FINAL PHASE 1 REPORT – FEBRUARY 2022

# Proving low ground pressure harvesting equipment in the field to extend SRC Willow and Poplar wood crops harvesting season and open up more marginal land for SRC Willow and Poplar crop planting

ENERGY CROPS CONSULTANCY

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| **Project Code (reference number):** | ECC-313-1-M – Biomass Feedstocks Innovation Programme | | | | |
| **Project Title:** | Proving low ground pressure harvesting equipment in the field to extend SRC Willow and Poplar wood crops harvesting season and open up more marginal land for SRC Willow and Poplar crop planting | | | | |
| **Lead Organisation Name:** | ECCL 2020 Ltd | | | | |
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# Contents

# 1 Introduction

Short rotation coppiced (SRC) Willow and Poplar provide an opportunity to accelerate the UK transition towards net zero emissions by providing a rapidly growing indigenous low carbon bioenergy source. This can help replace fossil fuels in power generation, avoid dependence on imported biofuels, create local jobs and unlock wide ranging environmental benefits. Evidencing the opportunity for low ground pressure systems for growing and harvesting SRC Willow and Poplar is multifaceted. The project team has included key advisers working alongside technical experts under leadership by Energy Crops Consultancy (ECC).

Growing SRC Willow and Poplar is the straightforward part - the field operations - planting and harvesting are where the main challenges arise. Low ground pressure systems are essential for efficient planting and harvesting, providing the prospect for turning land into use that is otherwise at risk from degradation, and of little productive potential. Importantly, the ability to harvest the crop at the correct time (late autumn/winter) when the dry matter content is at its highest, gives both yield and quality benefits.

By adopting low ground pressure systems assessed in the project, wide-ranging environmental and economic benefits are unlocked. In the field, Willow and Poplar provide an ideal habitat for many types of wildlife from ground-based invertebrates up to deer, as well as supporting a plethora of bird life. Mitigating soil compaction through Low Ground Pressure Equipment will provide better soil structure and growing conditions. Coppicing retains roots structures and sequesters carbon, while enhancing availability of a locally grown wood products, which allows mitigation of CO2 emissions in heating and power generation. It also creates new revenue streams for farmers – critical as farm funding schemes are moving towards a system that has yet to fully emerge.

Phase 1 undertook detailed engineering design studies to assess the technical opportunities for fitting low ground pressure machinery to existing tractors and trailers. It was concluded from these engineering studies, that a low ground pressure solution for the current harvest equipment will be essential to enable the scaling up of SRC Willow and Poplar. This is particularly the case on land that is poor-yielding in terms of food production (e.g., poorly drained “heavy” soil-types, difficult terrain). Bespoke low ground pressure machinery will enhance yields on this type of land and be able to work in areas with potentially high annual rainfall. In Phase 2 uses different scenarios and tests each to find the best solution to move the technology from Technology Readiness Level (TRL) 7 to TRL 8. By the end of Phase 2 the UK biomass supply chain will be able to draw down new intellectual property (IP) to scale up SRC/Short Rotation Forestry (SRF) production by using this technology. Ultimately, the productivity of UK contractors and farmers will significantly increase domestic biomass production capability.

The aim is not to ‘reinvent the wheel,’ but make the way it touches the ground a gentler process!

Section 2 of this report provides an assessment of our proposed innovations, based on work undertaken in Phase 1 of this project.

Section 3 details the plans for Phase 2 practical testing.

Section 4 describes the commercialisation plan for the technical innovation.

The Appendices contain the full reports of the detailed studies.

# 2 Assessment of the proposed innovations

This report provides a rigorous and thorough assessment of the innovation of low ground pressure harvesting equipment in the field to extend the short rotation coppicing (SRC) Willow and Poplar wood crops harvesting season, to be used for SRC Willow and Poplar crop planting. Wide-reaching environmental and economic benefits can be unlocked through our innovation. The following section provides an overview of the studies conducted in Phase 1 between July 2021 and January 2022.

