et al., 2018; Copeland & Turley, 2008; Glithero, et al., 2013ii; AEA, 2010; Townsend, et al., 2018). Given the fundamental necessity of being able to acquire sufficient feedstock, the assumption that farmers, as the biomass growers, are crucial actors appears well-founded. The consequence has been numerous approaches to model the market and policy conditions under which farmers will be incentivised to sell straw for energy. In the UK context, this has included the price point at which farmers are incentivised to bale straw for sale for energy instead of incorporating it into soil (Copeland & Turley, 2008; Townsend, et al., 2018), the types of contractual conditions to supply straw to bioenergy producers that farmers prefer (Glithero, et al., 2013ii; Glithero, et al., 2013i) or whether upstream electricity prices determine a farm gate price sufficient to incentivise farmers to sell straw for energy (AEA, 2010). Once established, these conditions are used to estimate the amount of straw that might be made available by farmers for bioenergy.

Yet these studies routinely reveal a further set of 'logistical constraints' that also need to be considered. Acquiring, transporting and processing biomass is repeatedly situated as influencing the economic viability and environmental sustainability of straw based bioenergy. Yet sustained policy or

academic interest in the actors undertaking this 'logistical' work has yet to manifest and they remain persistently absent from research and policy accounts of straw-based bioenergy. This is despite the Danish experience suggesting that these actors, sub-contractors and merchants, are a significant component of established straw-based bioenergy production chains (Voytenko & Peck, 2012).

The significance of 'middle actors' to the emergence of new energy systems and technologies has begun to be explored by an emerging body of broader energy research (Parag & Janda, 2014; Wade, et al., 2016; Kivimaaa & Martiskainen, 2018; Rocher & Verdeil, 2019; Janda & Parag, 2013). The central argument is that intermediary actors are "active participants in the system, capable of creating (and sometimes preventing) change above, below and across other actors" (Parag & Janda, 2014, p. 103). Furthermore, a body of rural research has highlighted how farmers are not isolated decision makers but situated within a "'web of influencers'" on their practices (Oreszczyn, et al., 2010, p. 409). A network of wider actors which includes agricultural advisors such as agronomists who provide crop cultivation and marketing advice (Angell, et al., 1997; Ingram, 2008), field level bureaucrats such as pollution inspectors (Lowe, et al., 1993), and contractors and merchants who provide labour, equipment and negotiate the sale and transportation of products between farmers and end users (Voytenko & Peck, 2012).

Drawing on qualitative interviews with English farmers, straw merchants and contractors, agricultural advisors and bioenergy industry representatives, the aim of this paper is to further our understanding of the significance of these missing intermediaries for emerging bioenergy systems, through examining the role of agricultural intermediaries as active influencers of, and participants within, straw-based biomass supply chains in the UK. This aim is directed through the following three research questions 1) What are the roles of different agricultural intermediaries in straw management and straw-based supply chains? 2) What are the implications of their influences on straw management for straw-based biomass supply chains?

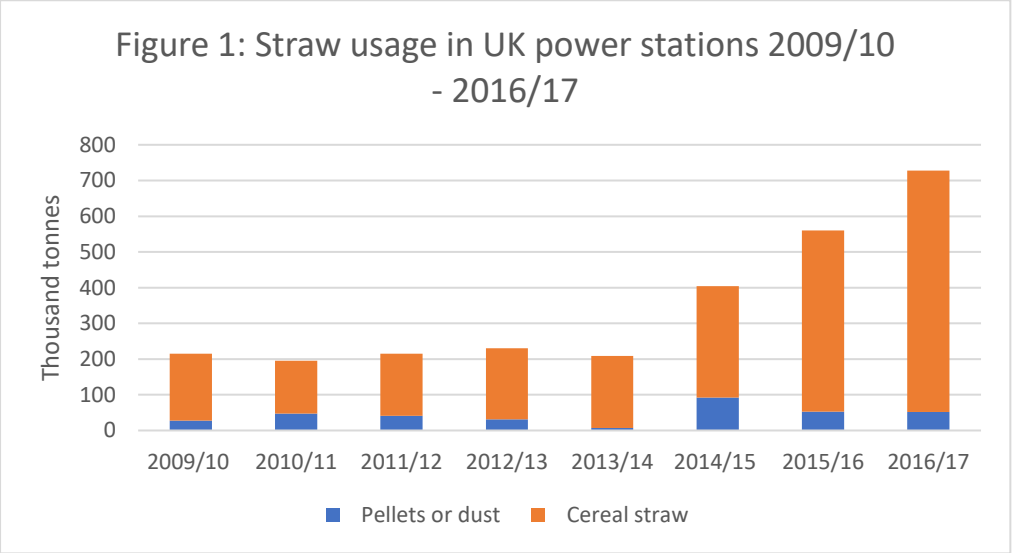
The UK provides a useful context to examine these dynamics because it has both a well-established straw market *and* an emerging bioenergy sector. It is therefore possible to examine the roles of already established agricultural intermediaries involved in baling, transporting, trading and advising on how best to use and market straw, in shaping farm level practices and emerging bioenergy supply chains. Although our empirical findings are specific to the UK, they are likely to offer valuable insights applicable to other national and regional contexts such as the northern half of France, central Germany, the Po valley, and the Danube basin which are the main areas in the EU producing agricultural residues from cereals and oilseeds (Camia, et al., 2018). They will also be relevant to other areas where the straw market is well-established, and agricultural intermediaries such as contractors, merchants and agronomic advisors have an active role within agricultural systems.

2 The UK straw market

In the UK, the Department for the Environment, Food and Rural Affairs (DEFRA) is responsible for monitoring and estimating the amount of straw yielded annually and used by different sectors. Unlike other agricultural products such as grains or livestock, DEFRA has not consistently collected data on straw production. This lack of state level surveillance of the national market is mirrored by a dearth of farm level data. Farmers have not generally accurately measured or recorded the amount of straw they produce (Montforti, et al., 2013). Since 2008 a clearer picture of the straw market has begun to emerge due to interest in straw-based bioenergy. Efforts to quantify the straw market to establish the amount of straw produced, baled and potentially available to meet UK energy objectives has led to the development of experimental statistics quantifying straw production on the basis of planted area and estimated recoverability ratios (DEFRA, 2013) and from 2014 direct in field straw yield measurements (DEFRA, 2019). These yield measurements are used to estimate the annual national yield of straw on the basis of selected cereal planting areas.

Since records began in 2008 UK baled straw production has been estimated as fluctuating between 11 and 12 million tonnes a year depending on crop areas planted and growing conditions (see HM

Government, 2019 for the full data series). The most significant uses of straw during the last decade have been for animal bedding and feed which together account for over two-thirds the annual straw market in the UK (DEFRA, 2019). Straw usage in UK power stations, in the form of co-firing or dedicated biomass combustion, is the third largest end use and the only use estimated to have grown, increasing from an annual consumption of 2% of the total market in 2009 to 6% in 2017 (see figure 1).



All other uses of straw, in carrot production, the mushroom industry and for export, consume less than 5% of the straw produced. The remainder is accounted for by an estimated persistent surplus of baled straw from between 1.5 to 2.5 million tonnes (DEFRA, 2019).

