SKANSKA

Wetland Biomass Feasibility Study

Somerset Highways, Dunball Highways Depot

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Executive Summary

The Somerset Rivers Authorities (SRA) primary objective is to reduce flooding across the county and as such have been exploring ways in which a more resilient approach to the management of the Somerset Levels and Moors can be promoted.

The purpose of this report is to outline the information and design requirements for the installation of a biomass boiler in a real-life case study based at Dunball Highways Depot to burn the arising from wetland management. The report is intended to provide the SRA with information to better understand the potential for the use of wetland biomass as a sustainable fuel source and as a potential income stream for local stakeholders.

The key focus of this report has been based around fuel production and the use of a biomass boiler situated at Dunball highways depot and the key findings related to each of these areas are summarised below:

Fuel Production
For this study we have focused on common reed and common rush with both showing potential as a biomass fuel, however, to date limited burn trials and testing have been carried out. Further, it has been confirmed neither form of wetland biomass is currently being commercially harvested within the UK so supply chains and fuel production will need to be established.

To this end, it is recommended that further wetland biomass materials trials and testing are carried out to confirm which material would be the most beneficial for burning as a biomass fuel i.e. loose, briquettes or pellets. We propose that this further study focuses specifically on the elements of the production of the fuel and the associated supply chain involvement to ensure the most viable method is achieved taking into consideration moisture content, particle size, contamination and storage requirements.

We have reviewed the Renewable Heat Incentive (RHI) scheme which pays operators of eligible heating systems based on the useable heat generated. Wetland biomass is not currently recognised as an eligible fuel source, but we have looked at what needs to be done to achieve this status and allow RHI support for Dunball Depot or even used in other existing RHI eligible biomass installations.

The Dunball Biomass Boiler
To forward the study and provide a sample design for a biomass boiler at Dunball we have assumed a best-case scenario for the fuel type (pellet). This is the most processed form of fuel but allows for the most automated biomass boiler system which would require the least amount of operational man power (cleaning ash, loading new fuel etc) to operate. Skanska have installed and operated 6 biomass boilers across its own buildings and PFI school estates, we have drawn from this experience to inform this selection.

The heat demand across the two buildings at Dunball Depot has been assessed and whilst it is possible to provide a biomass system which connects and meets the full seasonal load of both buildings this may not be the most efficient approach. We have proposed solutions to maximise

efficiency and looked at supporting the biomass system with supplementary heating technologies to reduce capital costs but still meet the objectives of providing an outlay for wetland biomass as well as achieving net zero carbon operation on the depot.

The RHI offers fundamental support to the financial case for the installation of a biomass boiler at Dunball, mitigating operating costs. However, it should be noted that a biomass only solution would currently cost more to run than traditional gas-based heating systems. Finally, the future of the RHI scheme for new biomass installations is uncertain beyond March 2022 although recent extensions have been announced.

1 Introduction

As part of the active management of wetland areas on the Somerset Levels and Moors, a large quantity of waste, including common reed, sedge and rush are generated. As part of taking forward the 20-year Somerset Flood Action Plan, the SRA have been tasked with promoting more resilient management of the Somerset Levels and Moors due to climate change contributing to more extreme weather events. This is impacting some of the wetter areas of the Somerset Levels and Moors and making it difficult to manage using traditional methods.

This study explores the opportunity to diversify the management methods of the Somerset Levels and Moors to harvest and increase the use of wetland biomass as a primary fuel source. The concept of use of wetland biomass will be theoretically applied to an existing commercial outlet, (Dunball Highways Depot) to enable the SRA to better understand the potential for the use of wetland biomass as a sustainable fuel source and viable income stream to support stakeholders such as local farmers. Finding a commercially viable market for these materials would greatly assist the management of these internationally important nature reserves for both Somerset County Council and local stakeholder groups whilst also providing a direct method of energy production which is anticipated to benefit carbon, cost and biodiversity too.

A comprehensive review of published papers and research previously commissioned by the SRA on the production of wetland biomass products has been completed in order to define the data source for this study and highlight any knowledge gaps or data inconsistencies. This study uses data from previous RSPB papers and trials. Due to there being no current manufacture of this material either locally or within the UK, it is assumed that the biomass system will be fed on pelleted reed material and that the supply is available to meet the demand.

This study does not primarily focus on the harvesting and manufacture of wetland biomass material. However, the characteristics and physical form of the fuel is of key importance to the future design of any biomass systems at the depot (or potential other existing installations). It is difficult to do one without the other. Therefore, a section of the report has been dedicated to understanding fuel supply to generate recommendations and considerations.

2 Fuel

Fuel Supply

An important factor for the success of this project is availability and consistency of the fuel to supply the biomass boiler at Dunball. A regular, secure, and financially feasible source of fuel of consistent quality is vital to maintaining the operation of the biomass boiler and a critical consideration in the overall business case for this project. The fuel must also be of consistent quality to ensure efficient combustion in the boiler and less harmful air emissions. The ideal case for boiler design and specification would be for fuel to be provided in pellet form. Production of a fuel to pellet would allow the maximum flexibility for use in a wide range of biomass installations, however achieving this has the greatest implications on the fuel supply and production.

For this study (the feasibility of a biomass boiler at Dunball depot), it is anticipated that a suitable fuel supply would be made available by an appointed supplier, who harvested, processed and produced the fuel in a pelletised form on a just-in-time basis. This would include the appropriate storage of the raw biomass and processed fuel, so that they did not deteriorate, particularly through water ingress and allow for delivery on demand for the customer. This is a best case scenario for operation, but one which we feel is necessary to make the operation of a biomass boiler at Dunball viable. The implications of this type of fuel supply is considerable and we have explored these further.

Skanska have found pellet boilers generally more reliable with a high degree of automation, all recent installations at our own head office and main plant yard have been pellet. Pellet boilers tend to have lower air emissions and better burn efficiencies. Wood chip boilers used on our Bristol Schools project have had historic problems with fuel storage and delivery auger systems. Storage time in delivery hoppers is now being minimised to improve operation, which requires a greater frequency of deliveries and one of the boilers has now been decommissioned.

Fuel Production Cost

The cost of harvesting and manufacturing wetland biomass fuel will need to form part of the consideration about its utilisation as a fuel and has a bearing on the financial case for the Dunball installation or scaling the solution for wider land management. If costs of fuel production are too far in excess of a standard wood-based biomass fuel, the potential to scale the supply of fuel beyond Dunball or controlled sample sites would be reduced. It is possible there is a niche market for wetland biomass fuels that demonstrate a strong conservation link for perhaps domestic use in boilers or burners which could be explored further.

Current fuel supply prices through the Skanska supply chain have been collated in table 1.0 below. This gives a good indication of the price target future development of wetland biomass fuel would need to aim. It should be noted that as with any market, fuel prices will vary.