## 2.1 Technical description of the innovations

To realise the benefits of SRC Willow and Poplar the following detailed studies were conducted in Phase 1 of the project:

1. Evaluating the feasibility of fitting low ground pressure equipment to a self-propelled forage harvester extensively modified for use in SRC Willow and Poplar harvesting. This was overseen by market leading agricultural equipment vendor CNH Industrial (operating brand name is New Holland), as a main sub-contractor to the project lead Energy Crops Consultancy (ECC).
2. Evaluate changes necessary to fit low ground pressure equipment to an accompanying load carrying system to transport the chips produced by the harvester to despatch from the field.
3. SRC willow provides an opportunity to utilise land with high clay and silt content that otherwise would be laid fallow. UK weather conditions at the time of the main harvesting window, typically September to March wet weather, can cause damage to the ground (particularly the headland) and SRC plants, with compaction in the ground. This creates cost and a reduction in revenue. Harvesting with existing conventional machinery also frequently leads to damage to vehicle tyres, particularly operating at reduced pressure. As tyre sidewalls come into contact with willow stumps, they are at risk of damage. While tyres with reinforced sidewalls solve this risk, they do not reduce ground pressure and reduce the opportunity of accessing other land types (e.g., clay-based ground).

The Phase 1 project engaged with key growers of SRC Willow and Poplar and the ultimate users of its products. This included the existing network of farmers and buyers that ECC works with. A number of key advisers were also included in the project team to enhance the evidence base, providing direct guidance on the economic and commercial opportunities as well as technical requirements.

### 2.1.1 Harvester innovations

Historically, SRC crops have been grown as two rows of plants, 75cm apart with 150cm between each double row. This spatial arrangement has allowed the mechanisation of field operations and particularly the use of conventional forage harvesters as by far the most widely adopted method of harvesting. The forage harvester can cut, chop and blow willow into a trailer drawn by a separate vehicle for subsequent extraction. The major disadvantage of a forage harvester-based system is they are designed primarily for operation on established grass crops during the summer months,

or occasionally on lighter sandy soils in autumn or early winter when harvesting maize. These are heavy machines and whilst tyre technology has improved, a novel solution is required to both reduce ground pressure and improve traction. The same is true for the vehicles extracting the SRC wood chips from the harvester to the point of despatch.

The vehicle assessments completed in Phase 1, showed the challenges of manufacturing machinery that works with both the newer and more mature plantations. If was found that by altering the spatial arrangement by which SRC crops are established, by increasing the width between rows, will allow adaptations to both the harvester and load carrying equipment carting the crop from the harvester. The Phase 1 research shows there is no one 'straight off the shelf' solution to achieve this and further testing will be required in Please 2 to establish the best machinery combination. Phase 1 does give confidence that what is proposed is well founded in the relevant scientific and engineering principles.

Increasing row width will allow replacement of the harvester's front wheels with rubber tracked units. This reduces the overall ground pressure by some 50% (doubles ground contact to half the pressure) when compared to wheeled alternatives equipped with suitable low ground pressure tyres. The rear steering wheels and tyres will be retained to optimise manoeuvrability.

The advantages of such modification are:

- Decreased soil compaction within the cropped area
- Decreased structural damage to soils around the cropped area (headlands)
- Improved spatial layout of crop to improve photosynthetic efficiency and improve harvest operation
- An extension to the harvest period of the crop can be achieved
- Improved quality with wider ability to harvest at the time when dry matter is at its highest – in autumn/winter
- Increase in traction allowing improved fuel efficiency and the ability to cope with more harsh terrain

Further modifications to the unit include fitting additional guarding to protect from any machinery damage and to ensure operator safety during harvesting. It is important to ensure that fuel and lubricant tanks are protected from rupture as they contain potential pollutants. These modifications and alterations can be carried out at the agricultural machinery dealer before delivery to the farm.

### 2.1.2 Crop extraction

If all the advantages of the harvester modifications are to be capitalised upon, then it is vital that the harvested crop is extracted from the field by equipment that is similarly equipped with low ground pressure running gear and similarly protected from damage during the harvesting operation. Three options were initially assessed in Phase 1. Due to the high cost and engineering limitations, the third option of a high-speed multi-purpose Unimog will not be included for further testing.