While one might assume that a consistent net surplus is an attractive position and conducive for further growth in straw-based bioenergy, DEFRA in 2019 outlined a more cautious outlook. In particular, DEFRA identified policy changes and straw supply shortages as being expected to cool interest in straw based bioenergy. Therefore, data collected on the straw market suggests a more complex picture than can be gleaned from estimating farmer production and end use consumption.

3 The role(s) of intermediaries in energy and agricultural systems

There is a general paucity of previous research that has explored the roles and influence of intermediaries within agricultural and energy systems, with two main exceptions. In the agricultural sphere the exception is work on agricultural advisors, which has been primarily in the context of agri-environment schemes (Angell, et al., 1997; Curry, 1997; DEFRA, 2014i; Morris, 2006; Ingram, 2008; Ilbery, et al., 2012). In the energy context there has been a growing literature emphasising the influence of 'middle actors', particularly in the context of residential energy efficiency where the focus has primarily been on the roles of building professionals, home installers and craftspeople (Janda & Parag, 2013; Parag & Janda, 2014; Wade, et al., 2016; Kivimaaa & Martiskainen, 2018; Fyhn, et al., 2019). This section will identify a number of key themes from across these bodies of research which we take forward in our analysis.

The crucial emphasis of this work is that intermediary actors are active participants with "many qualities and functions which are unique and essential for a durable systemic change" (Parag & Janda, 2014, p. 103). Work by Oreszczyn et al (2010) which draws on the literature on communities and networks of practice, highlights how farmers "draw on a wide network of people, including those who are not part of their professional or practice community, (or network), yet are significant influencers on that practice" [ibid, 2010, p.411]. This "'web of influencers'" [2010, p.409] is not just passively informing farmers but shapes how they engage with and learn about emerging agricultural innovations. Within these networks, agronomists, agricultural advisors that provide farmers with a wide range of business, cropping and regulatory advice, are often positioned as particularly significant. Ingram (2008) provides a review of different models of the agricultural adviser as change agent, with a spectrum which positions them at one extreme as agents whose technical expertise allows them to persuade and even manipulate farmers (Ward, 1995), and at the other as agents who

blend cultural rapport with technical competence and practical knowhow to negotiate change in demand led contexts (Juntti & Potter, 2002).

In contrast, merchants and contractors have been almost entirely overlooked in the academic and policy literature on agricultural networks and bioenergy supply chains. Contractors represent businesses and individuals providing for hire services to farmers which can include the full breadth of agricultural activities from crop planting to harvesting. The Farm Business Survey and June Agricultural Survey conducted in 2014 (DEFRA, 2014i) estimate that for cereal farms, between 30-42% of larger farms (farms requiring more than 3 full time staff (DEFRA, 2014ii)) and 16-24% of smaller farms contract out straw baling services on some portion of their land. Despite their neglect, contractors represent a key group of actors undertaking a significant proportion of the baling work, on behalf of farmers, required to bring straw to market. Agricultural merchants, representing individuals and businesses involved in the trading and haulage of straw, either through directly purchasing straw from farmers for subsequent sale, or acting as intermediaries between farmers and end users, have similarly been overlooked in the academic literature. Yet research by Voytenko & Peck (2012) in Denmark, highlights how both merchants and contractors are fundamental to the functioning of straw-based bioenergy supply chains. To use the words of Parag & Janda (2014), these middle actors are clearly 'more than filler'.

However, a major difference between the agricultural literature and the energy literature pertains to the direction of influence. Whereas the literature on agronomists appears to primarily focus on their downstream influence on farmers, the work of Janda & Parag (2013; Parag & Janda, 2014) aims to conceptualise middle actors as having more multi-directional effects. Through research on building professionals that highlight the upstream, downstream and sideways impacts of middle actors. Our analysis takes forward the latter multi-directional conceptualisation of intermediary influence.

A key theme that relates to this capacity to influence and enable other actors is the value of different intermediary's expertise interwoven with their ability to build trusting and respectful

relationships with other actors. Expertise is situated as cutting both ways. On the one hand a lack of sufficient expertise amongst middle actors is positioned as a problem when attempting to develop and implement new standards (Kivimaaa & Martiskainen, 2018), or install new technologies and appear credible to consumers (Wade, et al., 2016). On the other hand, the expertise of intermediaries is clearly highly desirable and a necessity for many downstream and upstream actors. The farmer-agronomist relationship is framed in these terms as agricultural advisors are deemed increasingly important given the expanded scope of farm-level managerial considerations to include changing production techniques, best practice guidance, environmental processes, legislation and regulation (Ingram & Morris, 2008; Ingram, 2008; Haign, et al., 2015). However, in contrast to upstream actors who tend to provide and value formalised, rationalistic and quantifiable knowledge and standards (McDermott, 2012; Fyhn, et al., 2019), downstream actors often favour more practical, informal advice relative to their context. Farmers, in particular are seen to value "less formal knowledge and practical advice provided by individuals" (specific known people) above "Formal knowledge passed … through organisations" (Oreszczyn, 2010 p.413) and typically position any advice in relation to their own experiential understandings (Harris & Lyon, 2008). Agronomists are brokers between regulators, scientists and farmers, translating scientific and regulatory knowledge and adding value to the information of use to farmer decision making (Haign, et al., 2015)

Interwoven with the importance of expertise or knowhow is the issue of trust and respect. Oreszczyn et al (2010) emphasise the importance of trust and respect in farmers' networks of practice, a point supported in a range of literature (see Ingram, 2008; McDermott, 2012) and explicitly evaluated by Sutherland et al (2013) in the context of multiple and increasingly privatised forms of agri-environmental advice. The latter authors' work highlights the importance of both longevity of interaction and credible expertise in generating trust. Ingram (2008, p. 407) reports the view that "of all advisers who visit the farm, agronomists are best placed to establish such trusted relationships with farmers due to their regular on-farm meetings, local knowledge, and often long-term relationships with farmers (Angell, et al., 1997; Ingram, 2008)". Even field level bureaucrats,

such as pollution inspectors, have long been aware of the importance of the personal and practical in their regulatory encounters with farmers (Lowe, et al., 1993).

However, the need to maintain good inter-personal relationships and reputations with other actors can be a source of tension particularly if intermediaries are torn between performing multiple roles that may be more or less mutually exclusive. For example, Fyhn et al (2019) note the difficulties faced by professional craftspeople in reconciling their government and interpersonal roles. On the one hand enrolled in selling government retrofitting programmes which require homeowners to retrofit the whole house, on the other building and maintaining good relations with homeowners usually interested in incremental solutions that suit them and their homes, with the latter winning out because of its centrality in maintaining their livelihoods and businesses.

The existing literature therefore highlights a number of shared themes regarding the roles intermediaries play and the mechanisms through which they influence other actors. Our analysis explores these key themes of active participation, multi-directional influence, expertise and trust in the context of agricultural intermediaries and straw-based bioenergy supply chains.

4 Methods

The empirical analysis presented within this paper is based on 55 semi-structured qualitative interviews. Interviews with 32 farmers and seven bioenergy and biofuel industry representatives were conducted between March and July 2013. These interviews identified agronomists and merchants as important bioenergy supply chain actors. A further nine interviews were conducted with agronomists, and seven with straw merchants and contractors in April 2014. Given the large potential participant pool of farmers, merchants, agronomists and contractors, the sampling strategy was narrowed to three geographical areas through postcode searches. Humberside (Hum) and Cambridgeshire (Cam) were chosen due to the location of a first-generation biofuel and a bioenergy facility respectively within these counties, and large annual production surpluses of straw.