Fuel type	Fuel Cost	Energy	Cost (pence per kwh)
Wood Pellet (ENplus A1)	£236/tonne	4722kwh/t	4.9p/kwh
Wood Chip	£167/tonne	3472kwh/t	4.8p/kwh

Table 1

Currently costs have been estimated for the harvesting and removal of reed to processing plant, (as illustrated in table 2 below). These costs and the availability of the Pisten Bully plant would have to be confirmed as this is specialist equipment with limited availability. However, little work has been done in the UK with regards to the cost analysis for the pelletisation although primarily discussions have been held with a manufacture who would be interested in trial runs. It is important to note volume and scale are important drivers of cost. A more detailed review of fuel harvesting methodology and fuel production is available in appendix 1

Activity	Cost
Activity required to harvest 5ha[1] of reedbed	Total Cost ££
Reed harvesting with Pisten Bully - 1 day's hire (Operative)	1,200.00
Haulage of cut reed with tracked vehicle - 1 day's hire	600.00
Haulage of cut reed with tracked vehicle - 1 day's hire	600.00
Haulage of harvesting and haulage vehicles - £1.50 a mile each for a round trip of 200 miles	300.00
Total	£2,700.00

Table 2

Availability and suitability of fuel

Current practices for wetland management on the Somerset Levels and Moors cover a range of different habitats which are managed to promote a maximum benefit for biodiversity. The most typical and significant habitats are lowland wet grassland and reedbed which produce very different material types - Common Rush and Common Reed.

The lowland wetland grassland areas are typically grazed, or cut for hay for animal feed, but very wet conditions can result in these areas becoming infested with soft rush, meaning this vegetation is largely unpalatable to many grazing animals. As a result, the rush is usually cut and removed generating large amounts of unwanted material to be disposed of as a waste product. Reedbed areas can be harvested for thatching reed. In Somerset they are predominately harvested purely to maintain the habitat, the resulting material is purely common reed. Cutting and removal of the stems and leaves on rotation helps to prevent them from building up a litter layer, caused by fallen leaves which results in them drying out and becoming invaded by other species such as willow which exacerbates the drying out process. By maintaining reedbeds in a wet condition they provide the maximum benefit for biodiversity, allowing free movement of fish and invertebrates which are important prey items for reedbed specialists. Another by-product of habitat management of the Somerset Levels and Moors is willow, whether as part of an aging reedbed or willow pollards sited on the field edges of lowland wet grassland.

With the exception of willow, wetland biomass is not currently being commercially harvested and processed as a fuel in the UK. The RSPB trialled and tested both Common Reed and Common Rush in a number of different biomass formats to highlight the potential usability of each material type in different forms as part of a project with the Department of Energy and Climate Change (DECC). Common Rush and Reed each have very different characteristics which become significant when looking to utilise material as a fuel, particularly in relation to the harvesting season for each and the resulting moisture content. It would appear the most ideal time to harvest is winter when the reed or rush has died back and therefore dryer, however this is the time of peak heat demand when processed fuel would be required. This could mean inter-seasonal storage could be required to bridge a gap between harvest and demand within the supply chain. It should not be assumed consumers of the fuel would be happy to store large quantities of fuel. Appendix 2 outlines a more detailed study on reedbed management and yield.

Common Reed or Rush are not currently commercially harvested for use as fuel, meaning studies to date have not adequately identified:

- which format of fuel would be most feasible to produce i.e. loose, briquettes or pellets to offer the best balance between burn performance and fuel production. This is required to accurately calculate demand, transport and storage requirements.
- how competitive wetland biomass is against other commonly used sources of biomass fuels are virgin wood, certain energy crops, industrial wood residues and certain agricultural residues. Biomass fuels are typically delivered as woodchips or wood pellets but can also be in other forms such as logs or straw bales.
- The key characteristics of a biomass fuel include its moisture content which affects its energy content (the calorific value), and the particle size/grade. Factors which affect fuel costs include the type of fuel and its associated market availability, the quality of the fuel, the form the fuel is delivered in and the proximity of the fuel source to the point of use.
- How much land is available to support this production of biomass materials (Common Rush or Common Reed). As an example, we would anticipate Dunball fuel requirement would need the following reed to be harvested based on reed age: 1-year old reedbed a 5.1-hectare area, 3-year old reedbed a 4.5-hectare area, 15-year old reedbed a 3.6-hectare area of would need to be harvested.

Fuel characteristics

A range of standards cover the production and characteristics of biomass fuels, the performance of a fuel against these characteristics are important for the specification of the boiler. If looking to develop the fuel for wider use, compliance with these standards should be ensured so boiler operators understand the likely performance of the fuel, which would minimise uncertainty. Detailed considerations on fuel characteristics and the impact on a biomass boiler are available in appendix 3.

Moisture content

Moisture content is a significant consideration for a biomass fuel. The wetter the material the less calorific value it will have, as the first part of the burning process will be drying the material out before it can then be converted into heat affecting overall boiler efficiency and the useable heat generated. High or variable moisture content can also cause problems within the fuel storage hopper, encourage fuel discomposure and aiding 'fuel bridging' around delivery auger. The moisture content of the harvested material also affects the ability to process the fuel. For example, briquetting and pelleting of biomass at a moisture content higher than 20% is generally not advisable and may damage the equipment being used.

Ash

Ash content is also an important characteristic of the fuel which has a considerable impact on the performance of the boiler in two ways. Previous burn test results show that although ash content is higher than wood chip or pellet it is not at a level which is unmanageable in a biomass boiler system. Ash is important to an operator as it generally needs to be manually removed from a collection hopper which is an operational cost. It can also affect air emissions as fractions will be blown through the burn chamber increasing maintenance on any emission abatement system installed. Finally, ash can melt in the burn chamber forming clinker which if allowed to build up will affect the performance of the system. Further investigation is required but the ash for common reed has shown a higher melting point than other biomass fuels in limited burn tests carried out to date which minimises the risk of clinker formation in the boiler – boilers will be designed to operate below ash melt points of the fuel.

Fines

A further performance consideration of a biomass fuel is the quantity of fines (small particles) in the fuel stock. Fines can affect both the storage, transfer and burning characteristics of the fuel. Fines can give problems in the fuel delivery system contributing to fuel bridging. Fines can also blow straight through the burn chamber causing similar impacts to ash on air emission abatement systems that may be installed.

Mechanical Durability

This is a measure of how resistant the fuel (pellets or briquets) are to break-up in transport, storage, delivery to the fuel hopper or within the boiler system itself.