**Self-propelled base unit:**

A self-propelled rubber tracked skid steer dump truck commonly used in construction and frequently adapted for forestry use, will be adapted by replacing the standard tipping body with a high sided silage trailer body. The base unit will require minimal conversion as it is well protected.

**Conventional agricultural tractor and trailer conversion:**

A conventional tractor and standard high sided silage trailer can be adapted for low ground pressure operation. The tractor will be fitted with tracks, which will achieve the same advantages listed for the harvester, above. Unlike the Harvester, an added advantage is that this unit can also be used for all other field operations:

- Pre-planting cultivations
- Planting operations
- Crop protection and nutrition
- Vegetation control

All round vehicle guarding modification to ensure operator and vehicle safety, will be carried out at the dealership premises. All four wheels will be replaced with tracked units as there is little or no detriment to manoeuvrability.

A basic high sided “silage” type trailer will have conventional running gear removed and replaced with tracks. This would be performed at manufacturer level and the tracks have the option of being powered again improving traction of the tractor trailer combination for use on wetter sites and those with harsher terrain.

**High speed multi-purpose on/off road vehicle (Unimog)**

It became apparent that this system does not offer significant advantages over and above the conventional agricultural tractor yet was considerably more costly and much less manoeuvrable. After consultation with relevant members of the project team, it was decided to discontinue this option.

### 2.1.3 Crop despatch

Producing clean wood chip is of paramount importance to prevent damage and increased wear and maintenance to equipment fuelled by the chip. It is essential to prevent any form of contamination from soil or other alien materials into the harvested chip.

To reduce the possibility of contamination, Phase 1 investigated the concept of transferring the harvested chip directly into the road going walking floor bulkers, for direct delivery to the end user. This is in contrast with the normal practice of forming a heap of chips adjacent to an area that is accessible by road going equipment. This will be achieved by using a standalone self-powered conveyor, (which may also be self-propelled and capable of moving from site to site). Using this format will allow the product to remain clean, prevent compaction and soil degradation, as well as removing the waste associated with field heaps. Additionally, portable trackway will also be used

to protect soil and ensure efficient transfer of the crop. The field equipment will stay within the cropped area, will ensure mud and detritus is not transferred from the field onto public roadways.

**Autonomous operation**

Autonomous operation and control of agricultural and forestry operations is beginning to present opportunities above and beyond labour savings. It is recognised that the normal layout of SRC crops lend themselves to autonomous vehicle use.

It is likely that the physical aspect of harvesting and chopping willow will continue to have a high-power requirement. Therefore, automation will, in the short term, be restricted to complete self-steering (as opposed to operator controlled “auto steer”) and alteration of speeds and settings.

The extraction of the crop from the field and other field operations such as planting and weed control, will increasingly be performed by smaller agile vehicles carrying smaller payloads more frequently, efficiently, and completely autonomously.

The project team is analysing opportunities for these innovations and will work in Phase 2 with organisations aligned to this technology and will include Phase 1 tested techniques.

**Alternative harvesting method – stem harvesting**

The technology options mentioned above, retain the established harvesting approach of coppicing. An alternative to this option would allow a different technology employment. This alternative approach is stem harvesting. Whilst it could offer a lower weight solution than forage harvesters, our Phase 1 research has shown that no suitable machine for Willow and Poplar harvesting currently exists on the market. Existing machines have insufficient harvesting capacity and cannot be economically modified to resolve this challenge.

Unlike the practice of harvesting with a forage harvester, the crop is not chipped and requires further processing. The need for additional processing and handling of the SRC stems to achieve the same finished product achieved in forage harvester systems will require further investigation and likely additional technical innovation. If this option were pursued, it should be considered in combination with a mobile handling technology to store and make the end-product into clean, uniform chip, as per the current New Holland forager solution. Due to the complexity and likely cost implications, the project has excluded this option from the Phase 2 field experimental plan.