Lancashire (Lanc) was chosen to represent a very different regional straw market due to the geographic concentration of livestock enterprises. The aim of this geographically bounded and qualitative work is therefore not to establish quantitative generalisations about agricultural intermediaries, their roles, interests and influences, but distil key qualitative themes with cultural meaning and resonance from across the data.

All interview participants were contacted through publicly available information drawn from professional registries, company websites and the Yellow Pages. Eleven bioenergy and biofuel industry representatives and consultancies were identified all of which were contacted. For farmers, 50 addresses were selected at random from each area. Twenty-seven merchants and contractors and 25 agronomists were identified from professional registries based on these geographic locations. Due to much smaller participant numbers all identified individuals and businesses in these areas were contacted.

Semi-structured interviews were conducted with all research participants. Semi-structured interviews utilise a number of open ended but topic specific questions ensuring resultant interviews address core research interests and requirements whilst providing a level of flexibility that allows exploration of topics that arise during the interview process (Bryman, 2012; Wilson & Maclean, 2011). This allows respondents to shape the interview in ways that are meaningful to them not just the researcher (Stephens, 2007). Therefore, semi-structured interviews were adopted as the most appropriate research method for elucidating the diverse interests, values, experiences and decision-making influences across the different actors.

The semi-structured interviews followed a set of interview guides. These guides were tailored for each participant group, reflecting their different positions and roles within bioenergy supply chains. All guides covered a number of shared topics aiming to identify in particular sections: 1] a participant's individual and business history and its change over time; 2] the geographical scope and scale of the current business; 3] the degree of interaction with other straw market actors, including

for bioenergy purposes, and; 4] exploration of the factors that constrained and facilitated farmers and merchants to supply straw for bioenergy purposes.

All interviews were audio recorded, and transcribed. Transcripts underwent thematic analysis which provided a systematic yet flexible means of analysis, ensuring a rich and detailed account of the data (Braun & Clarke, 2006). Themes, can refer to something that is directly observable, a repeated topic, or something implicit which requires interpretative analysis of the meanings and values within the data (Joffe & Yardley, 2004). The thematic analysis conducted in this research aimed to identify both explicit and implicit themes.

Once transcripts were available the key themes were identified through a coding protocol. This approach included a 'top down' (or etic) element which drew on the key themes introduced in the interview guide following examination of the background literature and expected to be prominent in the data (Bryman, 2012; Crang & Cook, 1995). It also included a 'bottom up' (or emic) element in that the semi-structured interview style provides space in which interviewees are able to shape the interview in previously unanticipated ways, and further recurrent themes were thereby identified across the transcripts (Strauss, 1987). This dual approach provides a robust understanding of the central themes within the data set that emerged through the discursive nature of semi-structured interviews (Crang & Cook, 1995; Joffe & Yardley, 2004).

This article focuses on reporting and analysing the prominent themes relevant to the topic of straw-based bioenergy supply chains and the role of intermediaries. Any quotes presented below, succinctly represent broader themes prevalent in the data and have been anonymised in accordance with the ethical procedure approved by the host institution and consent provided by participants. Additional information is provided solely to indicate the participant's geographical location and their position within the straw market.

5 Results and Analysis

5.1 Straw merchants and contractors: More than bridging the gap

Within straw-based bioenergy supply chains, straw merchants and contractors were crucial actors undertaking a significant proportion of the physical and social labour required to bridge the gap between farmers and bioenergy end users, as well as helping to underpin bioenergy investments and developments. We will now explore the significance of these roles and influences in more detail.

5.1.1 Providing Labour and Machinery

Contractors provide a large amount of the physical labour and machinery resources needed to bring straw from the field to the end user. They are thus an important linchpin in the collection and baling of straw for energy users. Straw merchants negotiated the sale and movement of straw between farmers and end users, predominantly on the basis of informal, contractual relationships with farmers and some end users. Finally, straw hauliers are involved in the loading, transport and unloading of straw. Although some straw merchants operated their own haulage business, interviews suggested that this was largely a nonspecialised 'for hire' job.

Of these activities, contract baling is particularly important, as it relieves farmers of the capital cost of increasingly expensive machinery and the work required to bale and handle straw. Of the 18 arable and mixed farmers interviewed, most did not own baling equipment or owned second hand machines producing smaller bales for personal use or sale to local horse owners. Baling contractors are therefore providing an important set of services to farmers. As a result, they are also operating in a distinct market for contracted services which has different priorities and pressures than those facing farmers. This meant contractors were more interested in, and able to justify the significant investments needed for the larger baling equipment because they are operating it over a larger acreage than most individual farmers, allowing them to achieve the economics of scale this equipment requires to justify its cost.

Crucially for bioenergy users, it was contractors that often owned the large expensive balers that produced the largest rectangular bales (1.2m x 1.2m x 2.5m), colloquially named the Heston bale. This is the desired bale for bioenergy users and the unit around which their straw handling and processing infrastructure is designed. Contractors are therefore not only important to farmers because they provide services which they do not want to undertake, but own and operate the equipment that produces bales to the specifications desired by bioenergy producers.

Sufficient prevalence of contractors with equipment to produce the Heston bale was not trivial. The straw market is highly differentiated on the basis of bale size. Bale size influences who is able and willing to utilise the straw, different bales finding different uses due to personal but also logistical preferences. Due to the differentiated market for bales, even if straw exists in sufficient absolute quantities, the prospective resource available to a single user may be significantly influenced by the ability of their handling system to deal with a diversity of bale sizes, as the following quote highlights:

> "You see when we sold the straw bales [to an energy buyer] they were round ones, and they couldn't fit these round ones in their burner and they had to re-bale everything." (Cam Arable Farmer 12)

So far, we have established that contractors provide important services to farmers and that their position in the agricultural system means they are able to invest in the largest baling equipment making them key to producing the types of bales sought after by straw-based energy producers. Finally, they are directly involved in straw-based energy supply chains. As outlined by a representative of a straw-based bioenergy facility:

> "we have our own straw purchase … [which buys a] relatively small percentage, 25% of the straw, we do all of the work ourselves… the remainder is all done through contracted supplies." (Bioenergy Processing Facility Representative 1)

Although operating a vertically integrated straw baling and collection business, this bioenergy facility also had contracts with baling contractors and merchants for the majority of their straw supplies. Most notably, this reduces the number of individuals that bioenergy producers have to personally deal with as contractors and merchants will source from multiple farmers. This allows bioenergy producers to streamline their own supply chain organisation by outsourcing the work of liaising with numerous farmers to a smaller number of intermediary actors who are then tasked with negotiating sale, baling and transporting the straw for energy users.

5.1.2 Underpinning Bioenergy Investments

Contractors and merchants do not only provide important services to both farmers and bioenergy suppliers but also act as gatekeepers to the straw market for buyers. Equally, in contrast to farmers, merchants are potentially more able (due to dealing with larger quantities of straw than an individual farmer) and interested (due to securing investments in machinery) to sign a longer term formal contract that are preferred by bioenergy operators (Glithero, et al., 2013ii). Two of the interviewed merchants held a direct contract to supply bioenergy plants at the time research was undertaken, whereas others had sold straw for energy purposes previously but on an ad hoc basis. Due to their established access to the straw market, enrolling merchants and contractors into existing and future bioenergy schemes was seen as key to securing energy development investment:

> "[an energy company] couldn't get the financial backing unless they knew that they could get a supply of straw, so another company went around lots of straw merchants and we had to sign up to supply the factory" (Cam Straw Merchant 7).