Bulk Density and Energy Density

The storage requirement for a biomass fuel is dramatically affected by its form. The bulk density and energy density are also very important considerations specifying the boiler system, its thermal output and fuel storage and fuel delivery system. It also affects transport / delivery frequency and costs. The burn test data analysed shows that although wetland materials have similar calorific values, they have a much lower bulk density meaning a greater volume of material is required increasing storage requirements. Pellets offer the best bulk and energy density for wetland biomass fuel, but this is the most processed form of the fuel.

Fuel Selection Considerations for Feasibility Study

Three main options have been considered for this feasibility study. These are loose or chopped material, briquettes and pellets. Each option researched was found to have pros and cons reliant on issues such as site conditions, availability, machinery availability and market or place of combustion. Please refer to *Appendix C* for these comparisons.

Pellets are considered the most favourable option for the design and specification of a biomass boiler at Dunball Depot. These conclusions have been made based on:

- Lack of existing material or established supply chain for wetland biomass fuels to compare
- Processed pellets have a higher calorific value and lower/consistent moisture content providing the best operational efficiency for the boiler
- Pellets allow the best level of automation in the biomass boiler systems and have proved the most reliable in operation in Skanska's experience
- The increase bulk density and energy density of pellets minimise storage volumes and fuel deliveries
- Potential dust emissions/air quality issues and higher ash content could mean that loose material is less likely to satisfy the RHI standards

Although these considerations and conclusions on fuel selection have been made for this feasibility study it should be noted that other existing biomass installation exist as potential outlays for all three fuel types. The conclusion that pellets offer the only commercial option for the fuel should not be taken from this report. For example, if the most viable fuel production methodology was loose chopped materials then it is possible to specify a boiler to work with this type of fuel but there would be operational consideration to manage.

The Renewable Heat Incentive (RHI)

The Renewable Heat Incentive (RHI) is a government backed incentive which pays owners of eligible heating equipment based on the generation of heat. Biomass boilers are an eligible technology under the scheme, however wetland biomass is not currently recognised by OFGEM as a usable fuel, which means the fuel would have to be pass a registration process and meet RHI fuel requirements for the installation to qualify for RHI payments.

The RHI is designed to offset high fuel costs and the increased capital investment required to install and operate low carbon heating systems and once set quarterly payments are made based on the quantity of usable heat generated for a 20-year period. The RHI therefore, plays an important role in the business case of any biomass installation. To receive RHI payments the heating installation must meet specific operating conditions and performance characteristics such as air emissions, heat metering and whilst these have been covered elsewhere in this report its important to note that the RHI also stipulates conditions on the type of fuel used.

The installation of a biomass boiler at Dunball depot will rely on the RHI so any fuel produced through wetland management will need to meet the RHI requirements, hence a review of these requirements has been undertaken. However, it is also important to note that meeting these requirements means the fuel could be used in other biomass installations which potentially opens a wider market for the fuel.

To be eligible for use in an RHI installation the fuel will need to be registered on the Sustainable Fuel Register (SFR) for 'non-wood' fuels. This process requires the completion of an application, which assess the RHI criteria for Land Use and Greenhouse Gas emissions created during the fuel production. There is an annual registration fee which varies depending on total fuel quantities produced. It is recommended further investigation of the most efficient approach to management of the SFR is carried out if fuel supply is scaled.

SFR key requirements

- Land Criteria – This criterion aims to ensure the fuel is not sourced through unsustainable land management. There should be no problem with the wetland biomass meeting this requirement, but this should be kept under review.
- Greenhouse Gas Emissions - The Sustainable Fuel Register puts a carbon emission limit on the production of the fuel. This is set at 34.8gCO2/MJ which equate to approximately 550kgCO2/t of wetland biomass. Carbon emissions are generated through fuels used to harvest, transport and process the fuel and will vary depending on harvest methods, processing and storage locations.

Other potential markets for the fuel

Whilst RHI eligibility is important for most domestic and non-domestic biomass boiler installations these are not the only potential markets for a variable fuel from wetland biomass. Larger industrial burning processes may also have use for the fuel. A limited desk study found the following installations within a geographic region to Somerset. No contact has been made with any of these uses during this study.

- Energy from waste plant Avonmouth (part funded by North Somerset)
- Exeter Energy from waste plant
- Western Wood Energy Pant (Port Talbot)
- Aberthaw Power Station,
- Uskmouth Power Station,
- Liberty Steel Biomass Power Station,
- Margem Green Energy plant

Regulations and waste management

The Environment Agency have confirmed that they would consider the grown biomass as equivalent to a purpose grown crop, meaning waste controls would not apply to turn the harvested material into a fuel product.

However, if the reeds are being discarded, intended to be discard or are required to be discarded then they may well be considered a waste. For instance, if they are required to be removed for disease control or due to land development. The introduction or mixing of other types and sources of biomass material may well introduce wastes i.e. waste wood chip. Consequently, the Environment Agency should be consulted in the further development of fuel harvesting and processing options.

3 Biomass Installation for Dunball Depot

Introduction

This section of the report investigates the installation of a biomass boiler system a Dunball Depot. It covers a general review of biomass technology, outline proposals for installation, energy consumption at the depot and capital and operation costs.

The characteristics and physical form of fuel to be burnt is integral to the design and specification of a biomass boiler system (see also appendix 3). Given this study is also looking at the development of new fuel source and without a full understanding of what is viable and feasible on the fuel production side it was not possible to provide actual specification for a biomass boiler for Dunball Depot at this stage. Instead, sample designs and prices from other similar schemes have been used as a guide.

Dunball Depot Gas Consumption and Cost Summary

A detailed review has been undertaken of current energy use at Dunball Depot to understand consumption patterns, costs and model how heating demands could be met with a biomass system. Gas and electricity are currently provided by Skanska through a supply contract with E.On. Electricity supply is on a 100% REGO (Renewable Energy Guarantee of Origin) tariff but gas is provided on a standard fossil fuel-based tariff. The proposed biomass boiler would displace gas use at the facility hence this energy source is the focus on the energy review. It should be noted that gas consumption is temperature dependant and can vary depending on seasonal conditions, so a number of years data have been used to try and minimise seasonal variation.

Monthly energy consumption has been modelled and is shown below in the graph and total annual summaries are provided in the table. The graph clearly shows seasonal variation over the year with peak use being in the winter heating season. It also shows a wide range between winter peak demand and the lowest levels of demand in the summer months. This variation can be an indication of poor insulation in both depot buildings but is also contributed to with the direct gas heating system in the depot workshop. This variation is important as a potential biomass system must be both big enough to meet the peaks in winter demand whilst still operating efficiently during the low demand in the summer.

