Should the Government continue to encourage the burning of straw?

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Abstract

In 2002 the UK Government introduced the Renewables Obligation, a statutory duty placed on electricity supply companies to obtain an increasing proportion of their electricity from renewable sources (Boyle, 2004 p417). These regulations have encouraged coal fired power stations such as Drax in North Yorkshire to burn cereal straw and other biomass, now up to 10% of their fuel mix. Drax is currently lobbying for continued and increased subsidy to enable them to burn greater volumes of straw (Guardian, 2011).

However, if decarbonisation is a main priority, should support be switched to encourage more building with straw? If soil health and food security are main priorities, should support be switched to encourage the return of straw to farmland?

Straw is often described as an agricultural waste or by product – this is definitely not the case. Incorporating straw back into the soil has useful nutrient, carbon and, most importantly, soil structure benefits. Straw or manure combined with biochar may provide even greater benefits in the future.

Building with straw has three environmental advantages; carbon is sequestered in the built environment; less energy is used than would be to make conventional building materials and less energy is needed for heating and cooling due to the exceptional thermal performance of rendered straw bales.

Replacing fossil fuels with biomass can decarbonise electricity generation but biomass must be more carefully defined. Energy crops are more efficient in terms of land use and can also sequester carbon in their extensive root systems. Financial support should be targeted at energy crops and straw should be excluded because it can be put to better use in soil and buildings - unless energy generation becomes much more efficient. Losing 70% of the energy in any fuel is totally unacceptable. Perhaps subsidies should consider what comes out of a power plant, in addition to what feeds into it?

Keywords straw building, carbon sequestration, soil structure, biochar

1. Introduction

The urgent challenge of the 21st century is to reduce the concentration of carbon dioxide (CO_2) in the atmosphere. This can be achieved by greater energy efficiency, by switching to renewable energy sources and by carbon sequestration.

Agriculture, construction and power generation are very different industries trying to rise to this challenge whilst providing more food, shelter and energy for a growing population. Straw can be used to aid decarbonisation in all three industries – each is busy making its individual case. The aim of this review paper is to begin a cross-sector comparison.

The UK grows just short of 2 million hectares (ha) of wheat and 1 million ha of barley (Defra, 2011). Yields of straw vary according to season, variety and agricultural practice but a reasonable estimate of the annual straw resource is 10 million tonnes (t) - an average yield of 3.3t/ha. Straw is either chopped as it leaves the harvester or it is baled and led off the field. Currently 40% of the annual straw resource is chopped in the field and 30% is used for animal feed and bedding (Biomass Energy Centre, 2011).

2. Carbon in straw and potential decarbonisation

Through the process of photosynthesis cereal plants absorb CO_2 from the atmosphere as they grow. There is approximately 400 kilograms (kg) of carbon (C) in each tonne of fresh straw. What happens to the C in straw when it is added to farm land, used for building or used to generate power?

Straw chopped behind the harvester is usually ploughed straight back into the soil and straw used for feed or bedding finds its way back to the field as farmyard manure. As straw decomposes most of its C is released back to the atmosphere as CO_2 but approximately 22% of C in straw is retained in the soil (Goulding, 2010).

The simplest way to build with straw is to stack bales of it to form a wall and then render it on both sides to provide fire protection. A well designed and constructed straw bale building can last hundreds of years (King, 2006). Therefore 100% of the C in straw is locked away in the built environment - indefinitely.

When straw is burned in a power station, *all* the C it contains recombines with oxygen and returns to the atmosphere as CO_2 (Boyle, 2004 p109).

Figure 1 illustrates the amount of carbon that can be removed from the atmosphere when straw is returned to soil, built with or burned.