In short, straw market intermediaries are underwriting emerging bioenergy ventures with agreements in principle to supply feedstock. Several of the interviewed straw merchants reported being approached by a prospective energy development at some point previously, but not all were persuaded to do so. Three had agreed to supply straw to such a venture in principle. The others preferred to maintain long standing relationships with existing livestock farmers over suppling new

energy ventures. This was not merely a financial decision but one influenced by the importance of interpersonal relationships built up over time between merchants, farmers and contractors which were an important part of the job satisfaction. We now move on to examine the importance of these relationships.

5.1.3 Trust, interpersonal relationships and baling

Maintaining trust and good relationships between farmers, intermediaries and buyers was recognised by bioenergy companies, straw merchants, contractors and farmers, as important to maintaining the supply of straw and for incentivising farmers to bale and sell their straw. Costs and payments inadequately convey the work that goes into getting straw from the field to the end user. Bioenergy users recognised this and tried to develop strong relationships with farmers through demonstrating reliability and actions aiming to cultivate good will.

One bioenergy plant representative explained how their company had approached this issue by taking over a pelleting plant that was going to close to

> "…show some good will to the farming community because they have all had contracts for this stuff so we took over their contracts." (Bioenergy Processing Facility Representative 4).

Another discussed the need to manage intermediaries in such a way as to cultivate, at a distance, a good relationship with the farmer:

> "… we go out to a number of suppliers … who then contract back through the process to the farm and it is making sure that we have the right relationship with the contractor and that he then passes that relationship on to the farm to make sure that it all works …" (Bioenergy Processing Facility Representative 1)

This quote implies that logistics involves much more than cost; it involves managing social connections through personal and professional relationships between different actors, both through direct and intermediary actions.

The relationship between straw merchants and contractors and the energy industry was also perceived to be having a sideways influence on others. The presence of large bulk straw buyers was noted by agronomists and straw merchants as driving increased professionalism of contractors. Professionalism being understood in this context as timeliness of operations and reliability of payment (Cooper, 2018) . Greater professionalism was linked to increased capital demands for new baling equipment and the need to ensure farmers continued having their straw baled. As two agronomists remarked, this greater contractor professionalism, and thus stronger community and business reputations, had sparked the interest of some farmers to revisit contract baling as an option for managing their straw. This likewise highlights the importance of reputation and trust in the development of relationships between straw intermediaries and farmers which influence the likelihood that a farmer will bale their straw. Although it is impossible to delineate what this specifically means for straw based bioenergy producers, if it contributes to an increased availability of straw, they are likely to indirectly benefit from these developments.

Trust and strong relationships were of central importance to the livelihoods of straw merchants and contractors. All straw merchants and contractors interviewed maintained close working relationships with arable farming neighbours, friends and family. Trust between these actors is an important part of the understanding between farmers and contractors, as the following straw merchant makes clear:

> "…it builds up and builds up over the years on a trust basis. They trust that we have the, er, capacity and the ability to do the job we say were gonna do given a fair crack with the weather." (Cam Straw Merchant 3)

Furthermore, trust involved not just the understanding that the job would be done correctly but, importantly, that the farm would not be contaminated as a result of baling contractors spreading weed seeds, most notably blackgrass, between farms. Blackgrass is a grass species that is common across Western Europe particularly England, France and Germany (Moss, 2013). Simplified crop

rotations, the dominance of winter cereals and a shift towards minimum tillage have encouraged blackgrass expansion and persistence as a problematic and costly weed in arable production (Moss, 2013). Understandably farmers who do not have blackgrass problems on their land are keen to keep it that way:

> "…we are in an area where there is very little blackgrass so quite a lot of farmers are wary of contractors coming in and spreading blackgrass onto their farms when they come with the balers." (Hum Agronomist 8)

The consequence for straw merchants of damaging that relationship of trust was the reluctance of farmers to bale in subsequent years and, in the most serious cases, complete relationship breakdown:

> "...we used to have somebody come and bale it but ... we have been let down badly over the years, so after that we stopped working with them and decided to incorporate it [straw]." (Cam Arable Farmer 5)

This breakdown and subsequent shift in on-farm practices, represented the experience of only a small number of farmers interviewed. Equally, whilst the above farmer had moved towards a system of straw incorporation, others purchased second hand baling equipment as a means of 'protecting' their land.

In contrast, maintaining trust in existing relationships often translated into a strong reputation in the farming community. Four of the straw merchants interviewed had been trading for over 50 years and their reputation within community networks was seen as an important part in maintaining their business. Good reputations and trust boosted farmers' confidence that baling straw would not adversely impact the timeliness of subsequent cultivation and crop establishment. Good personal and professional relationships between supply chain actors therefore provide a means of facilitating the baling of straw. Such developments are likely highly beneficial to bioenergy producers enabling

them to access more straw, particularly given that they are associated with increased professionalism amongst contractors.

5.1.4 Maintaining Supply Chain Resilience

Straw, as discussed in UK policy and by industry representatives, is assumed to be a nationally bounded resource predominantly available to UK based actors (Biomass Task Force, 2005; DEFRA, et al., 2007). This is supported by further assumptions that highlight the costly logistics of straw use for energy purposes. However, interviews with farmers and straw merchants highlighted how straw is traded inter-regionally *and* internationally. Country specific deficits in straw production and poor conditions elsewhere create annual uncertainties that impact on the market (Mohr, et al., 2016) and can result in shortages that impact on bioenergy producers as seen in 2017 and 2018 (DEFRA, 2019). During these occasions UK markets are placed under considerable pressure as new entrants from the continent are often willing to pay high prices to secure the straw they need.

Equally, the interviews suggest that these relationships between merchants, farmers and end users are not typically secured through formal contractual agreements. Work by Glithero et al. (2013ii) appears to confirm this, noting that farmers are often unwilling to enter into a long-term contract to supply straw. The vagaries of the weather impact on the amount of straw farmers produce and the ease with which it can be removed from the field. Understandably, these uncertainties mean that negotiations for straw were often conducted on an *ad hoc* basis. Gentlemen's agreements and a handshake over a kitchen table, or in the field from which straw was to be baled, underpinned many straw arrangements. The sale of straw to livestock farmers was similarly flexible and uncertain, with orders being placed as and when by the farmers. The prevalence of informal contractual arrangements might suggest that the straw market is highly fluid and open to the highest bidder. However, these informal arrangements were often very longstanding. Further highlighting the importance of social connections and trust. Indeed, when the market was tight maintaining strong connections and good relationships within existing networks becomes particularly important:

> "Erm like I say it's not a stable market, ... one year you hear nothing from them [Dutch, French or Irish Farmers] and then another year two lots turn up and it has a massive pull on the local market kind of thing, ... they can pay more than what we can. ... you just can't compete … but then again a lot of my people won't sell to them because they want me there another year." (Hum Straw Merchant 2)

A consequence of this is that new entrants, and customers outside of a merchant's established network, were potentially a disadvantage:

> "They suffer a little bit … when the demand is greater than the supply because er, we look after our regular customers." (Hum Straw Merchant 6)

Although relationships are price sensitive, when the straw market tightens the interpersonal relationships become important and actors outside of well-established networks are at a disadvantage.

