Potential new case study area assessment

Somerset Biomass Options Project

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Contents

1. Introduction

The objective of this assessment was to identify a potential new case study area in the southern Somerset Levels and Moors where a biomass to bioenergy scheme could be trialled. The intention was through a desk based study to look at the wider application of the ideas and proposals currently being progressed in the Brue Valley through the draft business plan[1] and see how such proposals could be replicated.

The business plan proposal considers an initiative to utilise wetland biomass, resulting from conservation and land management works as a bioenergy feedstock. The vision is to make operations more efficient and effective, thereby enhancing habitats for biodiversity, improving land for food production, whilst also reducing waste, serving the local communities and reaching out to new supporters. The scheme proposed through the draft business plan is the installation of a medium sized anaerobic digester (AD) with the utilisation of the heat and power generated through a combined heat and power unit, to run a separate plant producing biomass briquettes, with surplus electricity fed into the grid.

In the plan it is proposed that the scheme could be achieved by creating two separate companies: one running the AD plant and one manufacturing briquettes, this would enable the accommodation of different ownership options and income distribution between stakeholders and local communities.

This assessment will look to achieve the same vision, but through the utilisation of wetland materials off land in a variety of different ownerships, including that being produced off nature reserves and from land that is owned by private individuals.

2. Background

Habitat management on many nature reserves, and within the landscapes that they are located, generates unwanted biomass as a by-product. This material can significantly limit the quality and extent of the management that can be undertaken for both the benefit of biodiversity and the wider landscape area. Operations to ‘manage’ this material, together with the disposal of the resultant biomass, can incur a significant financial cost to organisations and land managers. Consequently, continuing to manage nature reserves and landscape areas in this way is not sustainable and an economically viable and ecologically sound solution is being sort.

So far the RSPB has been involved in the development and trial of a series of ‘conservation biomass to bioenergy’ approaches looking to convert this surplus material into bioenergy products.[2] Developing on from this they have been exploring different scenarios to see which could form a profitable business model which could help the RSPB to pay for more, and better conservation work. This assessment will use the knowledge and experiences gained through this work, and apply it to an area within the wider landscape of the Somerset levels and Moors.

It has been seen through the trials completed to date that converting biomass into bioenergy could offer the potential to create a financially sustainable approach to the management of nature reserves and the wider landscapes in which they sit. Working with neighbours (e.g. local farmers) and partners (i.e. other land managers who face similar challenges, e.g. Natural England) would provide the opportunity for a

[1] SRA funded project 2016
[2] DECC funded Wetland Biomass to Bioenergy Project (and other parallel initiatives, e.g. heathland trials)

landscape scale approach towards achieving more cost-effective management techniques, enabling more and better quality habitat management.

3. Energy Conversion Technology

Understanding the different conversion technologies available and their relationship to the types of biomass harvested off wetland sites and the time of year of the harvest is essential in making the right selection for each situation. The need to harvest at the appropriate time for the land management objectives will determine the biomass make-up and characteristics. The characteristics of the biomass itself will ultimately determine which are the most appropriate and efficient conversion techniques which can be employed to turn it into energy. For example it is widely accepted that woody biomass is generally not suitable for anaerobic digestion. The high lignin cellulose content of such materials which is difficult to break down and 'digest' is one of the governing factors and so the extent to which material contains lignin cellulose will affect its conversion into energy using anaerobic digestion.

Cutting biomass at different times of year can provide marked differences in its make-up and its suitability for potential conversion processes. For example in relation to combustion in 2010 Ash undertook moisture comparison studies with reed harvested in Sweden, from the Danube Delta and in Scotland from the Tay Estuary and he found that all showed a steady decline in the moisture content as the season progressed from May through to April. In these cases the reed was either being harvested for thatching or biomass combustion and harvesting was of the stems only (with panicles) with no litter collection. It was found that during January to April the moisture content of this material was typically around 15%, where as in December it was 38%.

By comparison in the case of feedstocks for anaerobic digestion Raj Akulain completed a study in Sweden and found that harvesting reed in October for biogas production, produced higher amounts of gas compared to reed harvested in August. His studies showed that there was a big difference in the amounts, with October producing the highest amount of gas at 107.9 l/kg wet weight compared to reed harvested in August which produced 60.6 l/kg wet weight. These findings were surprising as it would be expected that a later harvest may lead to material having an increased lignin content which it is thought to have a negative effect on gas production.

In addition on site conditions during the biomass harvest also need to be considered, these may alter the treatment and storage of the material and could even determine the energy conversion process which is most appropriate. This to a greater extent will probably be driven by site objectives; however weather conditions will also be a factor.

3.1. Anaerobic Digestion

Anaerobic digestion (AD) is the digestion of material in anaerobic conditions to produce biogas, which is then harvested and either cleaned and directly fed into the gas grid or converted through a combined heat and power plant to produce electricity and heat. AD can be used for processing green (vegetative) material, high in moisture content, ideally freshly harvested or if stored, stored as silage in the absence of oxygen. This process deals with green biomass well, and so is well suited to dealing with many of the wet grassland species found on nature reserves and farmland. However, the process can struggle with woodier material of high lignin content, such as common reed, and so briquetting this material is a more suitable option.

3.2. Briquetting

Briquetting is a process in which material is compacted under great pressure in a contained die / former to produce a product for combustion. The resulting briquettes can be used to replace logs, in a domestic environment, in log burners or open fires. Briquetting can be achieved in three ways and the choice of technique is particularly important in relation to the characteristics of the biomass being processed. As it is able to process woodier material well, it provides a complimentary energy conversion process to AD.

3.3. Feedstock supply

For any schemes looking at the conversion of biomass into energy, continuity of feedstock supply is one of the most important elements. An essential component of this is the identification of potential harvesting areas within an acceptable distance of the conversion process, to ensure the scheme is as economically viable and as carbon efficient as possible. Consistency and continuity of supply are important for anaerobic digesters. Unlike processing though combustion, AD needs a constant supply of material to maintain the activity of the micro-organisms and biogas production. To enable this continuity, materials will need to be cut and stored to provide a supply at times when material cannot be harvested e.g. through the bird breeding season.

3.4. AD operation – small and medium scale 7kW, 250kW and 500kW

The small and medium scale wet AD systems at 7kW, 250kW and 500kW identified are specified to take wet material annual amounts of 400, 3,500 and 7,000 wet tonnes respectively as illustrated below.

Per annum	7kW	250kW	500kW
Quantity of material processed (wet tonnes)	400	3,500	7,000
Equal to wet area of grassland[3] (ha)	100	875	1,750
Equal to area of reedbed[4] (ha)	40	350	700
Production of electricity (kWh-e)	53,956[5]	2,000,000[6]	4,000,000
Production of surplus heat[7] (kWh-th)	91,447[8]	1,300,000	2,600,000

3.5. Briquette manufacture

Effective briquette production relies on material being of a moisture content below 15%. This percentage increases the density at which the briquette can be produced, but most importantly its calorific value and burn efficiency rate – providing a higher quality product.

If the option to utilise the surplus heat from the AD to dry material for briquette manufacture is employed, then the ability to produce material of a consistent dry matter, which will aid the efficiency of the process,

[3] Assuming 4 wet tonnes per hectare
[4] Assuming 10 wet tonnes per hectare for reed cut in the summer months as a method of control rather than management.
[5] Based from figures from Qube Renewables
[6] Based on figures from Hallmark's modular AD, using material which generates 170m^3/t of gas at 53% methane.
[7] Available after parasitic load subtracted
[8] Heat output in hot water KWh heat which would raise 2870 litres of water from 10°C to 70°C per day = or 1,047m^3 of water per year

is increased. This surplus heat could be used to service a drying floor on which any material above the desired moisture content can be dried.

The auger screw briquette system[9] is able to convert approximately 1,500 tonnes of material of 15% moisture content or less, available annually. Unlike the AD operation the conversion of material through briquette production can be a little more flexible as it is not serving to support a living system

[9] http://www.en.asket.pl/biomasser_duo.html

4. Options of approach

4.1. Production of a combustion fuel

The most efficient way to produce energy from biomass is to use the material for combustion, which involves a simple number of steps which enable the burning of the material to produce heat. Depending on the market and the technology being used for the heat production will determine the processing steps required, but typically a method of compaction is used, to increase the calorific density, reduce friability and so conform to particulate matter amounts that are required under UK emissions standards. From the work done to date it has been shown that wetland materials can be converted into combustion fuels in the form of biomass briquettes. However the key to success is the ability to achieve a low moisture content, which is necessary for the compaction process, but also in the production of a fuel comparable in calorific value to other combustion fuels such as timber. The need to attain a moisture content of less than 15% often means that this technique may not be suitable for a number of wetland vegetation types, however for those species which die off significantly in the winter, such as common reed it has found to be an appropriate solution.

(See Appendix 1 for a comparison of essential properties of reed and rush briquettes with ENplus A2 and ISO 17225A/B standards for non woody briquettes).

4.2. Supply to large scale anaerobic digestion plants

Depending on material composition, time of harvest and tonnages produced, biomass generated from wetland management operations may be suitable for anaerobic digestion (AD). Although a landowner may not produce enough biomass to have their own plant, it is possible that the material they produce could supply an existing set up. If there is an existing large scale AD plant located within or adjacent to the local area, this option offers a straightforward, quick fix solution without the need for investment. If a tonnage payment can be secured and material hauled a short distance it could be a financially viable approach to land management.

For this option to be successful relationships need to be built with the AD plant operators, which will include developing their confidence in the performance of unconventional material and an understanding of some of the limitations posed when managing for different objectives, eg in relation to biodiversity the breeding season and seasonal flooding are just two factors which may need to be considered.

4.3. Small scale anaerobic digestion

This option offers a flexible, modular system which can be built to the appropriate size needed for biomass amounts available. It does not involve an external AD operator and so the land owner would be in control of the operation and the biomass utilisation, with the responsibility to store the feedstock and feed the system. There would be the need for upfront capital investment, but with potential returns from Government incentives.

4.4. Community Energy Scheme

The establishment of biomass to bioenergy community energy schemes is one option developed through the RSPB's Energy for Nature project[10] and which has been explored through the production of a draft business plan[11]. This option looks at the installation of a medium sized anaerobic digester (AD) with utilisation of the heat and power generated through a combined heat and power unit, to run a separate plant producing biomass briquettes, with surplus electricity fed into the grid. This is an approach that can deal with different biomass types with different characteristics. The two conversion operations proposed can provide the flexibility needed to deal with the variety of materials and harvesting times which can provide marked differences in the biomass characteristics and its suitability for each conversion process, as detailed in the previous section.

[10] DEFRA funded PES pilot project 2014/15
[11] Somerset Rivers Authority funded project 2015/16

5. Influencing factors considered

For the objective of seeking a new potential case study area a number of factors and associated issues were identified and then considered, these included:

5.1. Biomass potential

The location of sites within the context of the landscape, in relation to factors such as:

- Other large habitat areas, which have the potential to provide a suite of biomass feedstocks now and in the future, particularly in relation to continuity of feedstock supply.
- How issues such as water management regimes may influence their operation and biomass production now and in the future.

5.2. Current broad habitat types and biomass production

Identification of the broad habitat types within the area and the potential of these habitats to produce biomass at different yields from a generic perspective[12]. Consideration of how the characteristics of this biomass, eg moisture content, lignin percentage, may influence and direct their utilisation as a feedstock for bioenergy products. Identification of the amounts of material that is already available, without changing the direction or emphasis of the existing land management operations currently undertaken.

5.3. Site characteristics

The ability to utilise biomass being produced on sites as a bioenergy product, will be influenced by the characteristics of the site. This will include factors such as access, substrate, drainage, loading areas, haulage routes, which can all influence the way in which the biomass is produced, managed and then utilised. For example at the time of the harvesting season would the conditions be suitable for the material to be treated as hay, and so left to wilt and collected when dry, or do the site conditions demand that that material needs to be taken in one pass to avoid damage to the substrate. If the former then material might be suitable for combustion, if the latter then anaerobic digestion would probably be the best conversion process.

5.4. Need for diversification in land use

External factors, such as frequent flooding, lack of local graziers, may mean that land managers are looking for an opportunity to diversify their operation, which will help support their current management practices.