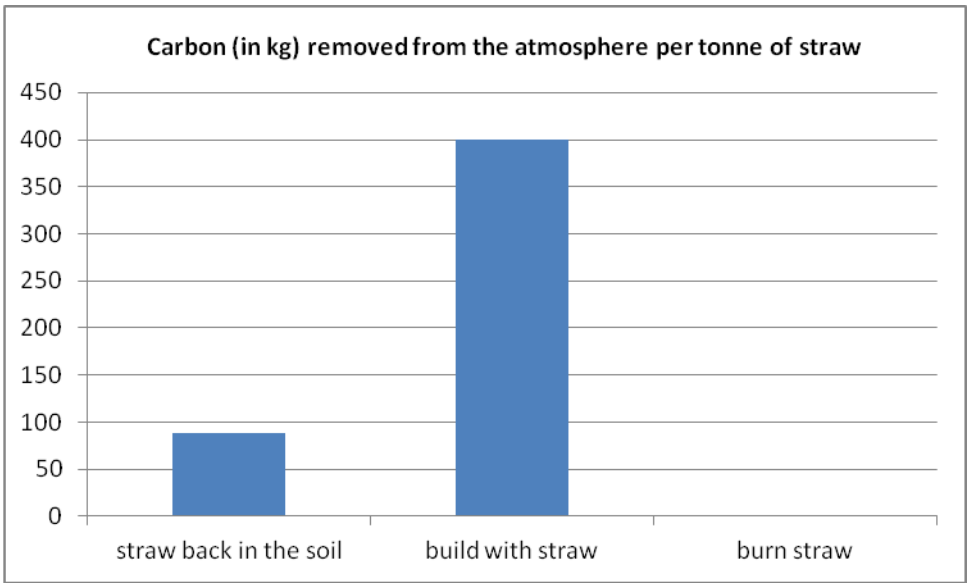

Figure 1 - Decarbonisation by use of straw

It is clear that if decarbonisation is a key priority, straw should be used to sequester C in buildings. There is no huge investment or fancy technology need to do this. The techniques

are simple and well established. There are also two significant energy efficiency benefits of using straw;

1. Using straw as a building material displaces conventional high embodied energy building materials such as bricks, blocks or polystyrene (Atkinson, 2011).

2. A rendered straw bale wall provides excellent insulation and other thermal benefits such as mass and air tightness (Atkinson, 2008). A well designed straw bale building therefore, can significantly reduce the energy needed for heating or cooling.

However, there are other issues to consider. Straw is a very important resource for farmers and burning straw could have some merits.

3. The importance of straw to agriculture

Only 4.2% of UK farmland is now managed organically (Soil Association, 2011). Although organic certification is not the only guarantee of a farmer's soil health awareness, this low percentage does highlight a trend. Farmers have become increasingly dependent on manufactured inputs and the art of soil husbandry is being lost.

Straw contains phosphorous (P) and potash (K). When straw is used with livestock the resultant farmyard manure contains nitrogen (N), other micronutrients and increased levels of P, excreted by the animals. Returning straw, especially manure, to farm land implies a reduction of upstream CO_2 emissions from fertiliser production.

When straw is added to farm land, microorganisms decompose it to stable, soil organic matter (SOM). It is the SOM that contains the 22% C sink discussed above. SOM also serves as a reservoir of nutrients and water and it provides a network of air spaces – all highly beneficial to plant growth. Raising levels of SOM will also improve resilience to climate change, helping crops to endure periods of drought and high rainfall alike (Defra, 2009).

Rebuilding SOM on degraded arable soils is a long term process. There are a number of ways to achieve this but encouraging a return to straw incorporation is a relatively simple step (Parliamentary Office of Science and Technology, 2006). Research suggests that removing straw once every three years may not have a negative effect on the long term build up of SOM (Paterson, 2011). Therefore a third of the UK annual straw resource, just over 3 million tonnes, could be available for building or burning annually.

4. Burning straw

The energy content of straw (harvested and baled) is 15 Giga joules per tonne (GJ/t) and that of coal (UK average) is 28 GJ/t (Boyle, 2004 p 110). Therefore, approximately 2t of straw is needed to displace 1t of coal in a coal fired power station such as Drax. The CO_2 emissions from burning 2t straw or 1t coal are more or less the same. The difference is that the straw absorbed it's CO_2 from the atmosphere as it grew that year. Burning coal releases CO_2 stored millions of years ago - thereby increasing current day levels of the gas in the Earth's atmosphere.