Baled straw supply is therefore locked to some degree into secure networks between farmers producing straw, the intermediaries and buyers, that emerge and shift on the basis of personal and community relationships. These informal personal connections are entangled within commercial and mutually beneficial relationships. The result is that they are often particularly resilient in the face of new entrants (which might include bioenergy producers) looking to disrupt them and secure their own straw. Expectations of access to straw on the basis of price alone simplify complex networks of interpersonal relationships that are important in determining who can access straw, alongside on farm decision making that is influenced by numerous factors other than price.

5.2 Agronomists: Examining their influence

In the context of emerging biomass supply chains, when considered, agronomists are typically positioned as a source of information (see Sherrington, et al., 2008). Yet the ways in which agronomic advisers frame the best use of straw have remained absent from empirical analysis of

agronomist-farmer interactions and bioenergy availability assessments. Therefore, while not usually considered an actor within straw supply chains *per se*, it is important to recognise that agronomists have influence over farm production practices and farmer decisions over straw use, with implications for the availability of straw for energy and non-energy uses.

5.3 Managing Straw to Manage Soil

Soil management is a key part of agricultural production with implications for the use of straw on arable farms. Not all fields are the same, being exposed to different weather, water availability and solar intensity, and having different topography and soil composition. Because the incorporation of straw has become seen as an important practice for managing soil health (Defra, 2009), assessment of soil needs has an important influence on the decision-making process with regards to straw management:

> "I think it depends on the soil type actually, for one man he chopped [straw in] one field for about 25 years because it seems to be the structure of the soil, then he bales a lot on other fields you know." (Hum Straw Merchant 6)

While farmers typically do not have in-depth scientific understanding of soils (Ingram, 2008; Stoate, et al., 2019; Ingram & Mills, 2019), by interacting with their soils over time and through different conditions, they accumulate considerable awareness of the needs of their different fields (Tsouvalis, et al., 2000). Many bring these perspectives into discussion with agronomists who have a key role in advising farmers on crop and soil management. It is here that agronomists play an important role in interpreting soil, with implications for straw baling:

> "I am actually encouraging people to chop more on some of the heavier [clay] land just to try and bulk organic matter" (Hum Agronomist 9).

All the agronomists interviewed favoured the incorporation of straw and advised as such, reflecting regulatory guidance (DEFRA, 2009; HM Government, 2018) and scientific cautions against annual

straw removal amid rising concerns over soil sustainability (Soane & van Ouwerkerk, 1995). Alongside organic matter straw also provides a source of nutrients which are factored into calculations about the rate of inorganic fertilisers added to further crop growth, and their costs.

An advisory regime that routinely favours the incorporation of straw over baling was deemed to have had a notable influence on straw availability. As one straw merchant remarked:

> "No there's been a undersupply for about 5-6 years, … the main of cause of the problem has been … [the] massive push, by, advisory authorities telling them they had to incorporate it." (Cam Straw Merchant 5)

This reveals a potential disjuncture between the roles and interests of agronomists and straw merchants. Agricultural advisory services and regulators who have shifted advice towards incorporation influence the ability of straw merchants and contractors to enable baling. Equally, this highlights a broader set of tensions between agricultural and bioenergy policy, which has been a key influence on efforts to develop biofuels and bioenergy in the UK (Thornley, et al., 2009). The former favours incorporation as part of a future orientated strategy to increase/maintain soil health as part of long term environmental and sustainability objectives (see HM Government, 2018), while bioenergy policy works against this grain, potentially incentivising increased levels of straw baling and the removal of organic matter from soils.

Nevertheless, straw incorporation is not a straightforward and problem free option. The farmer and the agronomist must attempt to tailor the management practices to ensure straw decomposes as desired. This can be navigated in different ways:

> "... you get slabby straw on the eastern … you get worse slugs so, … it's not the best thing to happen really so getting a good nice mix [during cultivation is needed]" (Hum Agronomist 1).

…

> "If it's wet weather it's better being baled if it's possible, erm because if it goes in the ground it sits there sour and nothing happens." (Cam Straw Merchant 5).

Straw that does not decompose properly, described here as 'slabby' or 'sour' straw, can occur when straw is ploughed at an inappropriate depth often in wet ground. Its impact is not trivial, potentially reducing vigour and yield of the following crop (Kumar & Goh, 1999). However, the quotes above point to different management options; clearly informed by the actors' respective positions in the arable production chain. The managerial choice ultimately rests with farmers, who typically position any advice in relation to their own experiential understandings (Oreszczyn, et al., 2010) of the respective risks and benefits of a particular straw management practice.

These types of value judgement were present in other aspects of management that have implications for straw. Soil compaction, a well acknowledged phenomenon in the literature (Soane & van Ouwerkerk, 1995; DEFRA, 2003; DEFRA, 2015) was a major cause for concern in relation to baling. Numerous passes over the field with baling and straw gathering equipment were seen to increase the risk of compaction of the soil. The judgement often swayed strongly in favour of incorporation in instances of wet weather, both due to the desire to reduce compaction risk but also the pressure to ensure the timely establishment of the following crop in optimum conditions. All interviewed straw merchants outlined the weather as a major driver of their job and determinant of market supply, both nationally and internationally. This research highlights soil is an object of active management and assessment with implications for whether farmers are influenced by agronomists to incorporate or straw contractors and merchants to bale. This has generated tension between different intermediaries with different interests in straw and on-farm roles attempting to influence farmers in different directions.

A recent article for instance seems to indicate that incorporation of straw is a much-valued practice with a number of farmers being unwilling to sell straw they currently incorporate regardless of the price (Townsend, et al., 2018). This suggests that even in times of serious stress in the straw market,

where high prices might be assumed to incentivise straw baling, there is a more limited capacity to bring straw to market than otherwise anticipated. It is likely that agronomists advising farmers to incorporate straw to protect soil health, key to the productive base of farming, are influential in this trend. How these tensions between agronomists and a more professional contracting industry play out over the long term are likely to have significant implications for bioenergy production in the UK. In particular, if a trend towards straw incorporation for environmental and business reasons reduces the overall availability of straw this might limit the attractiveness of the UK as a place for future investments in bioenergy, as well as the willingness of straw merchants to sign up to supply prospective plants.