5.5. Proximity to feedstock/energy need

Identification of a nearby feedstock/energy need to the site, eg a residential area which could utilise bioenergy products or an existing energy producer which requires feedstock will have an impact of the ability to maximise the use of the material.

[12] See Section 6 and Appendix 2 for generic yields off different habitat types

5.5.1.Combustion

If the material is to be used for combustion, due to the small volumes, it is likely that it will be converted into combustion products, such as briquettes, chip or similar, rather than sent to a large scale combined heat and power (CHP) plant, which are not that common place in the southwest of England. It is therefore important that there are opportunities for these products to be marketed and sold locally.

5.5.2.Anaerobic digestion (AD)

As already described, depending on material composition, time of harvest and tonnages produced, the biomass may be suitable for AD. Although the landowner may not produce enough biomass to sustain their own plant, it is possible that they could supply an existing set up. The location of the large scale AD plant in relation to the place of the feedstock production, will determine whether setting up a supply arrangement is cost effective both in financial and carbon terms. If the plant is located within 20 miles from where the feedstock is to be harvested this has potential to offer a straightforward, quick fix solution without the need for investment and it is worth completing a basic cost benefit analysis.

In addition to the haulage of the material to the plant a number of other factors will need to be considered when completing such an analysis. Some of the variables which could affect the economic viability of this approach could be:

- Whether a tonnage payment for the material can be secured.
- The cost of current practice.
- The types of vegetation being harvested.
- The condition of the substrate and whether specialist machinery is needed.
- Whether transport is included in the tonnage payment or needs to be covered separately.

If a tonnage payment can be secured and material hauled a short distance it could offer good savings compared to current practice.

5.6. Location in relation to other potential feedstock producers

Consider whether there is the opportunity to work with other potential feedstock producers present in the local area, eg cheese farms[13]. Look at the location of the site in relation to the other producers, who may require additional feedstock, or who are looking to set up a conversion operation, within the wider landscape and if there is a potential to work in partnership.

5.7. Land held by landowners who have expressed a desire to explore new initiatives.

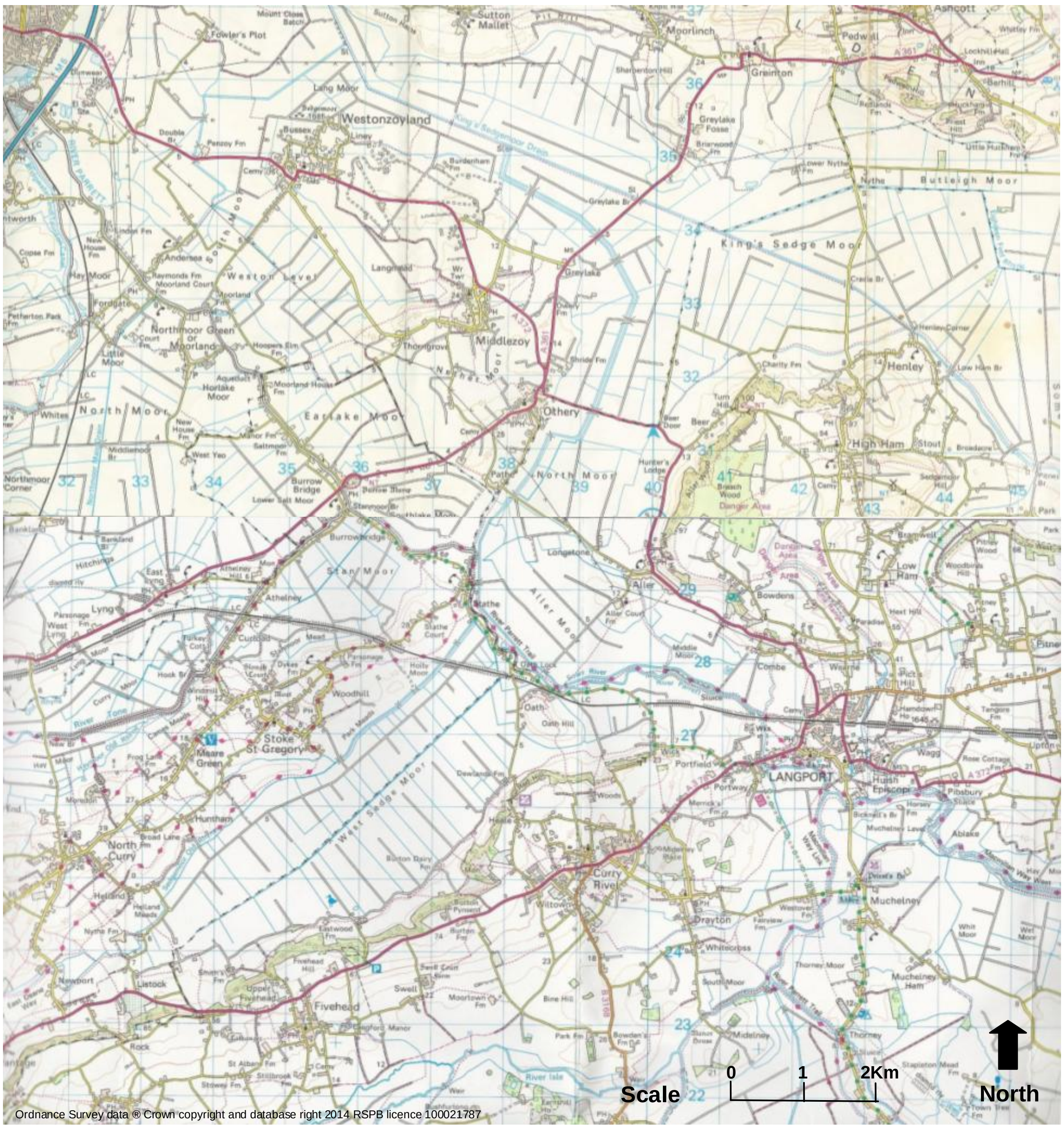
Having landowners present within the area who are looking to trial new initiatives, whether to support current practices or to find an alternative way of managing their land could facilitate the initiation of a new scheme.

[13] Eg Wyke Cheese Farms, Somerset, use a 1MW AD system to deal with all their cheese farm waste

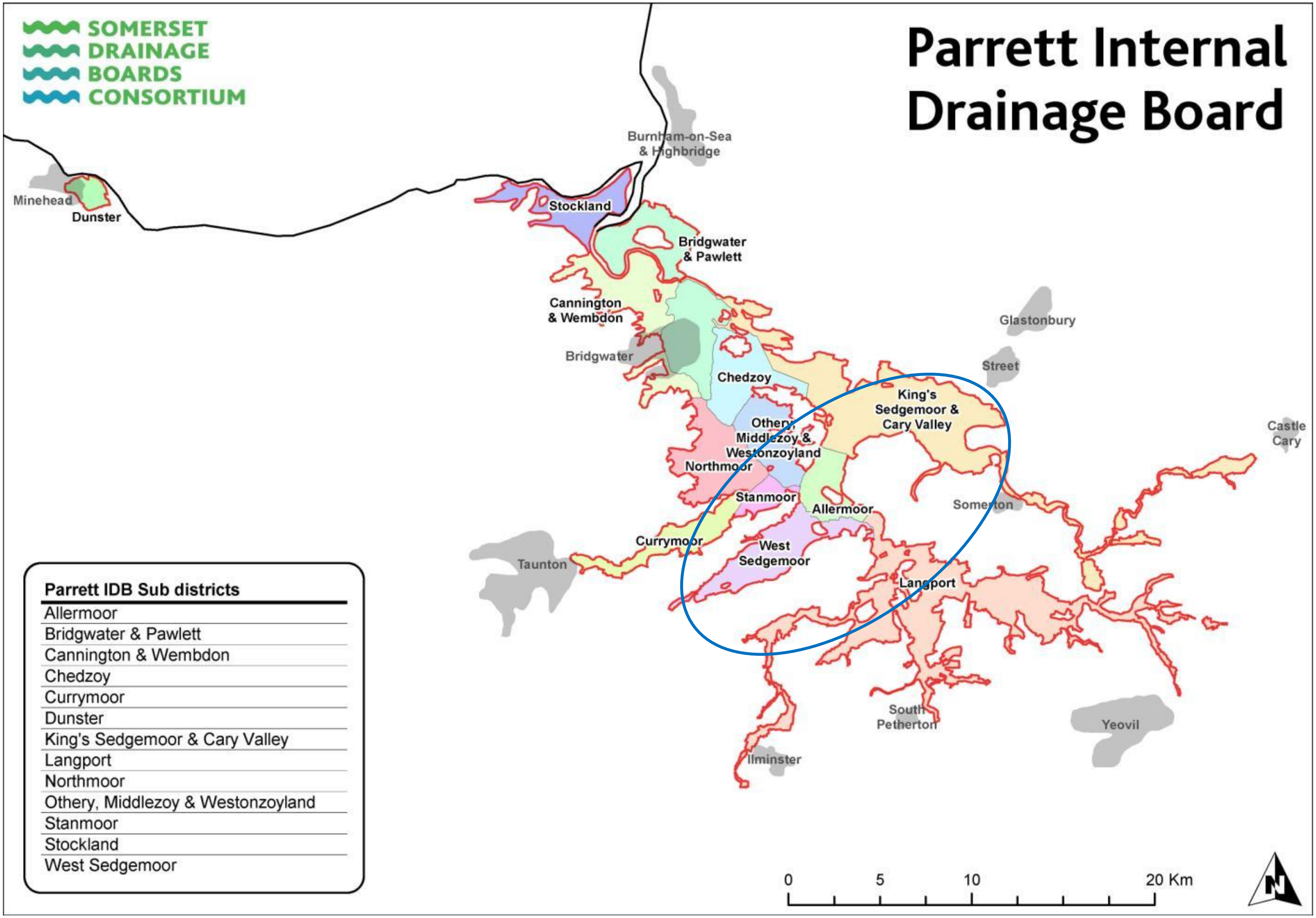
6. Area identified

6.1. Biomass potential

To identify a new potential case study site in the Southern Levels and Moors, the Lower Parrett Catchment and the large area of West Sedgemoor with the neighbouring town of Langport was selected as an appropriate focus area. West Sedgemoor is located between Stoke St Gregory to the north east and Curry Rivel to the south west. Over 522ha of this moor is under the management of the RSPB and as part of this management regime large volumes of biomass are currently being produced. In addition, the location of West Sedgemoor provides the potential opportunity to deliver a biomass to bioenergy approach with other large wet grassland sites within the landscape in the future. As illustrated on the map below, Aller Moor is adjacent to the North West, which leads through to King's Sedgemoor further north. It was considered that the total area covered by this suite of moors has the potential to offer a substantial selection of biomass types and amounts, within a 25km^2 area both now and in the future, with the opportunity for further expansion north of the King's Sedgemoor Drain.



Map illustrating location and drainage board boundaries of moors within the Parrett Catchment



6.2. Current broad habitat types and biomass production

The Somerset Levels and Moors covers some 55,000ha and are the largest area of lowland wet grassland remaining in England and one of the major inland wetland sites in the UK, good for breeding waders and an excellent example for delivery of birds and biodiversity. Some 6,300ha is internationally important, with significant areas being designated as SSSI/SPA and Ramsar sites.

To the north of the Polden Ridge; the floodplains of the Brue and the Axe cover some 30,400ha including the Avalon Marshes, a 1,500ha complex of wetland habitats, and grazing marshes which support wet grassland habitats.

To the south, the floodplains of the Parrett and Tone cover some 24,600ha; it is within this southern area that West Sedgemoor, Aller Moor and King's Sedgemoor are found.

6.2.1.Broad habitat types and information

In the floodplain grazing marshes of Aller Moor and King's Sedgemoor agriculture is the predominant and most extensive land use. Large areas of this land are divided into small fields which are typically separated by watercourses or a combination of hedge and watercourse. The linear networks of watercourses act as wet fences, and are used to provide drinking water for livestock. Livestock farming is the primary land use, with improved, semi-improved and unimproved grassland used for grazing and for winter fodder covering about 80% of the farmed area. The remaining 20% is in arable/grassland rotation. The livestock farming systems produce both food and is the mechanism for the wider land management which is crucial for delivering conservation outcomes, for example through agri-environment agreements.