This is the main justification used for burning straw. There is also an energy (and implied carbon) saving from mining and transporting less coal. Over 50% of coal used in 2010 was

imported to the UK (DECC, 2011), whereas straw is a locally grown source of biomass. However, there are much better local sources.

Specialist energy crops such as miscanthus or willow grown as short rotation coppice can yield over ***3 times*** the quantity of biomass per ha that cereal crops can (Biomass Energy Centre, 2011). In addition, they can grow on marginal land and once established they grow continually for 20-30 years, needing no annual, energy intensive soil preparation or manufactured inputs - simple and energy efficient.

Energy crops develop considerable root systems over this length of time which suggests significant below ground biomass - and carbon storage (Grogan & Mathews, 2001). So there is merit in the further development of energy crops for renewable fuel and below ground carbon sequestration. However, vast swathes of energy crops would bring unpopular changes to the landscape and there is competing demand for land for food production and biodiversity. It is vital, therefore, that energy crops are put to the most efficient possible use to minimise the acreage required.

In a power station the chemical energy in coal is converted to heat, then into the kinetic energy of the steam turbines and finally into electrical energy. Only 30-40% of the energy in the fuel emerges as electricity (Boyle et al, 2003 p93). Most of the 60-70% of the energy wasted is dumped into the sky from the cooling towers (Boyle et al. 2003 p114). New, purpose built power stations must be far more efficient. They must be close to the biomass source and close to a demand for both the heat *and* the power. In countries such as Denmark, heat from power stations is recycled into a massive network of insulated district heating pipes, greatly benefiting the Danish national energy balance (Boyle et al. 2003 p115).

Straw can be converted to energy by three thermochemical methods; direct combustion, gasification or pyrolysis. Direct combustion is the best route to maximise energy output - even though our current methods, as described above, are highly inefficient. Gasification can be used to produce liquid fuels which are difficult to make elsewhere in decarbonised energy scenarios (ZCB, 2010). Research is underway at the Biorefinery Centre, Institute of Food Research, Norwich (Farmers Guardian article 7/10/11 p17) into making bio-alcohols for the transport industry from plant material, including straw.

Pyrolysis is thermal decomposition in the absence of oxygen to produce syngas, pyrolysis oil and biochar (Hammond, 2010). Slow pyrolysis systems maximise char production which may prove useful as a soil amendment and for long term carbon sequestration. Hammond concludes that “pyrolysis biochar systems offer greater greenhouse gas abatement than any other use of biomass”. He included straw, energy crops and forestry residues but his assessment was limited to energy systems. Other uses of biomass particularly of straw, for agriculture or building, were not considered.

Biochar fresh from the kiln is sterile and when added to soil it will draw in and store nutrients at the expense of crops. However, if it is first “charged” with nutrients from compost (or manure), plants will thrive immediately (Bates, 2010 page 105). Biochar made from energy crops, mixed with straw based manure and applied to farmland could prove to be an important way to sequester large amounts of carbon, increase levels of soil organic matter, reduce fertiliser use and produce syngas and oil. Research is ongoing.

5. Conclusion

The introduction described a need for renewable energy sources, greater energy efficiency and carbon storage.

Straw is a source of renewable energy. Burning straw is a waste of that energy without significant investment in combined heat and power plants with an adjacent demand for heat. Carbon is cycled in and out of the atmosphere as the straw grows and burns. There is no permanent decarbonisation.

Retaining straw on farms is an energy efficient way to improve soil health, building resilience to climatic changes over the long term. There is some degree of decarbonisation. Straw should be returned to the soil at least two years in three. In the future, burning some straw to make biochar and returning it to soil along with straw based manure could raise levels of decarbonisation.

Building with straw reduces the demand for renewable energy sources by reducing the demand for heating and cooling over the life of the building. Straw bales have very low embodied energy compared to conventional building materials – another energy efficiency benefit. There is 100% decarbonisation.

Joined up thinking across sectors and across Government departments is required to ensure the best use of straw.

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