6 Discussion & Conclusion

Since the data collection in 2013-2014 the straw based bioenergy sector has continued to expand in the UK. In addition to Ely power station (Melton Renewable Energy PLC, 2016), two further straw burning plants, each consuming around 200,000 tonnes of straw a year have opened (Glennmont Partners, 2014; Brigg Biomass, 2017). The Renewable Heat Incentive has also been important in incentivising smaller scale domestic and non-domestic investments in biomass boilers (Department for Business, Energy & Industrial Strategy, 2017) which usually run on straw and/or wood pellets. In both cases, large scale power stations and small scale heating, the ability to reliably and affordably secure biomass feedstock has been noted as a barrier to future expansion (DECC, 2016; DEFRA, 2019). However, there is nothing to suggest that the roles agricultural intermediaries play in straw-based supply chains, their influence on other actors, and the implications of this for straw-based bioenergy, which we examine in this article, will have changed as a result of these more recent developments. If further expansion of UK bioenergy production, utilising domestic biomass such as straw, is to remain a policy ambition, then our research findings suggest that engagement with merchants and contractors is likely crucial to any effort to address these supply concerns. Their role providing a significant proportion of the labour and machinery required to make straw a tradable

commodity and brokering its trade between producers and end users means they are integral to straw supply markets. As the responses from existing bioenergy industry representatives suggests, enrolling these actors into bioenergy developments at an early stage is crucial. Firstly, it is necessary to securing financial backing of new projects by demonstrating the sufficient straw can be sourced. Secondly, during operation these intermediaries' source and supply the majority of the necessary feedstock. Furthermore, they influence individual farmers and the wider community to use their services and bale straw through building networks of trust, demonstrating professionalism and competence and expertise. This is particularly important given the different power dynamics of the straw market, in comparison to primary agricultural commodity markets.

Notably, straw has in-field and market value which mean farmers are presented with a choice over how to use straw which is not the case for example with oilseed or grain crops. Additionally, as a bi-product the sale of straw is not necessarily fundamental to the financial viability of the farm, has value in soil management and incorporation does not require additional specialist equipment to undertake. In this context, baling contractors and straw merchants are not in a privileged position providing services that farmers cannot do without, but rather have to incentivise farmers to bale. Given the baling is not without its own set of risks and costs, trust between farmers and baling contractors is key. Trust that they have the capacity and skill to remove straw quickly, without unduly compacting soil, introducing weed seed from other farms or disrupting other in-field operations needed to establish the next crop. Maintaining or even growing the straw market to accommodate further bioenergy developments therefore relies on the social labour undertaken by these intermediaries to continue influencing on-farm straw management practices in a direction that favours baling over incorporation into soil.

To date, bioenergy expansion in the UK suggests that contractors and merchants have been broadly willing to engage with bioenergy developments. However, it cannot be assumed that these intermediaries' interests will always align the expectations of bioenergy policy and the needs of new

entrants to the market. In situations where supply shortages require intermediaries to disrupt existing, well established networks of inter-relations with farmers (both suppliers and buyers) there will likely be considerable tensions. Straw sold for bedding and feed to livestock farmers will likely remain the core market for straw in the UK. At the time the interviews were undertaken some merchants had already made the choice preferring dealing with farmers than establishing contractual relationships with bioenergy producers. These choices might be linked to bioenergy producers being high quantity but low cost buyers and therefore being unable to outcompete livestock farmers for straw for whom it is a smaller proportion of input costs (National Farmers Union, 2014). Alternatively it might be linked to the bioenergy market being reliant on government regulatory and incentive regimes for commercial viability and therefore it being potentially an unreliable long term market. However, it is important not to overlook that these relationships with farmers (suppliers and buyers) were not simply commercial but inter-personal, informal, often very long standing and consequently highly resilient. A situation demonstrated through some merchants protecting these relationships from the sometime volatility in the straw market, such as that caused by international exporters.

The resilience of these well-established networks maintained by merchants offers both benefits and problems for the bioenergy sector. Problems in situations where a straw supply shortage requires bioenergy producers to source straw from outside of their own supply networks and attempt to disrupt others. Benefits in that where relationships with intermediaries develop over longer timeframes and on the basis of repeated interactions these same mechanisms for maintaining the resilience of established supply networks in the face of policy and market variability might also benefit bioenergy producers. However, in either instance, it is important to recognise that the relation of power potential favours intermediaries over bioenergy producers because there is a diverse market for straw in agricultural sectors. Furthermore, whether this resilience is a consequence of numerous reoccurring engagements over time and whether it can also be cultivated in instances where middle actors primarily provide one-off purchase of goods or services rather than

repeat business, as might be the case for home installers or craftspeople, is a broader question of future research interest given its potential importance for maintaining momentum in the face of policy or market volatility.

The role and influence of agronomists within straw-based supply chains as highlighted by our analysis also raises a set of reflections for the wider literature. Whether focusing on organisations producing energy standards (Parag & Janda, 2014), or installers (Wade, et al., 2016) and craftspeople (Fyhn, et al., 2019) providing products and services, these intermediaries are directly involved in the network of actors delivering particular energy agendas. In the context of straw-based bioenergy policy agronomists are currently perceived, and treated, as peripheral to these goals. They do not provide labour and machinery to bale or incorporate the straw, they are not enrolled by bioenergy producers within their supply chains, and policy has not engaged with advisory services in a meaningful way to deliver its bioenergy ambitions. However, these intermediaries are active participants in shaping straw-based bioenergy through providing valuable knowledge and expertise to farmers including on soil health and management with consequences for whether straw is used in-field. Similarly, the existing literature on agronomists suggests they are highly trusted actors, interacting with farmer's overtime and providing advice on a range of regulatory, crop management and business issues. These actors, despite being outside the supply chain, exert sideways influence on straw merchants and contractors through role advising farmers to incorporate straw for soil management. Consequently, a disjuncture between broader agricultural and environmental policy, and bioenergy policy, which have each mobilised straw differently to meet their objectives, plays out in the tensions between different intermediaries enrolled (directly or indirectly) in delivering these agendas. These tensions between intermediaries and the pressure to which they are responding, might have long terms implications for straw supply and suggest that the amount of available straw is less than previously anticipated (Townsend, et al., 2018).

Furthermore, our findings have relevance to bioenergy policy beyond a focus on straw-based supply chains alone. UK bioenergy policy makers are not just concerned with a straw-based bioenergy sector but continue to anticipate and model explosive growth of dedicated non-food energy crops to supply further bioenergy expansion (DECC, et al., 2012; Committee on Climate Change, 2018). Different scenarios have suggested that between 500,000 ha (DECC, et al., 2012) to 1 million ha (Committee on Climate Change, 2018) might be possible under different economic and environmental conditions. The well documented reticence of farmers to adopt energy crops (Convery, et al., 2012; Sherrington, et al., 2008; Tate, et al., 2012) suggests that without major policy changes, this remains largely a fantasy[1].

The analysis presented here contributes further insights into the failure of purpose grown energy crops that expand the scope beyond the farmers themselves to understand the difficulties this emergent market has faced. Intermediaries, such as contractors in the energy crop sector have struggled to remain solvent. This is particularly damaging because contractors, not farmers, have largely owned and operated the modified equipment that is used to plant and harvest Miscanthus and short rotation coppice trees. Uncertainty around the continued presence of these key actors has unsurprisingly been reported as a barrier to adoption (Adams & Lindegaard, 2016). That these actors have fallen through the gaps in the policy incentive regime and academic accounts, which have targeted bioenergy producers and the farmers, is likely a contributory factor to these uncertainties. Ensuring a strong, professional, and capable set of intermediaries is therefore an important component in translating demand into bona fide supply and incentivising farmers to enrol in the energy crop market.