West Sedgemoor SSSI (1000ha), to the south is part of the Somerset Levels and Moors SPA/RAMSAR floodplain situated between the low ridges of Stoke St Gregory to the North West and Fivehead & Curry Rivel to the south east. The RSPB Reserve in this areas comprises 522ha of low lying wet grassland, which is a mosaic of unimproved neutral coastal and floodplain grazing marsh, unimproved neutral lowland meadow, semi-improved neutral grassland, together with a small area (42ha) of swamp (fen, carr, marsh, reed). The reserve also has 60ha of neutral/calcareous grassland and semi-natural ancient woodland on the Fivehead & Curry Rivel ridge.

In summary the following broad habitat types can be identified:

Area	Habitat type	Dominant biomass type	Hectares (approx)	No of major landowners (over 20ha)	No of major landowners (over 40ha)	Comments
West Sedgemoor	Neutral lowland wet grassland. Fen marsh & swamp	Wet grassland species such as rush (*Juncus effusus*, *subnodulosus acutiflorus)* Swamp species such as *glyceria* and *carex.*	1,000	12	4	Complex mosaic of unimproved neutral coastal and floodplain grazing marsh, MG5, MG8, MG13, unimproved neutral lowland meadow, M22, semi-improved neutral grassland, together with a small areas of swamp.
Aller Moor	Neutral lowland wet grassland	Wet grassland species such as rush (*Juncus effusus*)	625	7	4	Complex mosaic of neutral grassland/coastal & floodplain grazing marsh, semi-improved and improved neutral grassland.
	Arable / grassland rotation	N/A	275	2	2	Maize, barley wheat, improved neutral grassland.
King's Sedgemoor (part)	Neutral lowland wet grassland. Fen marsh & swamp	Wet grassland species such as rush (*Juncus effusus*, *subnodulosus acutiflorus)* Swamp species such as *glyceria* and *carex.*	600 (part)	8	3	Complex mosaic of neutral grassland/coastal & floodplain grazing marsh comprising MG5, MG8, MG13, Ag-Cx grassland and M22 Fen Meadow.
Total (approx)			**2,500**			

Further detailed habitat information is available for RSPB landholdings on West Sedgemoor and can be found in Appendix 2.

6.2.2.Typical habitat biomass yields – RSPB UK sourced

The following information of volumes of materials taken off the listed areas has been complied from the work undertaken leading up to and during the DECC project[14]. As the vegetation on each site will be site specific, these figures should only be used as a guideline and indication of what a habitat type may produce. Illustrations of these broad habitat types can be found in Appendix 3.

Vegetation Detail	Site	Location (County/ Country)	Dry matter tonnes/ha	Notes
1-yr old common reed	Ham Wall	Somerset, UK	6.2	Reed litter layer depth – no more than 20cm Average reed stem height - between 150 and 200cm Reed stem density percentage of reed coverage in a $2m^2$ – 93%
3-yr old common reed			7	Reed litter layer depth – no more than 30cm Average reed stem height - between 175 and 270cm Stem density percentage of reed coverage in a $2m^2$ – 90%
15-yr old common reed			8.76	Reed litter layer depth – 70 to 90cm Average reed stem height - between 250 and 300cm Reed stem density percentage of reed coverage in a $2m^2$ - 86%
Sparse soft rush at a density > 10% and < 50%	Exminster Marshes	Devon, UK	1	Average diameter of soft rush tussock at the base – between 10 & 20cm
Medium soft rush at a density between 50 to 60%	Minsmere	Suffolk, UK	2	Average diameter of soft rush tussock at the base – between 30 and 40cm
Dense soft rush - densely packed.	Catcott Lows	Somerset, UK	4	Average diameter of soft rush tussock at the base – between 50 and 60cm
Medium density rush/sedge dominated fen	Shapwick Heath	Somerset, UK	1.6	Percentage of rush/sedge cover within a $2m^2$ quadrat – 41% Species density and composition within a $2m^2$ quadrat – Grasses 45%, Herbs 7%
Dense rush/sedge dominated fen			2.2	Percentage of rush/sedge cover within a $2m^2$ quadrat – 66% Species density and composition within a $2m^2$ quadrat – Grasses 6%, Herbs 18%
Medium density common reed dominated fen	Minsmere	Suffolk, UK	1.6	Percentage of reed cover within a $2m^2$ quadrat – 38% Species density and composition within a $2m^2$ quadrat – Rushes/sedges 35%, Herbs 26%
Dense common reed dominated fen			2	Percentage of reed cover within a $2m^2$ quadrat – 61% Species density and composition within a $2m^2$ quadrat - Rushes/sedges 22%, Herbs 15%

[14] Department of Energy and Climate Wetland Biomass to Bioenergy project, see Appendix 4 for summary

6.2.3.Typical habitat biomass yields – widely sourced

Other yields for wetland materials, these figures have been taken from work undertaken elsewhere – the source of the information has been provided.

Source	Vegetation Detail	Location (County/ Country)	Dry matter tonnes/ha
Common reed			
Timmermann 2003	Common reed	Germany	3.6 - 43.5
Ash 2010	Common reed	UK	5.5
Komulainen, Simi, Hagelberg, Ikonen & Lyytinen 2008	Common reed	Southern Finland	4 – 12.6
Wendelin Wichtmann,	Common reed	Germany	7.3 - 11.7
Kask, 2007	Common reed	Estonia	6 - 9.34
Common reedmace			
Timmermann 2003	Common reedmace	Germany	4.8 - 22.1
Pratt, D.C. Dubbe, D R. Garver, E. Linton P. J. 1984	Common reedmace	Minnesota	9.6
Reed canary Grass			
Timmermann 2003	Reed canary Grass	Germany	3.5 - 22.5
Sefai Bilgin, Can Ertekin, Ahmet Kürklü, 2005	Reed canary grass	Turkey	4.6
Pratt, D.C. Dubbe, D R. Garver, E. Linton P. J. 1984	Reed canary Grass	Minnesota	10.5
Wendelin Wichtmann,	Reed canary grass	Germany	7.3 – 9.6
Reed sweet grass			
Timmermann 2003	Reed sweet grass	Germany	4.0 - 14.9
Sedges			
Timmermann 2003	Lesser pond sedge	Germany	5.4 - 7.6
Timmermann 2003	Greater pond Sedge	Germany	3.3 - 12.0
Wichtmann, W. Haberl, A. Tanneberger,F	Sedge fen	Belarus	7.0
Wendelin Wichtmann,	Sedge	Germany	7
Grassland			
Bullock J, Pywell R, Walker K. 2006	Species rich grassland	UK	3.25-4.5
Prochnow, A. Heiermann, M. Plöchl, M. Amonb, T. Hobbs, PJ. 2009	Semi natural grassland	UK	6.7
Melts I, 2009	Floodplain meadows	Estonia	6.5

6.2.4. Biomass currently available

In the areas of Aller Moor and King's Sedgemoor agriculture is the predominant and most extensive land use. On West Sedgemoor over 50% of the landholding is managed solely for conservation benefit, through the use of agricultural practices, and the remaining percentage with more emphasis on food production.

To achieve the land use objectives above, whether for food production or conservation, low value surplus material of various types is already produced as a by-product. The quantities and quality currently available are season dependent and are affected by additional factors such as extensive flooding. These low value by-products are currently treated in a number of ways, each with different implications for the management operation.

- Poor quality hay and materials such as rush are typically taken for animal bedding, which although of poor quality may help to offset the cost of buying in material. However this is not always seen as a favourable option:
  - In the case where tenant graziers are used as on the RSPB land holdings at West Sedgemoor, the removal of this biomass can be reliant on graziers having a need for this low value material, which in some years due to higher quality bedding being cheap and relatively available, is not needed. On these occasions another method of disposal would have to be found.
  - Many farmers are often cautious about using rush for bedding due to the potential contamination of dung with rush seed. Farmers are reluctant to spread rush-dung back on to wet grassland due to the threat of dispersing seed and increasing the spread of rush. Only landowners with higher, plough ground can avoid this risk.
- Dominant vegetation types, such as rush species may be topped and the toppings left to rot on site, which can have implications for grass growth, seed dispersal and an increase in nutrients in the following year.

Currently on Aller Moor and King's Sedgemoor the agricultural ground is managed in a way that provides a balanced system, which supports the grazing operations needed, takes into account farm facilities eg wintering yards and aims to provide the maximum flexibility to cope with seasonal challenges. Except in extreme years, by-products are currently managed as part of these systems, but margins are tight and these operations could be easily affected if events occur to cause a shift in the balance.

On West Sedgemoor the challenge for the disposal of by-product material is more immediate, where the balance of management practices is to be altered with a change in graziers anticipated over the next few years. In this case it is known that the production of poor quality material will form a more significant challenge in the future management of this area. In view of this it is likely that the following amounts of material would be produced in the coming seasons:

Habitat	Vegetation type	Area / hectares	Estimated tonnes per hectare	Estimated total tonnes
Unimproved neutral coastal and floodplain grazing marsh	Mix of fine leaved grasses, sedges, herbs and rush with tall grasses (*phalaris*, *glyceria*) and sedges (*carex riparia*)	100	5 dry tonnes *(Based on 15 bales per ha assuming a bale weighs approx 1/3 of a tonne)*	500 dry tonnes
Unimproved neutral coastal and floodplain grazing marsh	Predominately dominant species such as rush	200 - 300	2 – 3 wet tonnes	400 – 600 wet tonnes

6.3. Site characteristics

Access by a network of droves is common across the project site; examples of this are Leazeway Drove that runs through Aller Moor, or South Drove which runs along the south of West Sedgemoor. Both droves on appearance provide excellent accessibility, but in many cases there may be sensitivities around usage, whether due to shared access, dwellings, or inappropriate surfacing which may need to be considered. These will need to be addressed on a site by site basis and if utilising the material for bioenergy means increase use of the drove than is demanded by current practices the necessary agreements and adaptations will need to be made. Site access may be one of the determining factors in the energy conversion technology selected and will need to be considered alongside the other issues at play. Seasonal conditions will determine how the biomass is harvested and on each of the moors this will almost be impossible to predict.

The biomass that is and could be produced across the three areas would be suitable for both anaerobic digestion and combustion and which method is chosen will depend on the ability to harvest at a certain moisture content. As mentioned in previous sections whilst combustion can provide more flexibility, it demands dry material compared to anaerobic digestion which needs continuity of supply but can deal with material of a higher moisture content. It also needs to be considered that conditions in present day may change and a commitment to supply material in a certain condition under contract needs to take this into account.

6.4. Need for diversification in land use

As quoted in the Water Level Management Plan 2010 for King's Sedgemoor and Aller Moor, 'farm businesses need continual re-investment to survive and if their food production and conservation land management are to continue. The growing need for food security, and the growing demand for quality food to supply the increasing population of the UK and elsewhere, may stimulate additional investment in agriculture on some farms in the area in the coming years. The larger farm units in particular have invested in productive capacity over the years and will continue to do so in line with market signals. Many will also continue to deliver environmental outcomes alongside food production. Within the King's Sedgemoor and Moorlinch SSSIs, appropriate balances will be sought between agriculture, nature conservation value, flood risk and the vulnerability of peat soils.'

Managing these systems is all about balance and on occasion a fine balance, which can be severely, affected by external factors, such as frequent, unpredictable flooding, market values such as fluctuating beef prices or lack of local tenant graziers. A shift in this balance may mean that land managers will look for an opportunity to diversify their operation, which will help support their current practice. Biomass to bioenergy could help provide this support or act as a 'safety net', will could enable the land to continue to be farmed.

Whilst the status quo on Aller Moor and King's Sedgemoor enable agricultural practices to continue, biomass to bioenergy could offer a form of resilience if circumstances change and the current balance is altered. With the potential changes predicted for the RSPB reserve at West Sedgemoor there is a more immediate need to find alternative solutions.

6.5. Proximity to feedstock/energy need

To complete the full end-to-end biomass to bioenergy delivery having a location to market the energy products produced or the identification of a nearby feedstock/energy need to the site is essential.

6.5.1. Combustion

For combustion products, in the form of biomass briquettes a local market is needed. In the vicinity of the project site the small market town of Langport, which has a monthly farmers market and an Agri-Centre nearby, could be a suitable location to establish such a market. In this rural area there is a high reliance on wood fuel for heating; biomass briquettes could potentially sit well within this already established demand.