### 2.1.4 New land planting opportunities

Innovations to enable informed and revenue-maximising choices by farmers were part of the Phase 1 research. It was concluded that an App would be a powerful innovation to this end. It would require combining existing public data sources, such as Defra’s MAGIC App[1] information on land designation, with hydrology data and linkages with existing market information sources such as the John Nix Guide, Farming Handbook and Farm Business Survey. Key information sources to be incorporated into the App also include opportunity mappings conducted for example by Forest

[1] Defra Magic App (https://magic.defra.gov.uk)

Research. An innovation of such combined information in an App has the potential to be transformative. However, the Phase 1 research has established that two other BEIS Feedstocks Innovation Programme Lot 1 projects – namely by Agri-Food and Biosciences Institute (AFBI)[2] and Forest Creation Partnership (FCP)[3] – are pursuing this as a solution. For this reason, this project will not pursue the App further in Phase 2. Full detail on the App study is included in Appendix 1.

## 2.2 How the innovation could be expected to contribute to biomass supply

The Phase 1 work undertook a detailed study[4] to assess the contribution of this project's innovations to increasing UK sustainable biomass supply. This was assessed, where possible, through key performance metrics such as efficiency, cost reductions and profitability. Data was quantified, wherever possible and framed within relevant economic parameters. In support of this the team undertook the following study:

- Biodiversity, soil, and carbon impact assessment

**Report Summary**

The report looked at the opportunity need for biomass and includes what the challenges are, looks at current practice and leads to a phase 1 conclusion.

A preliminary review which informs greater work in Phase 2 is set out within the report. Then the important impacts to soil carbon and diversity are analysed. This is concluded with the outline work package required in Phase 2 of the environmental impacts.

**Impact for the low ground pressure innovations on land availability**

The report found the current planting and harvesting regime is self-limiting for several reasons, not least the impact on soils. Farmers and contractors are unlikely to harvest in the wrong ground conditions and damage the soil. It is worth noting that crop is multi-annual and usually in the ground 30 years to 50 years or more. Any damage in early crops can have a significant 'lifetime' yield reduction impact – without the environmental degradation set out in the report.

Low ground pressure innovation and the appropriate training is crucial to allow more SRC and SRF – woody perennials to be harvested later into the season. Different soils may also benefit from a different approach and the ranking of harvesting and planting to minimise soil damage.

[2] AFBI (https://www.afbini.gov.uk)
[3] FCP (https://www.forestcreationpartners.com)
[4] Chestnut Natural Capital, sub-contractor)

**Benefit pathways**

The benefits to better carbon sequestration, less soil compaction and greater biodiversity are set out with academic references within the Catapult Energy Systems economic report mentioned below – and inform the work plan for Phase 2. Although there are nuances and exceptions, it is

clear the innovations laid out are integral to creating a biomass delivery system that will take the hectarage of target woody perennials in an upwards trajectory at pace once the innovations are evidenced and disseminated.

**Evidencing potential impact of knowledge on bringing forward land area suitable for SRC**

The report gives confidence that there is a strong future for woody perennials in a mixed landscape and for different purposes. Agroforestry is a good example where three years ago there were just a handful of practitioners in the UK. The rapid growth since has led to a fulltime member of staff advising within the Forestry Commission.

**Evidencing potential impact on farm level economics of SRC through innovation**

The report shows that farmers and growers will require clear practical advice and some additional education to achieve the true SRC potential, and that the individual circumstance of the holding is considered when using the new harvesting techniques.

The contracting to plant and harvest bioenergy crops industry, includes many small and large areas of crops. These areas are often many miles apart, giving high servicing costs to landowners. The commercialisation of the Phase 2 solution will expand the opportunity to grow SRC in new areas that are local to the existing sites, to give landowners economy of scale.

The supply chain would benefit from creating grazing of the understory with sheep, to lower sheep emissions. E.G., ECC have been promoting a mix of SRC Willow varieties and poplar varieties when their planting, that aides and benefits many areas of yield increase, production, and biodiversity, from pollinating insects to natural flood management.