Finally, the analysis provides key findings and directions for policy makers envisaging a bioenergy supply chain based upon securing feedstock supply from multiple individual farm businesses. First,

[1] The UK area planted with these crops has hovered around 10,000 hectares since 2009 (DEFRA, 2019)

policy makers must engage and understand the numerous behavioural, as well as market, drivers that lie behind on-farm decision making with respect to feedstock supply for bioenergy through understanding farm-level influences and influencers. Second, recognition, and understanding, of the role of agronomists, contractors and merchants, must be fully understood and appropriately captured, in order to ensure that the perceived competing demands of these actors appropriately inform policy formulation and implementation. Third, in order to overcome the challenge of re-directing feedstock supply form current uses towards bioenergy purposes, regulatory and policy certainty must be provided to all actors in the supply chain to provide confidence of market security for future feedstock supplies. In conclusion, policies that fail to acknowledge the need to provide well-founded incentives that work for all actors in the bioenergy supply chain, and support the development of committed and well-resourced intermediaries, with associated regulatory frameworks, are more likely to fail in their ambitions to develop a bio-energy supply base, than polices that take a more holistic perspective, as argued herein.

References

Adams, P. & Lindegaard, K., 2016. A critical appraisal of the effectiveness of UK perennial energy crops since 1990. *Renewable and Sustainable Energy Reviews,* Volume 55, pp. 188-202.

AEA, 2010. *UK and Global Bioenergy resource - Annex 1 report: details of analysis: Report to DECC,* Didcot, Oxfordshire: AEA Technology PlC.

Angell, B., Francis, J., Chalmers, A. & Flint, C., 1997. *Agriculture and the rural economy: Information and advice needs,* London: DEFRA.

Biomass Task Force, 2005. *Biomass Taskforce: Report to government,* London: Biomass Taskforce.

Braun, V. & Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3(2), pp. 77-101.

Brigg Biomass, 2017. *Brigg Renewable Energy Plant: Power for a Green Future.* [Online]
Available at: https://www.briggbiomass.com/
[Accessed 26 April 2017].

Bryman, A., 2012. *Social Research Methods.* 4th ed. Oxford: Oxford University Press.

Camia, A. et al., 2018. *Biomass production, supply, uses and flows in the European Union,* Brussels: European Commission.

Committee on Climate Change, 2018. *Biomass in a low-carbon economy,* London: Committee on Climate Change.

Convery, I., Robson, D., Ottitisch, A. & Long, M., 2012. The willingness of farmers to engage with bioenergy and woody biomass production: A regional case study from Cumbria. *Energy Policy,* Volume 40, pp. 293-300.

Cooper, O., 2018. *What to consider when selling straw for biofuel.* [Online]
Available at: https://www.fwi.co.uk/arable/sell-straw-biofuel-help-boost-wheat-margins
[Accessed 15 11 2019].

Copeland, J. & Turley, D., 2008. *National and regional supply/demand galance for agricultural straw in Great Britain: Report prepared for the National Non-Food Crops Centre,* York: Central Science Laboratory.

Crang, M. & Cook, I., 1995. *Doing Ethnographies.* Norwich: Geobooks.

Curry, N., 1997. Providing New Environmental Skills for British Farmers. *Journal of Environmental Management,* 50(2), pp. 211-222.

DECC, 2016. *Qualitative research with social housing providers,* London: Department of Energy & Climate Change.

DECC, DfT & DEFRA, 2012. *UK Bioenergy Strategy.* London: Department of Energy and Climate Change.

DEFRA, 2003. *Codes of good agricultural practice for the protection of water, air and soil: summary,* London: DEFRA.

DEFRA, 2009. *Protecting our Water, Soil and Air: A Code of Good Agricultural Practice for farmers, growers and land managers,* London: The Stationary Office.

DEFRA, 2013. *Area of Crops Grown for Bioenergy in England and the UK: 2008-2012 - Experimental Statistics,* London: DEFRA.

DEFRA, 2014i. *Contracting on English farms: evidence from existing surveys - Defra Agricultural Change and Environment Observatory Research Report No. 35,* London: DEFRA.

DEFRA, 2014ii. *Farm Classification in the United Kingdom,* London: DEFRA.

DEFRA, 2015. *Cross compliance in England: soil protection standards,* London: DEFRA.

DEFRA, 2019. *Crops Grown For Bioenergy in the UK: 2017,* Bristol: Department for Environment Food & Rural Affairs.

DEFRA, DTI & DfT, 2007. *UK Biomass Strategy.* London: Department for the Environment, Food and Rural Affairs.

Department for Business, Energy & Industrial Strategy, 2017. *RHI Evaluation: Synthesis: A report by Frontier Economics,* London: Department for Business, Energy & Industrial Strategy.

European Commission, 2005. *Communication from the Commission - Biomass action plan {SEC(2005) 1573} ,* Brussels: European Commission.

European Union, 2018. *Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources,* Brussels: Official Journal of the European Union.

Fyhn, H., Søraa, R. & Solli, J., 2019. Why energy retrofitting in private dwellings is difficult in Norway: Coordinating the framing practices of government, craftspeople and homeowners. *Energy Research & Social Science,* Volume 49, pp. 134-142.

Giannoccaroa, G., de Gennaro, B., De Meo, E. & Prosperib, M., 2017. Assessing farmers' willingness to supply biomass as energy feedstock: Cereal straw in Apulia (Italy). *Energy Economics,* Volume 61, pp. 179-185.

Glennmont Partners, 2014. *Sleaford Renewable Energy Plant: About Sleaford REP.* [Online] Available at: http://www.sleafordrep.co.uk/?page_id=817 [Accessed 12 January 2016].

Glithero, N., Ramsden, S. & Wilson, P., 2013ii. Barriers and incentives to the production of biothanol from cereal straw: A farm business perspective. *Energy Policy,* Volume 59, pp. 161-171.

Glithero, N., Wilson, P. & Ramsden, S., 2013i. Straw use and availability for second generation biofuels in England. *Biomass and Bioenergy,* Volume 55, pp. 311-321.

Haign, T. et al., 2015. Agricultural Advisors as CLimate Information Intermediaries: Exploring Differences in Capacity to Communicate Climate. *Weather, Climate, and Society,* Volume 7, pp. 83-93.

Harrions, R. et al., 2014. *Wasted: Europe's untapped resource,* Berlin: The International Council on Clean Transportation.

Harris, F. & Lyon, F., 2008. Combining scientific and lay knowledges - Participatory approaches to research in organic farming. In: R. Fish, S. Seymour, M. Steven & C. Watkins, eds. *Sustainable farmland management: new transdiscplinary approaches.* Wallingford: CABI International, pp. 94-106.

HM Government, 2018. *A Green Future: our 25 Year Plan to Improve the Environment,* London: Department for Environment, Food and Rural Affairs.

HM Government, 2019. *Estimates of the areas of crops grown in England and the UK for bioenergy..* [Online]
Available at: https://www.gov.uk/government/statistics/area-of-crops-grown-for-bioenergy-in-england-and-the-uk-2008-2017
[Accessed 03 July 2019].

Ilbery, B., Maye, D. & Little, R., 2012. Plant disease risk and grower-agronomist perceptions and relationships: an analysis of the UK potato and wheat sectors. *Applied Geography,* Volume 34, pp. 306-315.

Ingram, J., 2008. Agronomist-farmer knowledge encounters: An analysis of knowledge exchange in the context of best management practices in England. *Agriculture and Human Values,* 25(3), pp. 405-418.

Ingram, J. & Mills, J., 2019. Are advisory services "fit for purpose" to support sustainable soil management? An assessment of advice in Europe. *Soil Use and Management,* 35(1), pp. 21-31.