6.5.2. Anaerobic digestion

AcrEnergy - http://www.acrenergy.com/ are an AD operator who are currently building a new 3MW plant in Evercreech, Somerset and have an existing operation in Mansfield, Nottingham. The new plant will need a total of 60,000 tonnes of material as feedstock, it is planned that 2/3^{rds} will be food waste and other waste products and 1/3rd vegetative material, mainly break crop vegetation, but also potentially material from the Levels and Moors. The plant will be running at the end of 2016 and it is planned to be fully operational January 2017. AcrEnergy are looking for new biomass as feedstock whilst the plant is being constructed, with the view to material being available and supplied next year (2017).

AcrEnergy are currently looking for up to 4,000 tonnes of additional material which could be supplied from the Somerset Levels and Moors. They are offering to pay a 'farm gate' price of £20 a tonne (subject to the material conforming to certain biogas generation and moisture standards) and provide and pay for transport of the material to the plant. They are looking for areas that fall below within a 20 mile radius from the new plant. The area identified for this case study just sits within this radius.

6.5.3. Location in relation to other potential feedstock producers

Longmans Cheese, http://www.farmhousecheesemakers.com/cheesemakers/w_h_longman_sons/ and ABP Foods https://abpfoodgroup.com/ were the two most likely large feedstock producers with a potential energy use, in the Langport area. However Longmans Cheese is Yeovil based, with links to Langport and ABP Foods do not have a set up on site that could utilise material off the Levels and Moors. No other potential large scale feedstock producers offering the potential for collaboration were found.

6.5.4. Land held by landowners who have expressed a desire to explore new initiatives.

From liaison with land owners on both West Sedgemoor and Aller Moor (through farmer advisory work) it has been found that there is desire to look at new management solutions. On West Sedgemoor the RSPB have expressed a need to find an outlet for surplus material being produced off their unimproved meadows, which is considered to be a low value hay crop. On Aller Moor landowners are already exploring bioenergy options as a way to supplement their farming activities. This has been through trialling the production of briquettes and also considering the use of medium scale AD. In addition, a large scale solar venture is being considered with a proposal for the installation of over 65,000 panels, with the capacity to generate 4.65MW. This installation would cover approximately 12ha of land and was submitted for planning permission in September 2014, which was refused and is currently under appeal: https://www.southsomerset.gov.uk/planningdetails/?id=1404300FUL

7. Consideration of Approach

Based on the information gathered above, there are a number of scenarios which should be considered when looking at options for the delivery of biomass to bioenergy in this area. Which is most suitable depends on speculation on availability of material in the future and whether flexibility needs to be built into the approach to accommodate this material. This area has the complexity of an immediate need to utilise material, together with the potential need to accommodate biomass in the future which may be produced due to a changing landscape and market forces. The approach adopted will also be affected by the ability to secure continuity of supply or identification and securing of a local market. Dealing with this uncertainty and speculation will be important in the delivery of biomass to bioenergy as a landscape in this area.

7.1. The current situation

Based on the types and amounts of material currently being produced there are 3 main options of approach.

7.1.1. Small Scale AD

To use the modular small scale AD to process the biomass in a wet/silaged form. This would give the landowner complete control of the biomass conversion, but also the responsibility of ensuring continuity of biomass supply. Each 7kW system would require approximately 400 wet tonnes annually so to accommodate the predicted tonnes to be produced next season at West Sedgemoor this could be doubled up to a 14kW system which would have the capacity to process 800 – 1,000 wet tonnes. This system would deliver in the region of 100,000kWh of electricity and produce over 150,000kWh of surplus heat.[15] However this approach would be a stand alone system for the West Sedgemoor site and although capable of modular expansion, up to 9 module units, which would allow for generation of more material at this site, it would not be the most cost effective and efficient system for a landscape approach in the future. To accommodate supply of material from the wider area and reaching into the realms of 3,500 tonnes the move to a medium scale system would be a more cost effective and efficient approach.

7.1.2. Supply of exiting large scale AD

An opportunity to supply an existing AD plant within an appropriate mile radius has been identified. The AD operator is looking for amounts of material between 1,000 and 4,000 tonnes annually and is willing to offer a contract based on a 5 year term, to accommodate the conservation management planning process or longer (up to 20 years) from a farm business planning perspective. Subject to achieving the material specification, set out below, the current offer is to pay a tonnage payment of £20, with transport covered.

a) Dry Matter: The price of the Feedstock will be adjusted according to the Dry Matter content ("DM") based on £0.58 / %DM.
b) Dry matter content of between 28% and 38%; minimum organic dry matter of not less than 95%;
c) Biogas production of between 165m^3/t and 185m^3/t, with the price of the feedstock adjusted accordingly based on £0.58 / 5m^3/t;
d) Any sustainability requirements for Feedstock in order for the Plant to remain eligible for payments under the ROCs;
e) Free from excessive soil, inhibitors, pests and contamination including heavy metals, fungi and bacteria;

[15] Dependent on feedstock biogas yield and methane content.

f) Cutting height of Feedstock should always be adjusted in a way to secure minimum amounts of soil contamination in the raw material and should be at a minimum of between 5 cm and 15 cm above ground level.
g) Cutting length of Feedstock is to be between 5 mm and 8 mm.

When compared to the returns that could be gained from utilising material for personnel or community energy use,[16] securing a tonnage rate for the supply of a large scale plant is not as profitable. However this approach offers a quick fix, reliable, hassle free option, which does not require large upfront investment. In the case of this project area, with the likely change to current situation around biomass production, this option may be seen as the most appropriate scenario. It could provide a secure holding position over a 5 year contract term, which would allow the time needed to assess landscape and market changes. In 5 years time the project area subject to external factors, may be a very different place.

7.1.3.Biomass briquetting

To have the facility to briquette drier material provides the flexibility to deal with different biomass types and to accommodate different management practices. Eg rush that has been weed wiped would have little value for AD, but as a dry dead material would be suitable for producing briquettes. This approach can also offer a good rate of return, if a high quality product can be produced and branded appropriately. For a high standard non woody briquettes there are briquettes on the market which demand a good price, eg A box of Olalogs, which is 13.5kg (minimum) of Rapseed briquettes are priced at £9.99[17] a box, if scaled up this equates to £740 a tonne.

However to produce briquettes on this local scale, there would either need to be investment in the briquetting machinery and drying facility, (to enable the production of a good consistent product), or the need to hire in contractors, the latter can be expensive, so reducing profit margins significantly.

7.2. Planning for the future

As the landscape may change in the future, with the potential for this project area to become wetter and possibly subject to more unpredictable flood events, more regular amounts of biomass may be produced. Restricting these predictions to West Sedgemoor and Aller Moor alone, if the following percentages of these areas were producing wetland biomass at the following densities then we could estimate the following:

Area	%	Vegetation type	Biomass density	Est wet tonnes[18]
West Sedgemoor	20	Wet grassland rush (*Juncus effusus*) dominant	Medium[19]	600
	50	Wet grassland rush (*Juncus effusus*) dominant	Medium	1,340
	20	Wet grassland rush (*Juncus effusus*) dominant	Dense[20]	1,500
	50	Wet grassland rush (*Juncus effusus*) dominant	Dense	3,350
	20	Mix of fine leaved grasses, sedges, herbs and rush with tall grasses (*phalaris*, *glyceria*) and sedges (*carex riparia*)	Unimproved meadow mix with tall grasses & swedges	1,400
	50	Mix of fine leaved grasses, sedges, herbs and rush with tall grasses (*phalaris*, *glyceria*) and sedges (*carex riparia*)		3,500

[16] Subject to the availability of Government incentives
[17] http://www.olaoils.co.uk/olalogs.html
[18] 70% moisture content
[19] 3 wet tonnes per ha
[20] 6.7 wet tonnes per ha

Aller Moor [21]	20	Wet grassland rush (*Juncus effusus*) dominant	Medium	375
	50	Wet grassland rush (*Juncus effusus*) dominant	Medium	936
	20	Wet grassland rush (*Juncus effusus*) dominant	Dense	837
	50	Wet grassland rush (*Juncus effusus*) dominant	Dense	2090

Based on the above estimates each approach could be considered in the following way:

7.2.1. Small scale AD

With an increase production of biomass as suggested above, there could still be a role for small scale AD, but it would need to be operated on a site by site basis. The modular nature of these systems could mean they could be sized for each site, however the landowner would need to weigh up the small margins, the amount of investment needed, compared to the ability to handle their own material on their own terms. It would be recommended that as long as the continuity of biomass supply can be secured, there are far more benefits from working at a landscape scale utilising a community energy approach with medium scale AD and briquette production as the conversion technologies.

7.2.2. Medium scale AD – a community approach

A community energy type scheme, which utilises medium scale AD and briquetting, provides the flexibility to deal with biomass of different types and with different characteristics. As illustrated in Section 3, 250kW and 500kW AD systems require annual amounts of 3,500 and 7,000 tonnes of wet material respectively, from which the surplus heat can be utilised to dry biomass of a lower moisture content for combustion.

'Community' in this context is being considered in the broadest terms, eg farming community, local landowner community, the community of Langport etc.

If Government incentives in the form of the Renewable Heat Incentive[22] and the Feed in Tariff[23] can be secured, this approach can provide good returns on the large upfront investment needed. However to gain maximum benefit the utilisation of the surplus heat is essential[24]. In addition this type of scheme can focus on the AD operation initially with a few to developing a briquetting business later on.

However the delivery of this type of system will depend on a number of other factors such as:

- Ability to gain investment
- Ability to secure a site, of the appropriate size and nature, eg with storage capacity and the potential for the installation of dry facilities etc.
- Interaction with the 'community'
- Desire for a community approach

7.2.3. Supply of existing large scale AD

With the scale of the AD plant being built by operator AcrEnergy at 3MW, and from recent discussions, there is a high possibility that they would be prepared to take a larger volume of material than currently under discussion. The whole of the project area falls within the desirable 20 mile radius placing this option

[21] Wet grassland area only
[22] https://www.ofgem.gov.uk/environmental-programmes/non-domestic-renewable-heat-incentive-rhi
[23] https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme
[24] RHI can only be secured on heat used, rather than heat produced.

as a quick fix solution, with no investment required. At a landscape scale the AD operator could be approached as a consortium of landowners, which may be more efficient especially in terms of harvesting and transport arrangements, but would need coordination, or as a single landowner. Terms in relation to payments, contract length, etc for either option would need to be discussed and negotiated with the operator.

7.2.4.Biomass briquettes

Once a consistent product has been achieved and can be manufactured reliably, the option of producing biomass briquettes for combustion could be a viable one. For the conversion of large volumes of materials then investment in the necessary equipment would be the most cost effective. For this conversion process to be carbon efficient the drying of material in the field, before it is collected for conversion is important, unless operating alongside an AD set up which is producing surplus heat. On this point alone it is felt that there is more risk attached to the briquetting option for processing wet grassland materials (which are generally of a higher moisture content than is desirable) in isolation. It would be recommended that this option is used alongside the medium scale AD, both for the availability of 'free' heat and as it provides the outlet to take materials that are too wet to dry or off ground where a number of machinery passes are not acceptable / achievable.

8. Conclusion

From the research undertaken to date it has been shown that wetland biomass can be utilised as a bioenergy feedstock, both for combustion and for anaerobic digestion, to produce heat and heat and electricity respectively. However utilising this material, which can have certain challenging characteristics, (i.e. high in lignin, tendency to grow on soft, wet substrates), can mean that for systems to be cost covering or even profit making, they need to be as efficient as possible, benefit from the economies of scale where appropriate and if products are for retail sale, produced at a high quality and marketed well.

There are a range of technology sizes, (both for AD and briquette production), which are often in modular form and so easy to adapt to the scale and biomass type to suit individual sites. However it has been found through cost benefit analysis, that working at a landscape scale in wetland areas, delivering a 500kW AD or more, provides the best rate of return. Higher than 500kW puts less reliance on Government incentives, but of course demands more investment and commitment of feedstock. In comparison small scale AD systems are cheaper and provide the landowner with individual control, but they are not so cost effective when looking to expand to a landscape scale approach that the area could demand in the future.