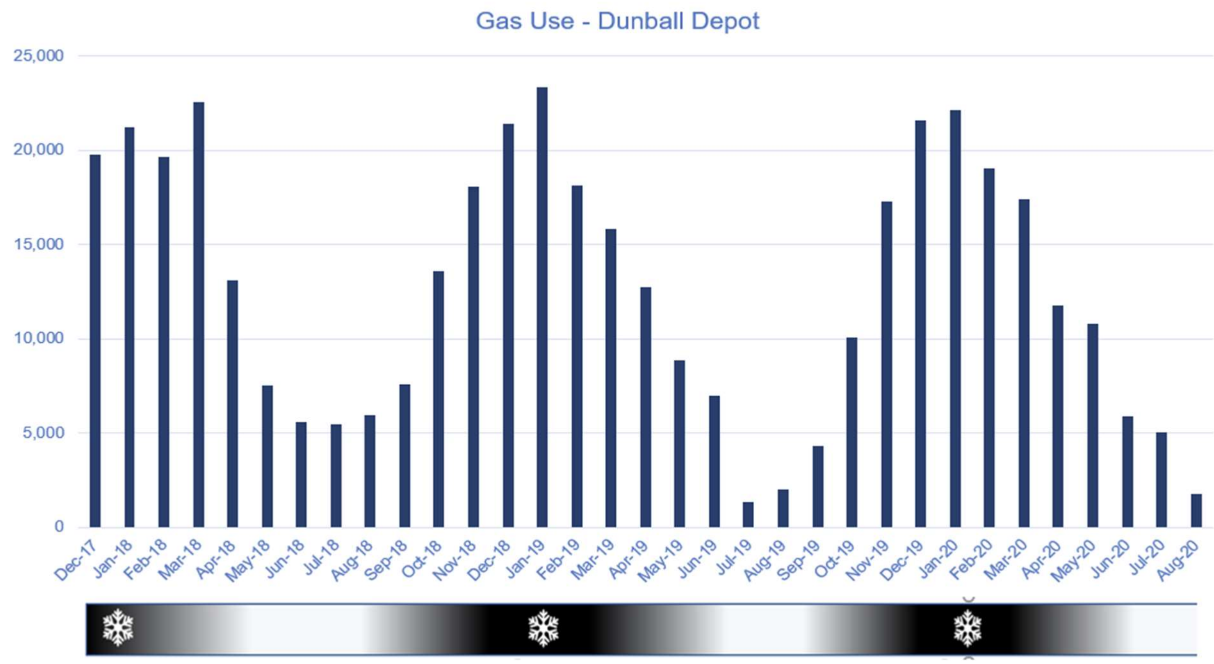

Fig 1

Year	Consumption (kWh)	Total costs	Consumption cost only	Cost (pence) /kwh	Carbon emissions kgCO2e / kwh	Total CO2e emissions (Tonnes)
2018	161,676	£6,235	£3,561	2.20p	0.184	29.75
2019	142,533	£5,662	£3,064	2.15p	0.184	26.23
2020 to Aug 2020	*93,830*	*£3,799*	*£1,986*	*2.01p* *(from April)*	*0.184*	*17.26*

Table 3

Biomass heating technology

Biomass boilers have become established as a low carbon heat technology over the last 20 years. Systems have become more efficient and automated allowing for greater integration in a wider range of applications and continued government support through the Renewable Heat Incentive has incentivised this development. There are now over 2,700 biomass installations across the South West (ref BIES RHI statistics). Biomass is considered a renewable low carbon form of energy and has a place in the transition from a fossil fuel-based heat system in the UK.

A biomass boiler works best when delivering constant heat outputs for longer periods of time such as winter base load heating or heat for an industrial process. Essentially the boiler requires time to heat up to operating temperature which means it is using fuel before it is ready to deliver heat meaning the system is inherently less efficient in meeting small, variable heat demands. This inefficiency can be exacerbated in periods of low overall heat demands such as the summer when the boiler is off for longer periods of time. Biomass boilers are expensive to buy and install so it is important to consider options to reduce overall costs and still achieve the wider objectives of this project.

There are several solutions that can be applied to reduce the impact of this characteristic of biomass boilers. The boiler's output can be modulated to help it meet lower demands, a thermal store can be used as a buffer between demand and generation meaning the boiler can provide the required heat in a short burst which is then fed from the store to meet the demand over a much longer time. Alternatively, and in combination with a thermal store, a supplementary heat sources such as a gas boiler, heat pump or even solar collector can be used to meet peak demand in the winter and the variable, low demand in the summer while the biomass would be used to provide winter base load shown by the shaded areas in the graph below.

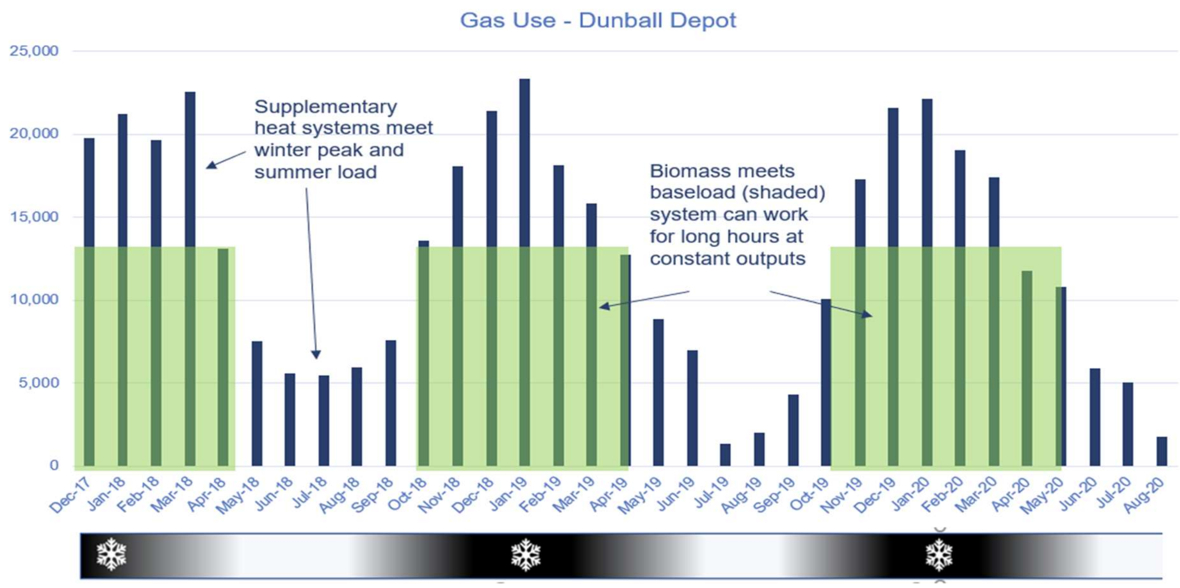

Fig 2

Skanska has two biomass boilers installed in their own facilities and this supplementary heat source strategy is used at both to maximise efficiency of the biomass systems. Obviously retaining the existing gas boilers provides a simple way of providing a supplementary heat source. However, as part of this study, we have looked at an alternative scheme utilising an air source heat pump and solar collectors alongside a biomass boiler which would, reduce the capital cost of the biomass system, still allow the testing of wetland biomass but would also achieve the zero-carbon ambition of the council - this can be seen in appendix 4. RHI support would be possible for both the biomass and air source heat pump in this case.