**Overall assessment**

The report states a preliminary finding that the innovations investigated will – if used in the appropriate way, meet the ambitions of the BEIS Feedstocks Innovation Programme (BFIP). The project team wrote to the other Lot 1 and Lot 2 organisations to offer support. This led to the discovery of innovations that can be worked on in collaboration with other projects and partners to give better overall project results. Examples include minimum tillage to avoid turning the soil over – changing the soil structure, appointing a student to complete a masters research degree on carbon impacts and creating the best practice science to reduce these, and adding clover to create under crop grazing (agroforestry silvopasture), where trees and livestock grow together. The innovations identified will make significant contributions to increasing the overall harvested crop.

## Next steps

The report on the biodiversity, soil and carbon goes on to consider what work package would be needed within Phase 2, identifying the importance of survey work to give accurate baseline data. The work completed in Phase 1 gives academically verification the thought process of the partnership, using the metrics to assess the innovations and determine the impact on the priority areas. This approach supports the project aims of social benefit, environmental (natural capital) outcomes and the economic outputs from bioenergy taking over from other less contributing landscape outcomes.

## Summary of the Draft Economic Report

The report of the economic benefits of Low Ground Pressure Machinery (LGPM) for SRC Willow and Poplar (SRC)[5], considers several crucial factors that will affect the economic benefits from LGPM, before reaching indicative conclusions and making recommendations for work in Phase 2 of the project.

## The policy case for LGPM

The starting point is the Climate Change Committee's Sixth Carbon Budget[6], that highlights sustainable biomass as a key tool for reaching the UK's net carbon zero by 2050 target. Furthermore, the CCC calls for a dramatic scaling up of domestic biomass supplies. One of the key barriers to current uptake is the economics of SRC are less attractive than most other arable crops. This Biomass Feedstocks Innovation Programme project looks to address this challenge, first by enabling farmers to plant SRC on marginal land which otherwise would not be used and secondly by improving the production economics for SRC Willow and Poplar.

The ability to grow energy on marginal/flood plain land opens new areas of what could previously be described as high-risk growing areas. The ability for SRC Willow and Poplar to flourish on these types of terrain introduces farmers and landowners to additional land use opportunities.

## Benefit pathways

Informed by feedback from SRC market experts and practitioners, the report examines various potential benefits of LGPM. Of these, the report considers the increase in the area capable of SRC cropping, lengthening of the harvesting season and unlocking of co-benefits (flood risk reduction, nitrate removal or biodiversity) to be the highest level of potential benefits. Methodological approaches for quantifying or estimating these benefits during Phase 2 are also put forward.

[5] Energy Systems Catapult Limited (ESC) Economic Report
[6] Climate Change Committee's Sixth Carbon Budget - https://www.theccc.org.uk/publication/sixth-carbon-budget

### Evidencing potential impact on land area suitable for SRC

The report considers the available evidence on the additional land that could become suitable for SRC cropping by using LGPM. ESC conducts an initial study of the available datasets and models. Among other key figures, there is an estimate that 360,000 ha of marginal land (if defined as ALC grade 4 and 5) is subject to flood risk in England and Wales. LGPM has the potential to open up SRC planting in these flood-prone areas.

The report considers land currently used for less productive grazing which may become suitable for SRC cropping, when LGPM is adopted. Although the report gives some caution to be exercised when converting existing pasture to SRC, it also advises on the potential cross over in datasets for the area of low-productivity grazing land and low-grade land on flood plains.

Various approaches are considered that can be implemented in Phase 2, to update and improve estimates of marginal land that could be opened for SRC cultivation.

### Evidencing potential impact on farm level economics of SRC

The final factor considered is evidence for the current economics of SRC cultivation from the perspective of UK farmers. For example, some evidence suggests that gross margins for SRC are generally lower than other competing enterprises. This is balanced by the increased opportunity that LPGM brings to flood risk zones and the general expansion of SRC cultivation bringing higher economies of scale from shorter travel distances between sites and a longer harvesting season.