Combining AD and combustion technologies provides the flexibility to take different feedstocks and also deal with the challenge of unpredictable seasons. Sole reliance on producing material less than 15% moisture for briquetting alone would be high risk, having an AD operation to deal with the wet material produced reduces that risk. Running the two systems together also offers a more efficient operation in relation to energy use, through benefiting from the surplus heat generated from the AD, which would otherwise be wasted (with its value not realised), to facilitate the production of high calorific briquettes.

Upfront investment may be the obstacle that is most difficult to overcome, in this case, working with the existing large scale operators could provide a quick fix solution. Agreeing terms that compliment the current land management practice, eg a 5 year contract term that sits alongside a 5 year conservation management plan can ensure that biomass supply works alongside existing systems. This approach would allow for diversification that did not require investment but provided a safety net to help deal with changing onsite conditions or market forces. It could be that in the case of the project area, this approach with a short contract length could 'buy time' to establish the right systems for the future once the effects of external factors have been explored further.

Turning wetland biomass into bioenergy can offer a diversification option for land managers who farm / manage wetland areas. Refinement of existing farm practices can facilitate the utilisation of materials that would otherwise be discarded or seen as a challenge to dispose of. In the project area identified this approach could be of benefit as landowners look to continue existing practices which at times are proving to be more challenging due to changing conditions and the effects of external forces.

The conversion of wetland materials into energy products does not currently offer large profit margins; however that said it has been shown that the production of high quality products with a local brand for local markets could demand a high price. Developing this product brand will take time and effort and is a plan for the future. However presently biomass to bioenergy can offer that ability to enable a level of diversification which can run alongside exiting practices, that helps to improve the margins and make the land management operation more sustainable.

9. References

Ash, N. 2010. Reed Biofuel Feasibility Study.

Community Power Ltd, 2016. A community energy model for the utilisation of wetland biomass for the generation of energy and improvement of landscapes for the benefit of biodiversity. Draft business plan.

Ecological Land and People, Ash, N, 2010. New Opportunities for the Sustainable Management of Fens: Reed Pelleting, Composting and the Productive Use of Fen Harvests. Final Report.

Mills, S.J. 2016. Wetland Conservation Biomass to Bioenergy report, draft unpublished document.

Natural England, 2008. King's Sedgemoor Conservation Objectives and Definitions of Favourable Condition for Designated Features of Interest.

Paget-Wilkes, H. 2012. West Sedgemoor Management Plan – RSPB unpublished document.

Parrett Internal Drainage Board, 2010. King's Sedgemoor and Aller Moor Water Level Management Plan

Raj Akulain, V, 2013. Wetland biomass - suitable for biogas production?

10. Appendices

Appendix 1 - Comparison of essential properties of reed and rush briquettes with ENplus A2 and ISO 17225A/B standards for non woody briquettes

Essential Properties	Unit	ENplus A2	ISO 17225 A	ISO 17225 B	Reed Briquettes	Rush Briquettes
Dimensions	mm	State diameter, width and length			175mm width x 80mm diameter	
Moisture	w-%	>15	<12	<15	5.3	3.8
Ash	w-% dry	<1.5	<6	<10	4.7	3.9
Particle density	g/cm3	>0.9	>0.9	>0.6	0.8 to 1.198	1.2
Additives	w-% dry	<2	<5	<5	N/A	N/A
Calorific Value	MJ/kg	>15.3	>14.5	>14.5	19	16.7
Nitrogen	w-% dry	<0.5	<1.5	<2.0	1.04	0.58
Sulphur	w-% dry	<0.04	<0.2	<0.3	<0.01	<0.01
Chlorine	w-% dry	<0.03	<0.10	<0.3	<0.01	<0.01
Surface Incl. Hole	cm2	Should be stated			140	140

Trace Elements	Unit	ENplus A2	ISO 17225 A	ISO 17225 B	Reed Briquettes	Rush Briquettes
Arsenic	mg/kg dry	<1	<1	<1	0.3	0.3
Cadmium	mg/kg dry	<0.5	<0.5	<0.5	0.1	0.1
Chromium	mg/kg dry	<10	<50	<50	0.7	1
Trace Elements	Unit	ENplus A2	ISO 17225 A	ISO 17225 B	Reed Briquettes	Rush Briquettes
Copper	mg/kg dry	<10	<20	<20	1.9	1.1
Lead	mg/kg dry	<10	<10	<10	0.7	0.5
Mercury	mg/kg dry	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/kg dry	<10	<10	<10	<0.5	<0.5
Zinc	mg/kg dry	<100	<100	<100	16.8	17.9
Burning time	Min	Should be stated			60mins	60mins

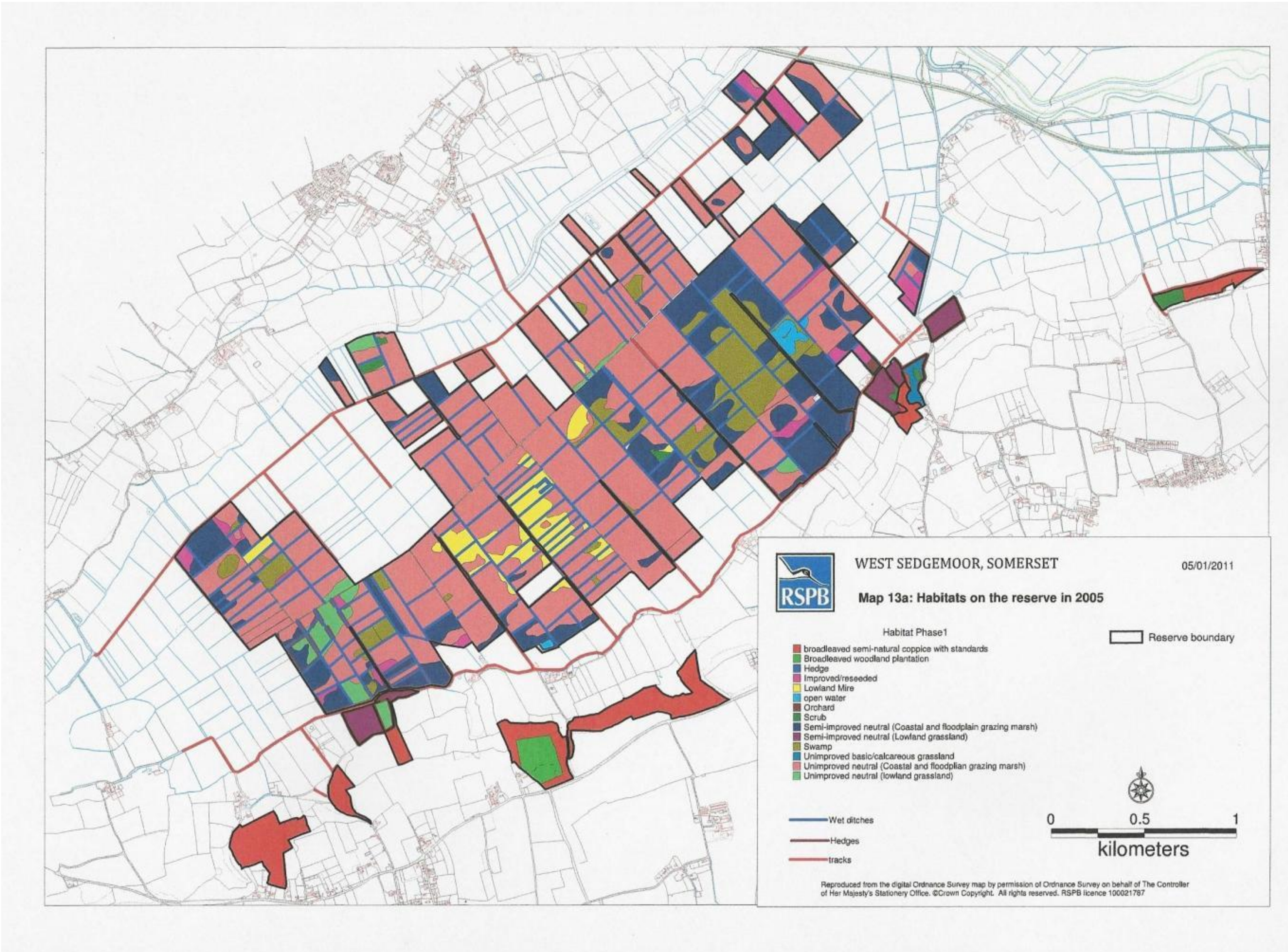
Appendix 2 - West Sedgemoor detailed habitat information

The areas of NCC Phase 1 habitats are provided in the table and the distribution of habitats are shown on the map.

NCC Phase 1 habitats on the RSPB West Sedgemoor reserve

Habitat		**Code**	**Status**	**Area (ha)**	**Comments**
Woodland	Broadleaved semi-natural coppice with standards	A.1.1.1.3	SSSI interest feature	34	
	Broadleaved woodland plantation	A.1.1.2		5	
	Scrub (includes derelict withy	A.2	SSSI interest feature	6	
Grassland	Unimproved neutral (Coastal and floodplain grazing marsh)	B.2.1.2	SSSI interest feature	241	
	Unimproved neutral (Lowland meadow)	B.2.1.2	SSSI interest feature	21.5	
	Semi-improved neutral	B.2.2.2	SSSI interest feature	193.5	
	Unimproved basic/calcareous	B.3.1.2	SSSI interest feature	4	
Swamp	Fen, carr, marsh, reed	F.1.1	SSSI interest feature	42	
Fen	Lowland mire	E.3.3B	SSSI interest feature	21	
Water	Standing eutrophic water	**G.1.1.3**	SSSI interest feature	2	This figure is the lowest open water ha. In winter there is between 275 and 500ha of open water depending on flooding.
Boundaries	Hedges	J.2.3.1	Mentioned on SSSI citation.	9.0km	
	Permanently wet ditch	J.2.6.1	SSSI interest feature	13.5	53km of slow running ditches
Buildings	Buildings	J.3		0.5	
Tracks	Droves	j.5		7.5km	
Total				**584ha**	

Map of West Sedgemoor (RSPB holdings) showing distribution of habitats



Appendix 3 – Generic biomass yields off different wetland habitat types

Soft rush – *Juncus Effusus* dominated grassland

Sparse

Frequency of soft rush tussocks – scattered with 'other' vegetation in between, rush at a density > 10% and < 50%

Average diameter of soft rush tussock at the base – between 10 and 20cm

Average height of soft rush tussock – between 70cm and 90cm

Yield – t DM ha – < 1

Management routine, it there evidence of previous years growth and or a thatch on the ground

- If there is evidence of previous years growth/thatch on the ground add 15%

Medium

Frequency of soft rush tussocks – scattered with 'other' vegetation in between, rush at a density between 50 to 60%

Average diameter of soft rush tussock at the base – between 30 and 40cm

Average height of soft rush tussock – between 90cm and 110cm

Yield – 5.7 wet tonnes per hectare at 66.3% moisture content

t DM ha – 2

Management routine, it there evidence of previous years growth and or a thatch on the ground

- If there is evidence of previous years growth/thatch on the ground add 15%

Dense

Frequency of soft rush tussocks – densely packed, with very little gap between each one