Existing Heating Infrastructure at Dunball Depot

The Dunball site comprises several buildings of which two are heated and the remainder depot/store structures are unheated. The two heated buildings are be described as follows:

- Building A – Council Offices, houses reception and office areas (see fig 3). A floor standing gas fired boiler is located in the kitchen and provides low temperature hot water heating to serve radiators throughout the building. Domestic hot water is generated via an electric, unvented water heater providing domestic hot water to serve the kitchen sink. The floor standing boiler is an older model and is likely coming towards end of life

- Building B – occupied by Skanska, comprises of offices, kitchen, meeting, workshop and changing room areas. The ground floor boiler room houses one floor standing gas fired boiler with an approximate rated output of 65kW. This generates low temperature hot water to serve:
    - A variable temperature heating circuit serving radiators via run/standby pumps
    - A constant temperature heating circuit serving indirect hot water cylinder for domestic hot water generation via run/standby pumps
- The boiler room in Building B houses a gas fired boiler and associated heating pipework, valves and controls, hot water cylinder, circulating pumps, wall mounted control panel and gas safety controls.
- The flue from the gas fired boiler discharges above roof level.
- The overdoor gas fired space heater in the workshop of building B is not covered by this study and would be retained as the most efficient method of heating the workshop space heating. However, this system could be replaced with an electric infra-red panel heating system.
- The gas supply for these two buildings originates from a metered incoming supply within an outbuilding at the corner of the car park which runs to building B before crossing the tarmac hardstanding area of the facility to service the heating plant in building A

More detail on the part equipment review and specification is available in appendix 5

New biomass system for Dunball Depot

Due to uncertainties around fuel characteristics an exact boiler has not been specified for Dunball Depot, however information has been developed to provide budget prices and outline designs. Approximately 75Kw output biomass boiler would be required to deliver the peak winter loads for both buildings - appendix 6 gives example supplier information and specification. A large thermal store would buffer demand allowing the biomass boiler to charge the store at maximum efficiency, the store then providing the heat to both buildings as required. Hot water flow and cold-water return would be piped from the thermal store to building A across the main car park and into Building B on a separate loop.

The boiler would either be provided in a standalone containerised system or would be housed in a new plant room to the side of building B. There would not be enough space to house the new biomass system within the existing plant room of building B. The containerised system or newly constructed plant room would house all the associated pumps, controls and importantly the fuel store so safe delivery and vehicle access has been considered. A separate flue system would be installed for the new boiler. It should be noted that planning permission may be required for the install and this will need to be reviewed with the local authority as detailed design is developed.

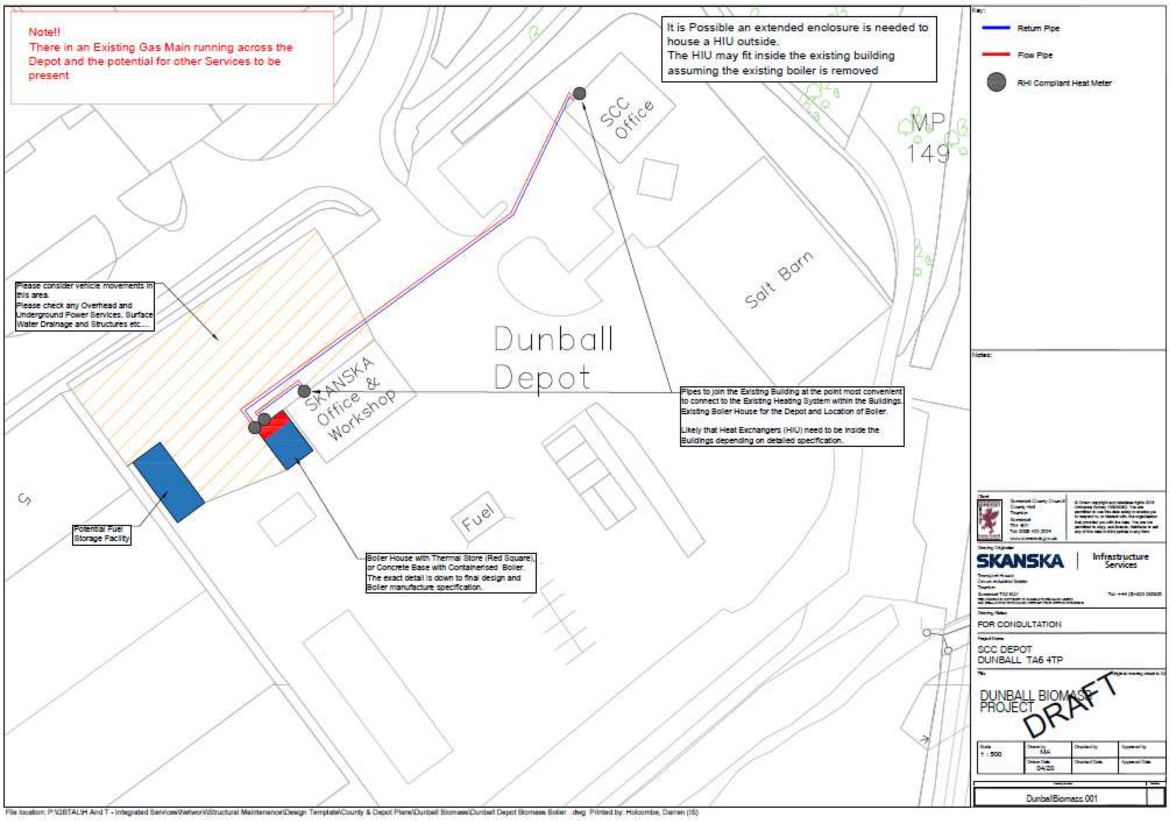

Fig 3

Removal of redundant plant

The installation of a new biomass heating system would require the removal of redundant plant. Part of the study reviewed the possibility of retaining the existing plant in Building B as back up or the provision of peak load capacity, this maybe an option that is explored further in detailed design, but it should be noted that the existing plant in both buildings is old and near the end of its serviceable life. For the purposes of this study, we have assumed the old heating systems will be removed.

The floor standing boiler in Building A will be removed and replaced with a Heat Interface Unit (HIU) to take the hot water piped directly from the new thermal store and provide both the domestic hot water and heating for Building A. The old electric heater for domestic hot water would be removed from Building A. The existing boiler pumps and associated pipework would be removed from the boiler room in Building B and replaced with a HIU plumbed into the existing heating and hot water system. Old radiators in both buildings would be removed and replaced by new ones to improve heat distribution. The electric heater in the upstairs meeting room in Building B would be removed so a new radiator can be plumbed in. Existing gas connections to any removed boiler plant would be disconnected and made safe.