### Overall assessment

Based on data on land suitability for SRC cropping the reports states a preliminary estimate for LGPM to unlock a UK area of up to 200,000 ha for SRC over the period to 2050[7]. Carbon benefits are considered, that could unlock (based on assumptions clearly stated in the report) with a high-level estimate valued at up to £5.33 billion. As the report concludes, “These figures must be taken as an initial estimate of the potential scale of benefits, using a simplified methodology. It is probable that only a proportion of these benefits should be attributed specifically to the adoption of LGPM. However, they are sufficient to indicate that widespread adoption of LGPM – along with other factors to make SRC cropping more attractive - can deliver substantial economic benefits and have an equally substantial impact on the development of the UK biomass production base.”

### Next steps

Finally, the report considers practical next steps, within Phase 2, of more detailed field trials of the LGPM technology within a range of land types and circumstances, to provide empirical evidence in supporting the scaling of benefits indicated during Phase 1 of the project. This should include extensive qualitative evidence obtained from harvesting contractors and current and potential SRC growers, about factors that would need to be in place to make SRC an even more attractive cropping choice.

[7] Catapult Energy Systems internal Phase 1 report for Energy Crops Consultancy (ECC)

## 2.3 Wider environmental benefits and trade-offs

The overall aim of the project is to increase the production of UK grown woodchip by exploiting the productive capability of land suitable for SRC growing, which due to water retention or general topography, has been deemed unsuitable for the current equipment range capable of carrying out field operations.

Increasing the supply of UK grown renewable energy sources has environmental benefits over and above reliance on either fossil fuels or processed and imported renewable feedstocks.

Growing SRC crops brings additional benefits above leaving land parcels fallow or farmed in inappropriate ways.

- SRC crops have a high-water demand and can be used to stabilise soils preventing soil erosion. SRC has been shown to remove potential pollutants from entering watercourses.

- SRC crops provide biodiversity and can act as a source of pollen and nectar for bees and other insect pollinators. As it is rare for a farm to be growing SRC solely, pollen and nectar will be available at other times, from other farmed sources.

- SRC crops have a normal lifespan of 30 years plus. The only soil disturbance/cultivation occurs in year 1 before planting. The crop can be established with companion cropping, meaning that there is no bare earth within a SRC crop. This helps with soil erosion and also sequesters carbon from the atmosphere, storing it as soil organic carbon or within the plants.

- The use of LGP machinery in the SRC production process will ensure that soils are not damaged and better able to support increased populations of micro-organisms within the soil complex.

The Game and Wildlife Trust research showed that adding tree leaves to the diet of sheep could be instrumental in reducing harmful greenhouse gas emissions.

Scientists from the trust tested the theory on 24 Aberfield lambs, comparing them in 4 groups of six. Half the lambs received 200g of goat willow leaves per day. The willow-fed lambs showed significant reductions in NO2 and CO2 in their urine. These lambs also had reduced urine ammonia.

While cutting willow for fodder can be labour-intensive, the Short Rotation Coppice (SRC) method employed by ECC allows for silvopasture – that is, allowing livestock to browse amongst the coppices.

Willow is well known for its water holding capabilities, a feature which will have increased importance as the climate continues to change and drought periods increase. Using it as fodder can therefore not only mitigate against climate change fodder shortages, but it can also actually reduce the causes of climate change in the first place!

Defra has stated that agroforestry is eligible for the Basic Support Scheme – both for silvoarable (trees planted amongst arable or bi-energy crops) and silvopasture (trees planted in forage alongside grazing animals). The Committee on Climate Change in its latest report estimates that

annual carbon emissions could be reduced by 5.9 MtCO2e by 2050 through agroforestry principles.

Professor Chris Stoate, who performed the research, states: “The results are preliminary, but they provide an exciting indication that feeding willow leaves to ruminants may contribute to national targets for both climate change and air quality. It certainly warrants further investigation.”