Average diameter of soft rush tussock at the base – between 50 and 60cm

Average height of soft rush tussock – between 100cm and 125cm

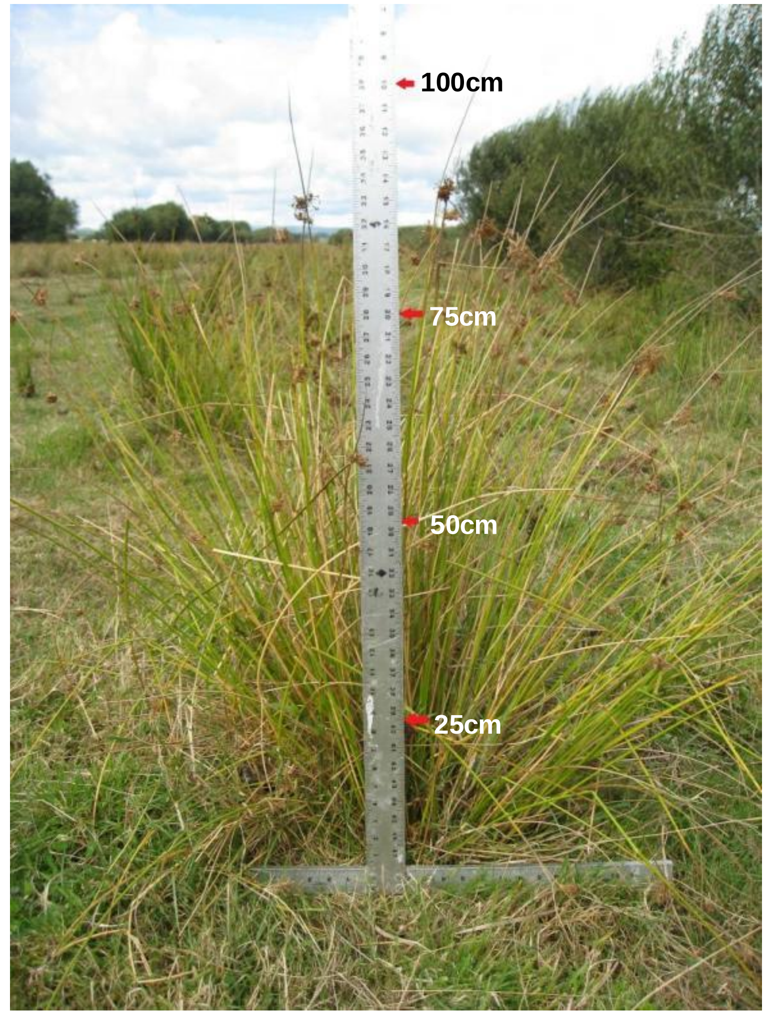
Yield – 11.7 wet tonnes per hectare at 66.3% moisture content

t DM ha – 4

Management routine, it there evidence of previous years growth and or a thatch on the ground

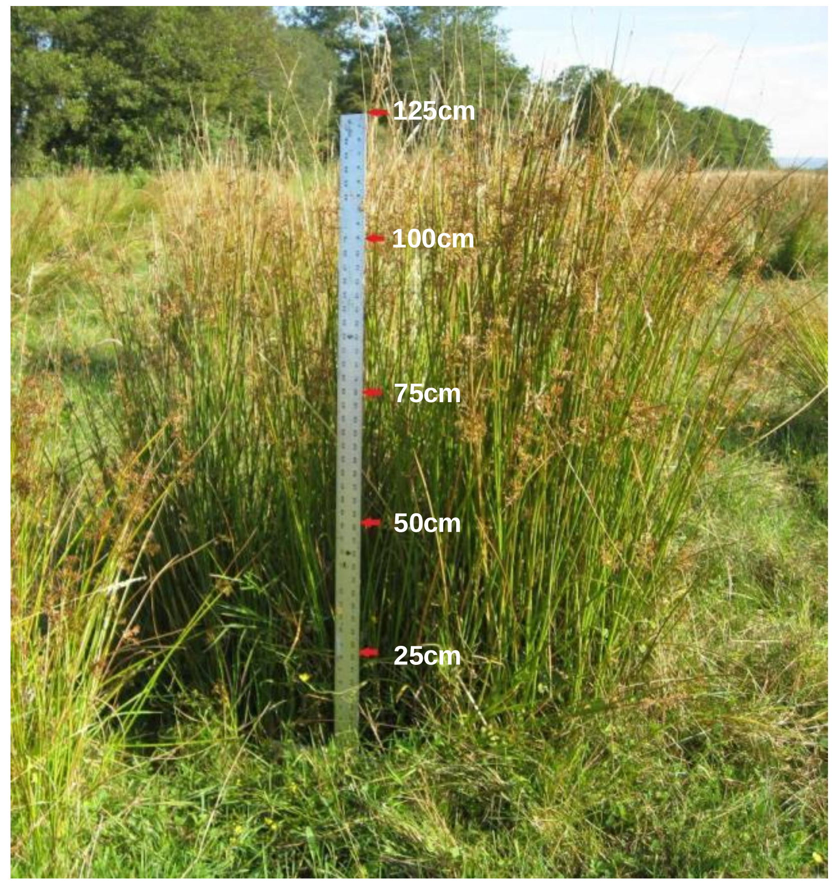
- If there is evidence of previous years growth/thatch on the ground add 15%

Soft rush – *Juncus Effusus* dominated grassland
Sparse



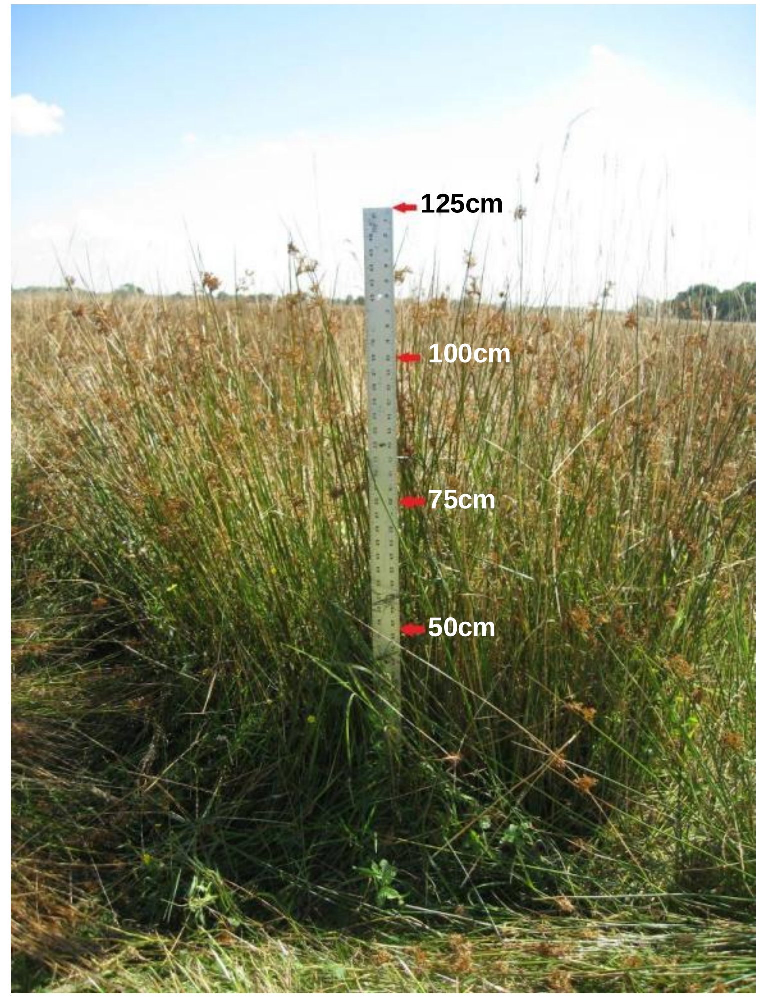
Soft rush – *Juncus Effusus* dominated grassland

Medium



Soft rush – *Juncus Effusus* dominated grassland

Dense



<u>Common Reed - *Phragmites Australis* mono-culture</u>

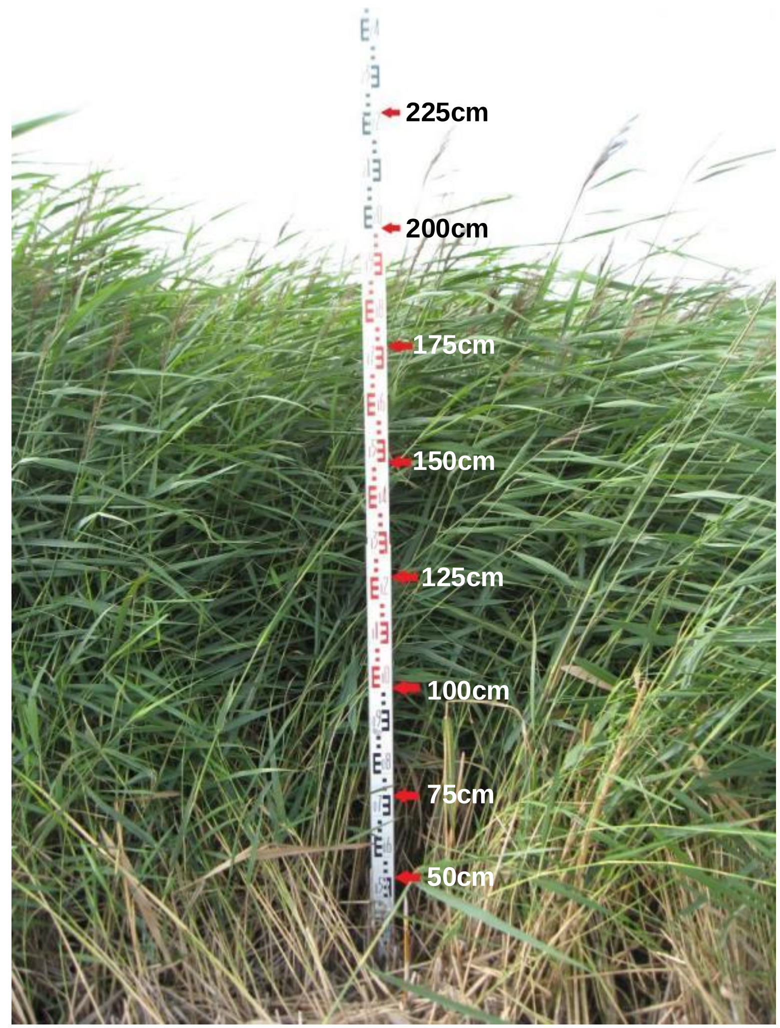
<u>Sparse – 1-year old</u>
<u>Reed litter layer depth</u> – no more than 20cm
<u>Average reed stem height</u> - between 150 and 200cm
<u>Reed stem density percentage of reed coverage in a 2m^2</u> – 93%
<u>Number of new reed stems in 20cm x 20cm</u> - 23
<u>Yield</u> – 17.75 wet tonnes per hectare at 64.7% moisture content
<u>t DM ha</u> – 6.2
<u>Previous management</u> – cut the year before and all previous dead reed stems have been removed.

<u>Medium – 3-year old</u>
<u>Reed litter layer depth</u> – no more than 30cm
<u>Average reed stem height</u> - between 175 and 270cm
<u>Stem density percentage of reed coverage in a 2m^2</u> – 90%
<u>Number of new reed stems in 20cm x 20cm</u> - 15
<u>Yield</u> – <u>t DM ha</u> – 7
<u>Previous management</u> – cut 3 years before, evidence of dead reed stems and some leaf litter.

<u>Dense – not been cut for 15 years+</u>
<u>Reed litter layer depth</u> – 70 to 90cm
<u>Average reed stem height</u> - between 250 and 300cm
<u>Reed stem density percentage of reed coverage in a 2m^2</u> - 86%
<u>Number of new reed stems in 20cm x 20cm</u> – 11
<u>Yield</u> – 11.68 wet tonnes per hectare at 25% moisture content
<u>t DM ha</u> – 8.76
<u>Previous management</u> – Not been cut for 15 years or more, dead reed stems very numerous and limiting new growth. Litter layer deep and made up of dead reed stems and fallen reed leaves.