The existing workshop direct burn gas system could be replaced with a more modern infrared electric panel system. This would remove gas completely from the site achieving zero carbon emissions ambition, however this heat would not affect the sizing or new heat delivery proposed for the new biomass system so has not been investigated further. Skanska have implemented infrared heating to our new paint shop building constructed as part of our zero-carbon redevelopment of a main plant yard in Bentley.

Resilience Strategy

Although a robust boiler and low risk fuel strategy has been identified by this feasibility study the following resilience strategies have been considered in case of failure of the biomass boiler or break down in fuel supply.

- Temporary electric heaters could be used in both buildings to maintain comfortable working conditions in the offices of both building A and B
- One electric shower could be installed in Building B's changing rooms to maintain this welfare facility
- The potential use of electric emersion heater back up for the thermal store will be investigated in detailed design
- The biomass boiler selected will be capable of running on commercially available wood pellets in case of fuel availability issues. Wood pellets also qualify for RHI payments

The use of an electric emersion heater in the thermal store is considered the best resilience strategy for boiler failure as this allows the heat delivery system to work in the same way and could be implemented seamlessly without significant disruption to the occupants of both buildings.

The potential to retain existing gas fired plant as a resilience strategy has been reviewed, however both boilers in Building A and Building B are old and near the end of their serviceable life. Also, space required to integrate the new heating equipment means the most cost-effective solution is to remove the old plant rather than provide new enclosures for the new equipment, for example it is envisaged the new HIU would fit where the existing floor mounted boiler is currently located in Building A.

Installation Costs

Biomass boilers are comparatively expensive against more traditional gas-based systems and costs increase significantly as the system increases in heat output and complexity. The complete price of a biomass system relies on its exact specification and this is closely linked to the fuel type, fuel burn characteristics and fuel preparation (Loose, chip or pellet). The characteristics of the fuel are required before a biomass boiler system can be fully specified and priced. As the details of the fuel production and processing are not yet known, costs from biomass boiler installations have been used to create a budget price.

A full budget price of £125k should be allowed for the purchase, installation and commissioning of a biomass boiler at Dunball. This price would include the thermal store, pipework, controls, radiators and the associated civils work required to link the two buildings at the depot into the heating system. This budget breakdown as follows:

- £85-90K 75kw output containerised pellet burning biomass boiler including thermal store, fuel store with autorotated delivery, pumps, valuing, controls, air emission control and ash removal system

- £12k Heat Integration Units radiators and pumping
- £13.5k civils and pipework connection between two buildings
- 30% risk and continency

SoR Item			SoR Description	Unit	Rate	Quantity	Cost
02	020	10	Take down & Dispose - Pre-cast concrete kerb, concrete bed and backing	lin m	£ 8.22	3.64	£ 29.92
05	067	05	150mm drainage pipe - Concrete surround Type Z - Up to 900 mm average depth	lin m	£ 50.29	107.2	£ 5,391.09
05	591	05	EO excavation in paved areas - Asphalt concrete carriageway; cut one side	lin m	£ 3.88	12.6	£ 48.89
05	591	10	EO excavation in paved areas - Asphalt concrete carriageway; cut both sides	lin m	£ 4.64	78.5	£ 364.24
05	661	20	Reinstatement - Flexible carriageway - Type 4a (HAUC appendix A3.4)	lin m	£ 50.94	91.1	£ 4,640.63
05	681	15	Reinstatement Footway & Verge - Grass verge	lin m	£ 0.72	16.1	£ 11.59
05	681	20	Reinstatement Footway & Verge - Kerb and foundation	no	£ 25.22	4	£ 100.88
00	000	01	Provisional Sum - Contingency	%	£ 0.25	10587.24	£ 2,646.81
							£ 13,234.05

Table 4

An alternative scheme using supplementary heating systems has also been investigated which may reducing the overall size of the biomass system could reduce the capital cost and still deliver the key objectives of the study.

Operation and Maintenance

A review of operational costs has been carried out to give an indication of the ongoing annual costs required to fuel, operate and maintained a biomass boiler at Dunball Depot. As well as fuel costs biomass boilers do require more ongoing maintenance than traditional gas boilers to keep them running efficiently. There is also the ongoing task of ash removal and disposal, which we have investigated in other sections of this report. For this study we do not yet know the actual cost of wetland biomass fuel so we have used comparative prices for wood pellets, we have also assumed the biomass system would have automated fuel delivery and ash removal system which would minimise daily attendance.

Annual fuel cost

Annual fuel costs have been estimated using current pricing data from Skanska biomass fuel supplier (AMP Celan Energy). Skanska have a fixed price framework agreement in place with this supplier. Table 1.2 is repeated here as this table lays out the existing energy use and gas costs for the facility.

Year	Consumption (kWh)	Total costs	Consumption cost only	Cost (pence) /kwh	Carbon emissions kgCO2e / kwh	Total CO2e emissions (Tonnes)
2018	161,676	£6,235	£3,561	2.20p	0.184	29.75
2019	**142,533**	**£5,662**	**£3,064**	**2.15p**	**0.184**	**26.23**
2020 to Aug 2020	*93,830*	*£3,799*	*£1,986*	*2.01p (from April)*	*0.184*	*17.26*

Table 3 (repeated)

Cost information on gas chargers

A gas invoice is made up of several components, including standing charges, tax and the unit cost of energy – this is shown as “Total costs”. It's important to note that unless gas is completely discounted from the site (which is not recommended until new system is well established for back up and site resilience) standing charges are still applicable and it is therefore only the cost of the energy and Climate Change Levy elements of the cost which would be displaced by the biomass system (£3,468).

2019 is being used as a baseline year for this study and the total costs break down as follows:

Item	Cost
Total invoice amount	£5,662
Cost exclude VAT	*£4,807*
Cost of fuel (2.15p/kWh)	*£3,064*
Climate Change Levy (.339p/kWh)	*£404*
Standing charges	*£1,339*

Table 5

Predicted biomass fuel costs for the facility

ENPlus A1 Wood pellets at <10% moisture are purchased at £236/ tonne (ex VAT) and 1 tonne of wood pellet provides approximately 4,722kWh of energy (allowing for boiler efficiency of around 85%). Wood pellet fuel works out approximately at 4.9pkWh. 30-31T of wood pellet would be needed to meet Dunball Depot annual heating demand at a fuel cost of £7,316. Before RHI contributions the overall spend on wood pellet to meet 100% of the heating demand for Dunball Depot would be £3,848 more than the existing gas heating. This is before RHI contribution.