Ingram, J. & Morris, C., 2008. The knowledge challenge within the transition towards sustainable soil management: an analysis of agricultural advisors in England. *Land Use Policy,* Volume 86, pp. 214-228.

Janda, K. & Parag, Y., 2013. A middle-out approach for improving energy performance in buildings. *Building Research & Innovation,* Volume 41, pp. 39-50.

Joffe, H. & Yardley, L., 2004. Content and thematic analysis. In: D. Marks & L. Yardley, eds. *Research Methods for Clinical and Health Psychology.* London: Sage Publications Ltd, pp. 56-68.

Juntti, M. & Potter, C., 2002. Interpreting and Reinterpreting Agri-Environmental Policy: Communication, Trust and Knowledge in the Implementation Process. *Sociologia Ruralis,* Volume 42, p. 215–232.

Kivimaaa, P. & Martiskainen, M., 2018. Dynamics of policy change and intermediation: The arduous transition towards low-energy homes in the United Kingdom. *Energy Research & Social Science,* Volume 44, pp. 83-99.

Kumar, K. & Goh, K., 1999. Crop Residues and Management Practices: Effects on Soil Quality, Soil Nitrogen Dynamics, Crop Yield, and Nitrogen Recovery. *In Advances in Agronomy,* Volume 68, pp. 197-319.

Lowe, P. et al., 1993. Regulating the new rural spaces: uneven development of land. *Journal of Rural Studies,* 9(3), pp. 205-222.

McDermott, C., 2012. Trust, legitimacy and power in forest certification: A case study of the FSC in British Columbia. *Geoforum,* 43(3), pp. 634-644.

Melton Renewable Energy PLC, 2016. *Ely Power Station.* [Online]
Available at: http://www.mreuk.com/ely-power-station
[Accessed 26 April 2017].

Meyer, A., Ehimen, E. & Holm-Nielsen, J., 2018. Future European biogas: Animal manure, straw and grass potentials for sustainable European biogas production. *Biomass and Bioenergy,* Volume 111, pp. 154-164.

Mohr, A., Shortall, O., Helliwell, R. & Raman, S., 2016. How should land be used?: bioenergy and responsible innovation in agricultural systems. In: I. Gordon & H. Prins, eds. *Food Production and Nature Conservation: Conflicts and Solutions..* London: Earthscan (Routledge), p. In Press.

Montforti, F., Bodis, K. & Scarlat, N. D. J.-F., 2013. The possible contribution of agricultural crop residues to renewable energy targets in Europe: A spatially explicit study. *Renewable and Sustainable Energy Reviews,* Volume 19, pp. 666-677.

Morris, C., 2006. Negotiating the boundary between state-led and farmer approaches to knowing nature: an analysis of UK agri-environment schemes. *Geoforum,* 37(1), pp. 113-127.

Moss, S., 2013. *Black-grass - Everything you really wanted to know about Black-grass but didn't know who to ask?,* Harpenden: A Rothansted technical publication.

Nakada, S., Saygin, D. & Gielen, D., 2014. *Global Bioenergy Supply and Demand Projections: A working paper for REmap 2030,* Bonn: International Renewable Energy Agency.

National Farmers Union, 2014. *Eco2 answers local livestock producers' concerns regarding the proposed Mendlesham straw fired power station.* [Online]
Available at: https://www.nfuonline.com/straw-faqs-final
[Accessed 15 11 2019].

Oreszczyn, S., Lane, A. & Carr, S., 2010. The role of networks of practice and webs of influencers on farmers' engagement with and learning about agricultural innovations, In. *Journal of Rural Studies,* 26(4), pp. 404-417.

Parag, Y. & Janda, K., 2014. More than filler: Middle actors and socio-technical change in the energy system from the "middle-out". *Energy Research & Social Science,* Volume 3, pp. 102-112.

PricewaterhouseCoopers, 2017. *Sustainable and optimal use of biomass for energy in the EU beyond 2020,* Brussels: European Commission.

Rocher, L. & Verdeil, E., 2019. Dynamics, tensions, resistance in solar energy development in Tunisia. *Energy Research & Social Science,* Volume 54, pp. 236-244.

Scarlat, N., Martinov, M. & Dallemand, J.-F., 2010. Assessment of the availability of agricultural crop residues in the European Union: Potential and limitations for bioenergy use. *Waste Management,* Volume 30, p. 1889–1897.

Sherrington, C., Bartley, J. & Moran, D., 2008. Farm-level constraints on the domestic supply of perennial energy crops in the UK. *Energy Policy,* 36(7), pp. 2504-2512.

Soane, B. & van Ouwerkerk, C., 1995. Implications of soil compaction in crop production for the quality of the environment. *Soil and Tillage Research,* 35(1-2), pp. 5-22.

Stephens, N., 2007. Collecting data from elites and ultra elites: Telephone and face-to-face interviews with macroeconomists. *Qualitative Research,* 7(2), pp. 203-216.

Stoate, C. et al., 2019. Participatory research approaches to integrating scientific and farmer knowledge of soil to meet multiple objectives in the English East Midlands. *Soil Use and Management,* 35(1), pp. 150-159.

Strauss, A., 1987. *Qualitative Analysis For Social Scientists.* Cambridge: Cambridge University Press.

Sutherland, L.-A.et al., 2013. Considering the source: Commercialisation and trust in agri-environmental information and advisory services in England. *Journal of Environmental Management,* Volume 118, pp. 96-105.

Tate, G., Mbzibain, A. & Ali, S., 2012. A comparison of the drivers influencing farmers' adoption of enterprises associated with renewable energy. *Energy Policy,* Volume 49, pp. 400-409.

Thornley, P., Upham, P. & Tomei, J., 2009. Sustainability constraints on UK bioenergy development. *Energy Policy,* 37(12), pp. 5623-5635.

Townsend, T. et al., 2018. Wheat straw availability for bioenergy in England. *Energy Policy,* Volume 122, pp. 349-357.

Tsouvalis, J., Seymour, S. & Watkins, C., 2000. Exploring knowledge-cultures: precision farming, yield mapping, and the expert - farmer interface. *Environment and Planning A,* Volume 32, pp. 909-924.

Voytenko, V. & Peck, P., 2012. Organisational frameworks for straw-based energy systems in Sweden and Denmark. *Biomass and Bioenergy,* Volume 38, pp. 34-48.

Wade, F., Hitchings, R. & Shipworth, M., 2016. Understanding the missing middlemen of domestic heating: Installers as a community of professional practice in the United Kingdom. *Energy Research & Social Science,* Volume 19, pp. 39-47.

Ward, N., 1995. Technological change and the regulation of pollution from agricultural pesticides. *Geoforum,* Volume 26, pp. 19-33.

Weiser, C. et al., 2014. Integrated assessment of sustainable cereal straw potential and different straw-based energy applications in Germany. *Applied Energy,* Volume 114, pp. 749-762.

Williams, D., 2018. *First French straw-fuelled biomass plant set for 2019 debut.* [Online] Available at: https://www.powerengineeringint.com/articles/decentralized-energy/2018/03/first-french-straw-fuelled-biomass-plant-set-for-2019-debut.html [Accessed 2019 07 02].

Wilson, S. & Maclean, R., 2011. *Research methods and data analysis for Psychology.* London: McGraw-Hill.