Common Reed - *Phragmites Australis* mono-culture

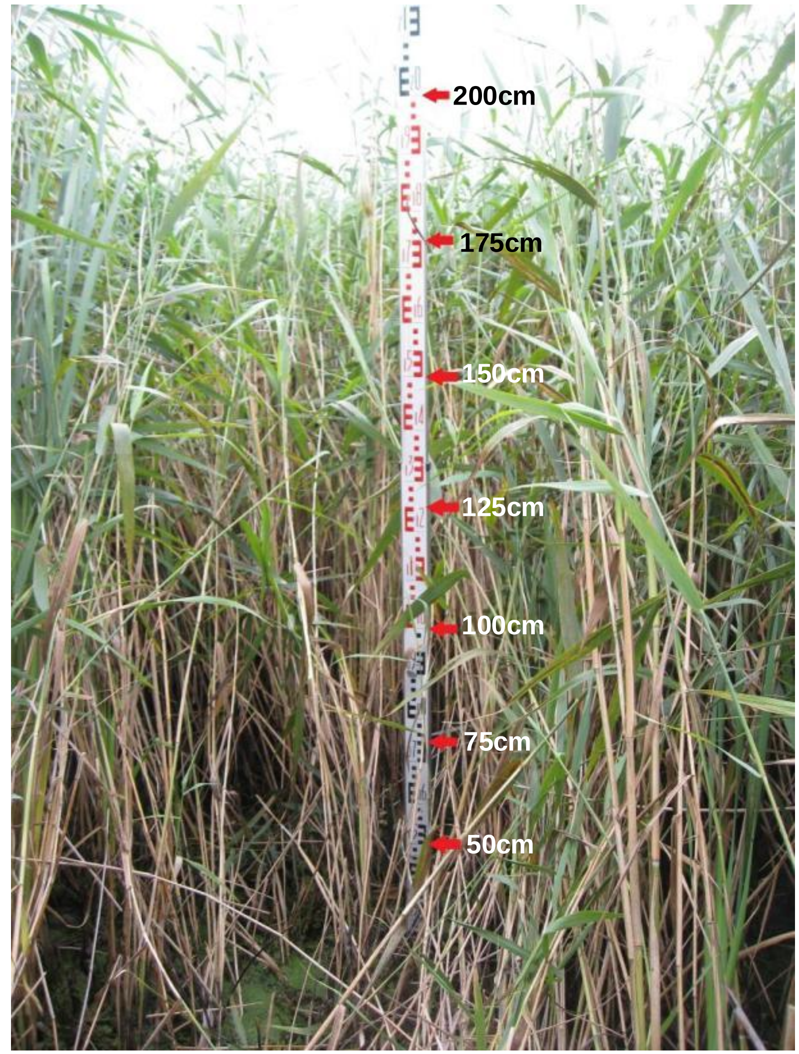
Sparse – 1-year old



<u>Reedbed</u>

<u>Common Reed - *Phragmites Australis* mono-culture</u>

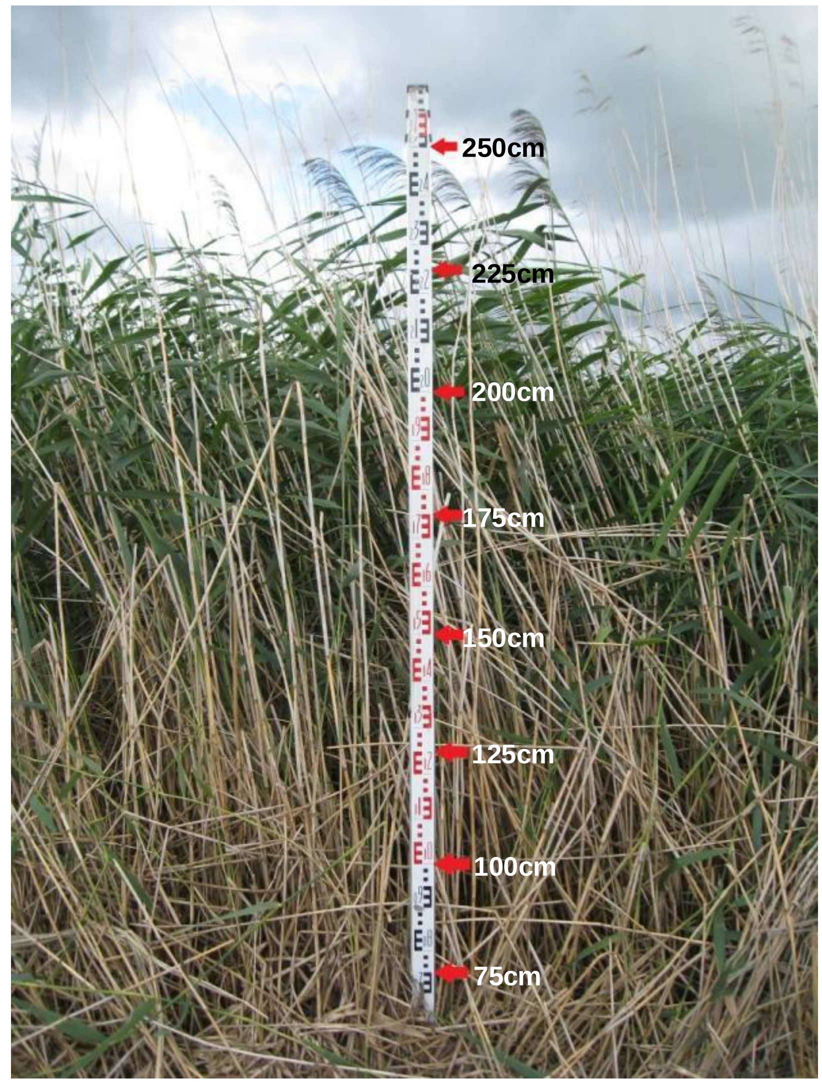
<u>Medium – 3-year old</u>



<u>Reedbed</u>

<u>Common Reed - *Phragmites Australis* mono-culture</u>

<u>Dense – not been cut for 15 years+</u>



Mixed tall fen rush/sedge dominated – generally not large tussock forming

Medium

Average vegetation height – 93cm
Percentage of rush/sedge cover within a $2m^2$ quadrat – 41%
Species density and composition within a $2m^2$ quadrat – Grasses 45%, Herbs 7%
Yield – 3.42 wet tonnes per hectare at 55.4% moisture content
t DM ha – 1.6
Management routine, it there evidence of previous years growth and or a thatch on the ground

- If there is evidence of previous years growth/thatch on the ground add 7.5%

Dense

Average vegetation height – 107cm
Percentage of rush/sedge cover within a $2m^2$ quadrat – 66%
Species density and composition within a $2m^2$ quadrat – Grasses 6%, Herbs 18%
Yield – 4.81 wet tonnes per hectare at 55.4% moisture content
t DM ha – 2.2
Management routine, it there evidence of previous years growth and or a thatch on the ground

- If there is evidence of previous years growth/thatch on the ground add 7.5%

Mixed tall fen Common Reed dominated – generally not large tussock forming

Medium

Average vegetation height – 107cm
Percentage of reed cover within a $2m^2$ quadrat – 38%
Species density and composition within a $2m^2$ quadrat – Rushes/sedges 35%, Herbs 26%
Yield – 6.2 wet tonnes per hectare at 68% moisture content
t DM ha – 1.6
Management routine, it there evidence of previous years growth and or a thatch on the ground

- If there is evidence of previous years growth/thatch on the ground add 7.5%

Dense

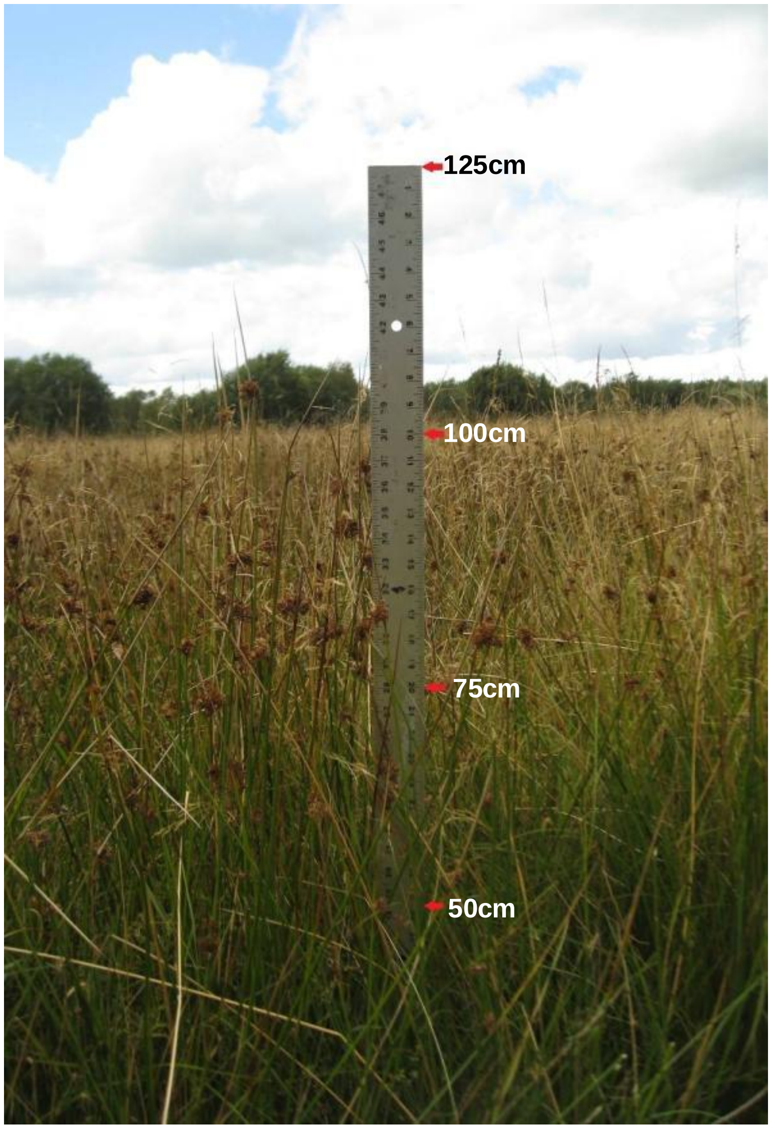
Average vegetation height – 157cm
Percentage of reed cover within a $2m^2$ quadrat – 61%
Species density and composition within a $2m^2$ quadrat - Rushes/sedges 22%, Herbs 15%
Yield – 5.6 wet tonnes per hectare at 73% moisture content
t DM ha – 2
Management routine, it there evidence of previous years growth and or a thatch on the ground