RHI is explained in more detail below but payments have been calculated at a rate of 3.11p/kWh. RHI contribution would be approximately £4,400. This means the combined cost of running a biomass system with full RHI contributions would be £550 cheaper than the existing gas system. Table 6 below outlines the comparison.

Fuel type	Cost (p/kwh)	RHI (p/kWh)	Final tariff
Gas	2.15	0	2.15p/kwh
ENplus A1 wood pellets	4.99	+ 3.11	1.88p/kWh

Table 6

Maintenance

Skanska operates both pellet and wood chip boilers and have drawn on this experience to inform this section. A budget of £1700 is allowed for annual maintenance this covers two technician visits, parts and replacements. This cost does not include costs for regular attendance to the boiler to empty ash bins etc. It should be noted that the sort of general operative assistance is not available at Dunball Depot. There is no general facility manager or support staff to oversee the operation of the boiler, which is why it is considered necessary to install an automated biomass system. It is advised to install fuel level monitoring, ash level warning and air emission control system performance monitoring for example, fuel monitoring in the storage hopper should be installed which can let the delivery supplier know when fuel levels are running low so new delivery can be arranged rather than relying on highways maintenance staff.

Renewable Heat Incentive (RHI) in Operation at Dunball

There are some operational implications of the RHI that should be considered. In this section it is assumed that the wetland biomass fuel can be processed in line with RHI requirements and the necessary certifications are obtained to allow its contribution to the operational cost assessment. As stated in an earlier section the RHI is a government backed incentive but does have rules in how it is administered.

- RHI will only be paid to the **owner** of the equipment not the operator and is designed to recoup capital as well as cover high fuel costs. The scheme does not translate very well to a landlord tenant situation where the landlord owns the equipment and receives the RHI based on the heat generated but the tenant buys fuel on a variable tariff. This can lead to a split incentive of the tenant not wanting to pay for expensive fuel and the landlord trying to compensate from income based on use. The commercial arrangement around heating costs and RHI payments would need to be considered for the long-term operation of the Depot between Somerset and its highways contractor – it should be noted that RHI payments last for 20 years so longer than typical highways maintenance contracts.
- RHI pays based on the kWh of heat generated and not on the quantity or cost of fuel used. This means two things. First, the RHI payment is not a fixed amount each quarter and will vary seasonally. Second it means the RHI will not pay for heating plant down time, heat lost in a distribution system, thermal store, inefficiencies in the boiler or for short term fluctuations in fuel costs.
- A detailed heat metering strategy will be required on the system between the boiler, the thermal store and building A and B to measure the heat used. This metering strategy will require sign off by OFGEM as part of the application process
- RHI cannot be used with any other form of grant, loan or incentive. For example, RHI payments will not be granted if, for example, Salex funding has been used to cover capital costs. This should be reviewed between the County Council and the SRA
- RHI payments are linked to CPI and increase every year over its duration but are not linked to biomass fuel costs which can vary over the period.
- To prevent overuse of the system the RHI payment is calculated on a two-tier system. Tier 1 payments are made on the kWh delivered by the system if it had operated at full power for 35% of the year. Tier 1 is currently set at 3.11p/kwh. Tier 2 is payable for the remainder of the heat generated by the system at 2.18p/kwh .
- The future of the RHI is not secure and is currently the Non-domestic RHI tariff is only guaranteed until March 2022 but the system must be fully operational at that point. The scheme may be extended but this depends on the government policy. Tariff rates (the pence per kwh paid for usable heat) can be changed every quarter but these have not been changed for a number of years.

The Public Sector Decarbonisation Fund

The new £1bn Public Sector Decarbonisation Scheme has recently been launched by the UK Government for a limited time, application deadline is 11th January 2021. This scheme aims to fund, up to 100% of the capital cost for energy efficiency and heat decarbonisation measures in non-domestic public buildings. This scheme cannot be used in combination to RHI and the current applicable technology list **does not** cover biomass systems.

4 Carbon/biodiversity benefits

Carbon Emissions

Carbon reduction is an important motivation of this study as any installation of low carbon heating would tie into wider carbon strategies such as Somerset County Council's aim to reduce emissions and become carbon neutral by 2030. Biomass heating displaces natural gas and would reduce annual greenhouse gas emissions from the Dunball facility by between 25 and 30 TCO2e per year. Further to this the use of wetland biomass supports and important carbon sequestration habitat which could lead to much wider benefits.

Calculating carbon emissions

Carbon emissions for Dunball have been calculated by taking an average consumption of gas for a year in kWh and converted into tonnes of carbon dioxide emissions (CO2e) using the 2019 UK Government Greenhouse Gas Reporting Conversion Factors as published by DEFRA and BIES. UK government conversion factors account for the global warming potential of other emissions associated with the fuel, such as NOx emissions and this denoted with a lower case 'e' after CO2 against reported emissions.

For a full and fair comparison of the carbon reductions between the base case and biomass it is important to consider the impacts of producing the fuel and getting it to its point of use at the depot. In the case of the wetland biomass, it is important to consider the impacts of harvesting and processing the fuel to ensure carbon impacts created at this stage do not outweigh the benefits of its use, however it is therefore important to consider the same for gas used in the base case. These would be considered upstream emissions or "well to tank" emissions (WTT) and cover the harvesting, extraction, processing, refining and transportation of the fuel to its point of use. WTT emission rates are also given in the UK Greenhous Gas Reporting Conversion Factors.

Finally, the overall efficiencies of both the existing gas boilers and new biomass plant has been considered the same at approximately 85%.

<u>The Gas Base Case:</u>
The average gas consumption for Dunball Depot across 2018 and 2019 generates approximately 31.6TCO2e per year, because gas consumption is seasonal and winter heating demands can differ year on year, it is sensible to think of a range of CO2e reductions of between 28 and 33 TCO2e per year.

- Average gas consumption = 152,104kWh
- 1 kWh of gas use generates 0.184kg/CO2e = (152,104 x 0.184 = 27,987kgCO2e)
- WTT associated with 1kWh of gas 0.024kg/CO2e = (152,104 x 0.024 = 3,650kgCO2e)
- Total Carbon emissions for gas base case = ((27,987 + 3,650)/1000 = 31.6TCO2e)

The Wetland Biomass Case:

There is currently no carbon factor for wetland biomass in current government greenhouse gas reporting conversion factors. Whilst further work would be required to estimate a carbon factor for wetland biomass when final harvesting and processing methods have been developed, carbon conversion factors for wood chip/pellets have been used to estimate the emissions associated with the wetland biomass case.