- If there is evidence of previous years growth/thatch on the ground add 7.5%

Mixed Tall Fen

Rush/sedge dominated – generally not large tussock forming

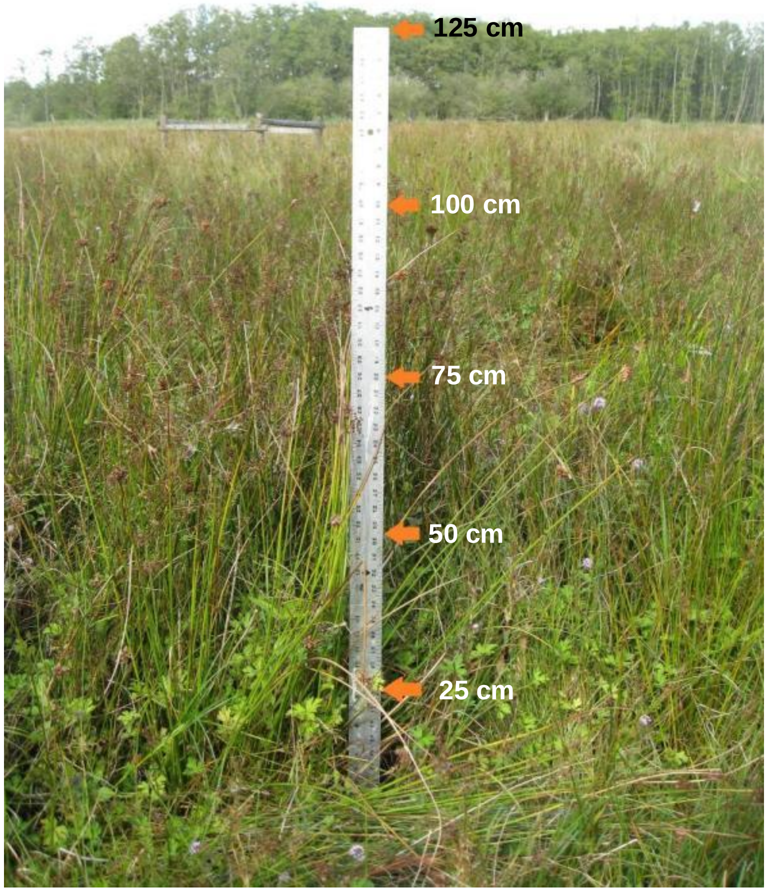
Medium



Mixed Tall Fen

Rush/sedge dominated – generally not large tussock forming

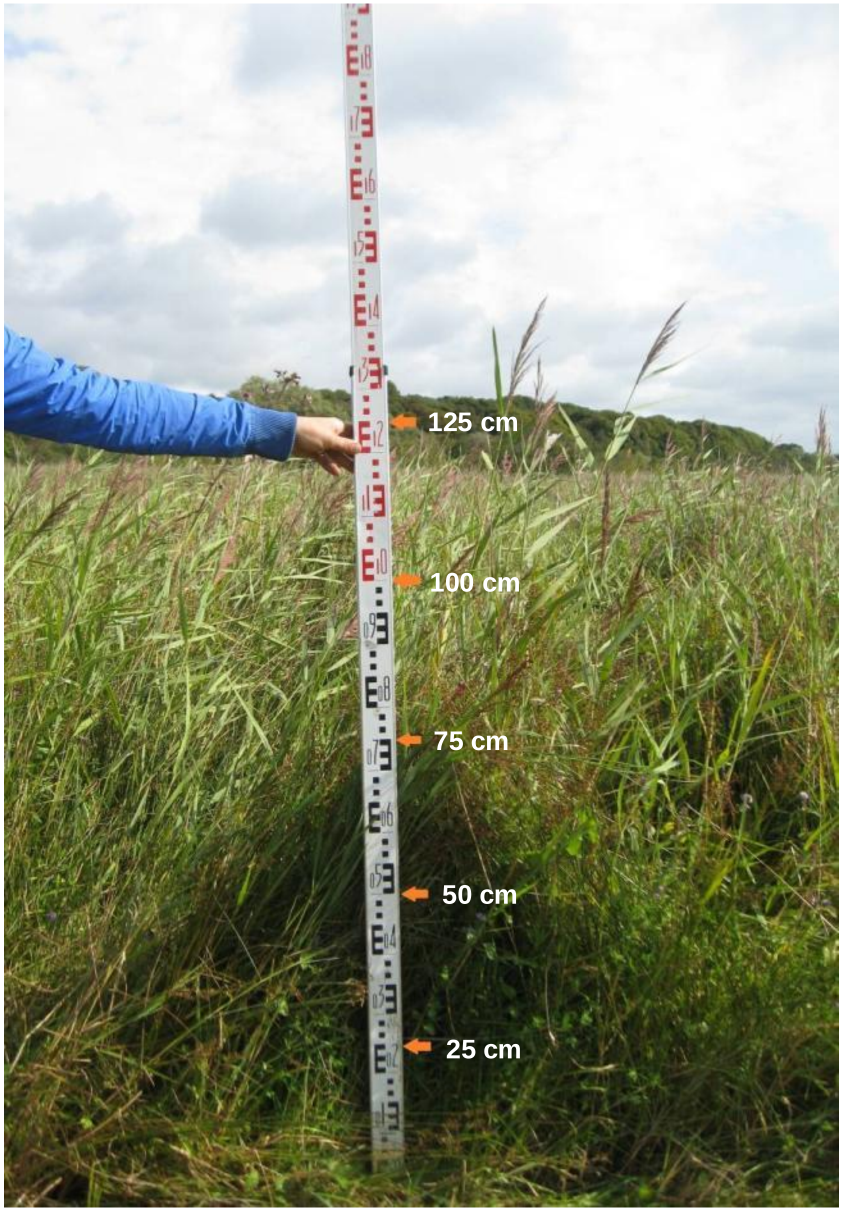
Dense



Mixed Tall Fen

Common Reed dominated – generally not large tussock forming

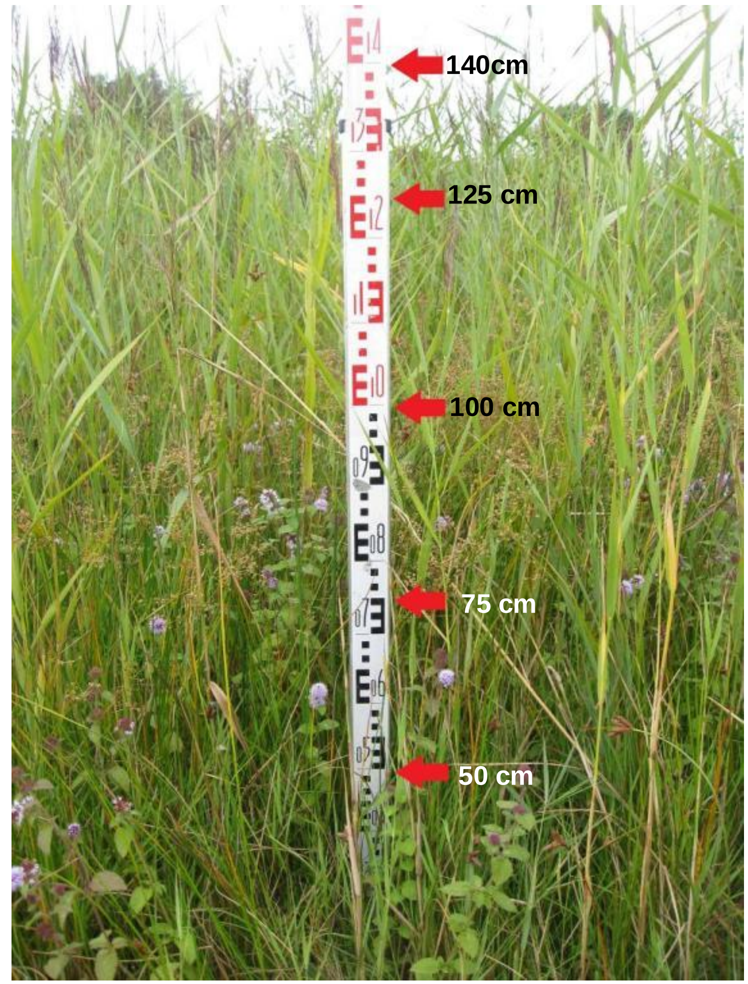
Medium



Mixed Tall Fen

Common Reed dominated – generally not large tussock forming

Dense



Appendix 4 – Wetland biomass to bioenergy project summary

giving nature a home

Wetland Biomass to Bioenergy Project

Department of Energy & Climate Change

Background

The Wetland Biomass to Bioenergy Competition was born out of the Department of Energy and Climate Change's (DECC) **UK Bio-energy Strategy** (April 2012). This strategy identified the need to source new feedstocks for bioenergy, which sat within the limits outlined in DECC's sustainability criteria. This specifically states feedstock production must not pose a threat to food security, in the UK or internationally, or present risks to biodiversity and ecosystems.

What did the project aim to achieve?

Funded by DECC, the **Wetland Biomass to Bioenergy Competition** aimed to demonstrate the untapped potential of using existing biomass produced on wetland nature reserves generated from habitat management, as a new energy feedstock. It was designed to encourage business and academia to develop a solution for the end-to-end delivery. To design, build and procure the technology needed to create and deliver the complete process from harvesting through to energy production from wetland biomass in an energy efficient way.

Biomass generated from **conservation management** can be a challenge for many land managers, often limiting the management work undertaken or compromising what can be achieved, and in some instances resulting in the need for sites to have sacrificial areas, where the material is left to rot down.


Unutilised biomass

The competition was delivered in **three phases**; Phase 1 commenced January 2013 and concluded March 2013. Phase 2 ran between May 2013 and March 2014, with Phase 3 from April 2014 to March 2015 concluding the project.

The project was undertaken in **three geographical wetland areas** which were selected based on habitat diversity, scale and complexity, they were:

- The Somerset Levels and Moors.
- The Broads, Fens and Suffolk coast.
- Northern and Eastern Scotland.

Within each of these areas there were consortiums of conservation land managers who provided the sites and biomass needed for the trials and demonstrations undertaken throughout Phase 2 and Phase 3.

What were the results?

Initially **14 applications** were submitted for Phase 1 of the project, a large percentage of these were consortiums of applicants, with a wide range of expertise from academics to engineers. From the 14, seven were selected to proceed to the feasibility stage and were provided with funding to undertake this work. From these seven, three applicants were chosen to receive funding for Phase 2. During this phase, the competition element was removed by DECC and the same three applicants continued through to complete the project to the end of March 2015.

The **three successful applicants**, AB Systems (UK) Ltd, AMW-IBERS and Natural Synergies Ltd employed a diverse range of approaches that have now provided land managers with a portfolio of techniques for the conversion of conservation biomass into bioenergy. These include specialist harvesters, drying and storage systems, together with energy conversion processes such as pyrolysis, anaerobic digestion and combustion.

Harvesting material off wetland sites in a suitable condition is essential in its utilisation; through the project new specialist tracked harvesters capable of dealing with challenging wet conditions, were developed. The large 300hp Pisten Bully equipped with a precision chop forager was both effective and efficient for the removal of thick vegetation in large areas with good access and ground not considered as exceptionally sensitive. In comparison the design of the smaller 120hp Softrak operating a double chop forager, was more manoeuvrable, with a lighter footprint, but with a slower work rate.

Pisten Bully and Softrak harvesters

The sledge cableway

Once cut, **haulage** of the material off site was either achieved via the harvesters' collection bins or through adapted tracked haulage vehicles and the newly developed sledge cableway system. This cableway could transport 1,000kg of biomass up to a distance of 1,000m with a footprint of 0.2 psi when hauled over wetland areas, significantly reducing the impact of vehicle movements on sensitive ground.

Storage of the cut material was dealt with through conventional means such as wrapped bales and silaging using existing farm structures for wet materials, or via the AgBag system which was capable of storing biomass in both dry and wet condition. To reduce the moisture content of the biomass to be used for combustion, **drying** was undertaken in two ways: through the use of a pyrolysis kiln, which dried small amounts of material quickly and through the AgBag system using perforated pipes and solar panels, bringing the potential to dry larger volumes over a longer period - which is still to be trialled.

Pyrolysis kiln

A **pyrolysis** kiln was developed as part of the project to produce biochar, (in addition to drying) which was successfully achieved using rush, reed and scrub. This process proved excellent for reducing the volume of materials (conversion rate of 3 to 1 for reed), whilst increasing their energy density, producing a high calorific value additive which was mixed with other materials during the briquetting process.

Medium scale anaerobic digestion

Both small and medium scale **anaerobic digestion** were trialled during the project, each with satisfactory results. The small scale 7kW system utilised liquid produced from the screw-pressing of wetland biomass, this provided the energy needed to power processing the remaining solid fraction into briquettes at a feed rate of 500 litres a day. The pilot medium scale system explored cell disruption techniques to process whole crop foraged material and achieved a biogas composition of between 54 to 56% bio-methane. Further trials and investment are needed to progress this system beyond pilot stage and to the desired 150kW scale, with significant changes needed on the design of the feed mechanism.

Combustion of the wetland materials was achieved successfully through the production of briquettes, with emissions results displaying that each of the wetland biomass briquettes performed satisfactorily to be burned as an alternative to pine. Although briquette composition, density and production efficiency would benefit from further trials. Loose material and briquette wafers were trialled in a biomass boiler and performed effectively, however further emissions testing is needed to achieve RHI accreditation.

Burning rush briquettes

The efficiency of each process was monitored and **life cycle analysis** revealed the following results:

Participant	Energy Conversion Technology	Greenhouse gas savings (MJ/a)	Biomass Energy Efficiency (MJ/a)
AB Systems	Briquette production	89.8%	65.0%
AMW-IBERS	Briquette production	84.1%	68.7%
Natural Synergies	Anaerobic Digestion	73.4%	58.9%

What's happening now?

Next steps are to progress the areas already mentioned and to identify opportunities to utilise this range of techniques on the ground, to both maximise conservation management whilst providing a new bioenergy feedstock. Exploration in to the application of knowledge and experience into other habitats has also been initiated, with heathland as the next priority.

The project has illustrated that this approach has immense potential and could range from small scale briquette production on a site by site basis to replace fossil fuels, up to operating at a landscape scale to deliver a complete community energy system. The options are now being explored further using the mechanisms identified in the Energy for Nature project which looked to develop a PES based model for delivery[25]. Through this project, linked with the DECC research it has been demonstrated that the idea of 'conservation biomass to bioenergy' can form a sustainable means of financing essential management of key habitats for biodiversity whilst providing an environmentally sound alternative energy feedstock.

Thanks must go to the many organisations who allowed their sites to be used as guinea pigs and biomass donators without which the project wouldn't have been possible. They also showed much appreciated patience when trials didn't always go to plan!!

Where can I find more information?

The applicants' reports have been published by DECC and can be accessed online through the following link under the section Wetland Biomass to Bioenergy Competition.

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[25] Energy for Nature project report