The burning of biomass is not completely free of greenhouse impacts. Carbon dioxide emissions generated during the actual combustion are considered net zero as the fuel fixes CO2 from the atmosphere during growth, however burning a fuel creates other air emissions such as nitrous oxides which have greenhouse potential and therefore contribute to the carbon emissions associated with the burning of biomass. It is also important to consider the production of a useable fuel (Well to Tank emissions) generally requires carbon-based fuels to power plant, equipment and transportation, which should be considered in the overall carbon analysis. For this study the WTT emission rate for wood pellets has been used as a worst-case scenario.

- Total 152104kWh gross fuel value
- 1kWh wood chip/pellet generates 0.0156kg/CO2e = (152,104 x 0.0156 = 2,372kgCO2e
- WTT associated with 1kWh wood pellet 0.037kg/CO2 = (152,104 x 0.037 = 5,627kgCO2e)
- Total worst case carbon emissions for wetland biomass = 2,732 + 5,627/1000 = 8TCO2e

The use of wetland biomass as a fuel at Dunball Depot would save at least 23.6TCO2e per year. It is estimated that the actual case will save more carbon than this as it is likely the UK Greenhouse Gas Conversion factor for Wood Pellet is overestimating the “WTT” emissions for the production of fuel that could be achieved for the wetland biomass pellets.

Carbon sequestration

The potential wider benefits of developing wetland biomass as a fuel have been reviewed to identify and support the project. Findings are summarised as:

- Lowland peatlands are among the most carbon rich habitats in the UK and have been identified by the Committee on Climate Change as an important carbon mitigation for the UK meaning increased focus will be placed on this resource in future climate budgets
- Paludiculture is a growing concept looking at the productive cultivation of wet and rewetted peatlands to reduce atmospheric carbon dioxide while deriving economic benefit from the land (productive lowland peatlands, IUCN UK Peatland Programme’s Commission of Inquiry on Peatlands 2019)
- Research in this area is ongoing to understand the true carbon implications of increased land management on wetlands for fuel or other purposes, but a recent study suggested a positive impact ranging anyway between 3 and 6TCO2 per hectare can be achieved. (DEFRA Paludiculture literature review). Considering between 4-5 hectares would be required to supply Dunball Depot this could effectively double the carbon savings of the initiative.
- Although this project looks at using biomass from conserved established wetlands the potential of the combined positive carbon benefit of displacing fossil fuel and carbon sequestration could be reviewed more widely for the area.

- Carbon offsetting credit potential. Government policy is increasingly focusing on incentivising carbon offsetting through sequestration and habitat improvement. Although policy in this area is still developing, the recently announced a new £640m Nature for Climate Fund offers support for peatland restoration. The use of peatland restoration was also identified in carbon offsetting strategies such as Heathrow 2.0 Sustainable Development Strategy. The potential to provide further economic benefit from the wet management should be kept under review as this area develops.

Biodiversity Benefits

The potential biodiversity of an initiative to improve existing wetland habitats or even the establishment of new habitat could be considerable. The policy landscape is rapidly developing in this area and will need to be kept under continued review. As part of this report, we have used the Skanska Biodiversity Calculator to assess the biodiversity units as per the DEFRA metric which could be achieved - the tool itself, output report and methodology can be found in appendix 7. The number of units per hectare will depend on the land management regime put in place but even wetland rated as poor in the calculation methodology generates biodiversity credits. These units are important as they could be used under the Net Gain requirements proposed under the Environment Bill. Although this legislation is not yet law and the actual mechanics of how this system would work is still subject to amendment this potential could provide further financial support for land use change. A balance between conversation and fuel production will have to be reviewed to ensure the best balance is established.

Biodiversity net gain is not the only habitat related incentive that this initiative could investigate. The new Agriculture Act and the Green Recovery Challenge Fund should be investigated further.

5 Conclusions and Recommendations

Wetland biomass shows potential as a fuel source. The desk study review of burn test data shows good results. Ash content is higher than wood pellet and wood chip fuels, which will raise concern with boiler operators, but high ash melt point a benefit. We believe there could be market for the fuel – especially if connected to a conversation benefit.

A biomass boiler system is expensive, and the fuel characteristics are important to its design and specification. We would recommend further work is done to develop a viable scalable fuel production methodology and before further development of the biomass boiler. The fuel demands of one site should not dictate the potential fuel production.

Without a pre-set fuel type to consider in this study we chose the best option from an operator’s perspective which based on our experience is pellets, although with understand this is the most processed fuel with the biggest implications on the supply chain. We also consider pellet fuel to provide the best operating conditions for a highways depot where there is minimal onsite supervision or maintenance to look after the boiler.

There are a wide range of existing biomass installations operating across the South West and Somerset region. If an RHI qualifying fuel could be developed from wetland biomass and we see no reason why it couldn't' it could be used in existing installations. This could offer great market potential for scaling fuel production and should be investigated further.

A biomass system can be designed and installed to provide heat for Dunball depot, however the business case is weak. With RHI support the boiler would generate a small annual income but this is unlikely to ever recoup the capital investment. We would also recommend supplementary heat sources are used to maximise boiler efficiency. Our rational for this using supplementary heat sources is that the installation of a biomass boiler running on wetland biomass would be a demonstration project and should be designed to show the best possible operational efficiency.

Recommendations

We have set out a number of recommendations to help take this initiative forward:

Recommendation	Justification
Undertake desk study on options for fuel production and supply chain requirements to identify most viable, scalable harvest and production method for the fuel. Consider fuel performance characteristics, seasonal circles, both from point of view of heat demand and harvest, storage implications and conservation requirements.	It is important to ascertain what would be the most viable fuel production scenario which could be scaled and expanded to maximise habitat potential. If this is dictated by biomass boiler design on one site it may miss saleable opportunities.
Review market options for chosen fuel.	This should consider residential (domestic) commercial (non- domestic) as well as industrial markets. It should also consider potential non-RHI markets (biomass installation which do not have RHI support).
Produce sample fuel to test methodology but also provide representative fuel sample which can be used for live boiler tests.	Allows development of fuel production methodology and understanding of costs.
Use sample and undertake testing to confirm physical and burn characteristics of the fuel i.e. ash, moisture, calorific value, mechanical durability etc	Provides detailed information to engage boiler manufactures and existing biomass boiler operators. Also allows chance to refine production methodology.
Engage key boiler manufacturers and understand warranty issues, undertake some fuel tests– ensure to select manufacturer which suits best fuel type and market sector focus.	If targeting existing operators of biomass installations potential warranty issues could be a barrier to adoption of the fuel. Some key suppliers already accept reed and rush.

Consult existing biomass boilers about potential trials. These can be identified through biomass boiler design specialists or maintenance contractors.	Build contacts and interest in potential fuel sources. Develop price point information for fuel supply.
Review potential biomass system at Dunball Depot to suit fuel production options.	Design the system to suit the fuel not the system dictating fuel production. this can then be used as a demonstrator project for the actual fuel solution.