To put these gas emission reductions into perspective, some estimates show that 1kg of NO2 produces 300 times the amount of warming of the atmosphere as 1kg of CO2 over a 100-year timescale. The National Farmers’ Union (NFU) has set a goal for farming to reach net zero by 2040, so all methods to reduce greenhouse gasses in farming are worth pursuing.

# 3 Project plan for Phase 2

Based on the strength of our Phase 1 findings, ECC has applied for Phase 2 funding to undertake detailed field trials of our harvester, tractor and trailer innovations. The areas shown below are planned to deliver between 1st April 2022 and 31st March 2025, following a successful Phase 2 bid.

## 3.1 Timelines for deliverables, including key milestones

The ultimate project aim is to achieve immediate end project commercialisation of the proven Low Ground Pressure Machinery (LGPM) solution that extends the current 2 to 3 month harvesting season to 7 to 9 months. This includes the novel technology accessing land that is currently inaccessible due to the UK weather and meteorological conditions. This will be achieved by using the following project milestones:

| Milestone (DMADV) | Description |
|---|---|
| Define | What is going and not going to be delivered within the project |
| Measure | Phase 1 data and Phase 2 benchmarking |
| Analyse | Researching, recording and analysing data |
| Design | Testing and final solution build |
| Verify | Demonstrations, feedback and write-up |

The milestones are supported by the 7 work packages that build to final project delivery:

| Work Package | Key Deliverables |
|---|---|
| Project Management | + On time delivery of all milestones<br>+ Delivery within budget parameters<br>+ Quarterly steering group meetings to remain on target<br>+ Dissemination activities to inform stakeholders of progress |
| Technical Experimentation | + Research that complements Phase 1 machinery concepts<br>+ Controlled testing of physical technical machinery<br>+ Trailer design experimentation for lowest ground impact<br>+ Rubber track experimentation for lowest ground impact |
| Environmental | + Soil physiochemical and biological properties<br>+ Energy balance of the biodiversity for wider landscape |

| | |
|---|---|
| | + Soil organic carbon and nitrogen content for soil health<br>+ Ecosystem CO2 exchange using eddy covariance flux towers |
| Testing and Demonstration Trials | + Different harvesting site maturity rates (first harvest onwards)<br>+ Different ground types (soil, clay etc)<br>+ Equipment performance (harvester, trailer, collector etc)<br>+ Wood chip movement from plantation site to roadside pickup |
| Technical Solution Design | + Formalising key manufacturing supplier relationships<br>+ Creating production facilities<br>+ Ensuring the most cost-effective spares stocking levels<br>+ Building the relevant equipment servicing and repair levels |
| Dissemination | + Hosting and presenting at third-party events and conferences<br>+ A strategic and managed media planned approach<br>+ Sense checking communication content with BEIS<br>+ Continuous research of the voice of the customer |
| Write-up | + Creating a library of findings for future reference<br>+ Data collection, analysis and interpretation<br>+ Section report writing<br>+ Project reports |

The key tasks are broken down into annual objectives to ensure an on-time project delivery:

**Year 1**

- Construct accurate engineering project timeline via Gant chart
- Appoint lawyer to team for IP issues etc.
- Finalise contractual arrangements with project team
- Appoint financial team to ensure budgetary control
- Finalise design of crop extraction system and reduce the 4 options down to the 3 considered most satisfactory through in-field testing and complete procurement
- Finalise design of the forage harvester and ancillary equipment required for conversion, and procure from suppliers (e.g., guarding systems for tracks)
- Identify suitable sites for testing and evaluation of the LPGM options
- Finalise required environmental studies and carry out baseline environmental surveys
- Complete specification for inter-row cropping and headland areas
- Begin operator briefing and training
- Complete necessary reporting

**Year 2**

- Completion of all necessary risk assessment of in-field operations
- Confirm necessary measuring and testing procedures
- Complete engineering works on all machinery and begin in-field testing
- Begin monitoring environmental impact of field works
- Completion of all engineering elements and begin individual testing
- Continue operator briefing and training and dissemination with growers
- Test LGPM options in-field to ensure a practical working solution
- Complete the required reporting to BEIS in line with agreed milestones

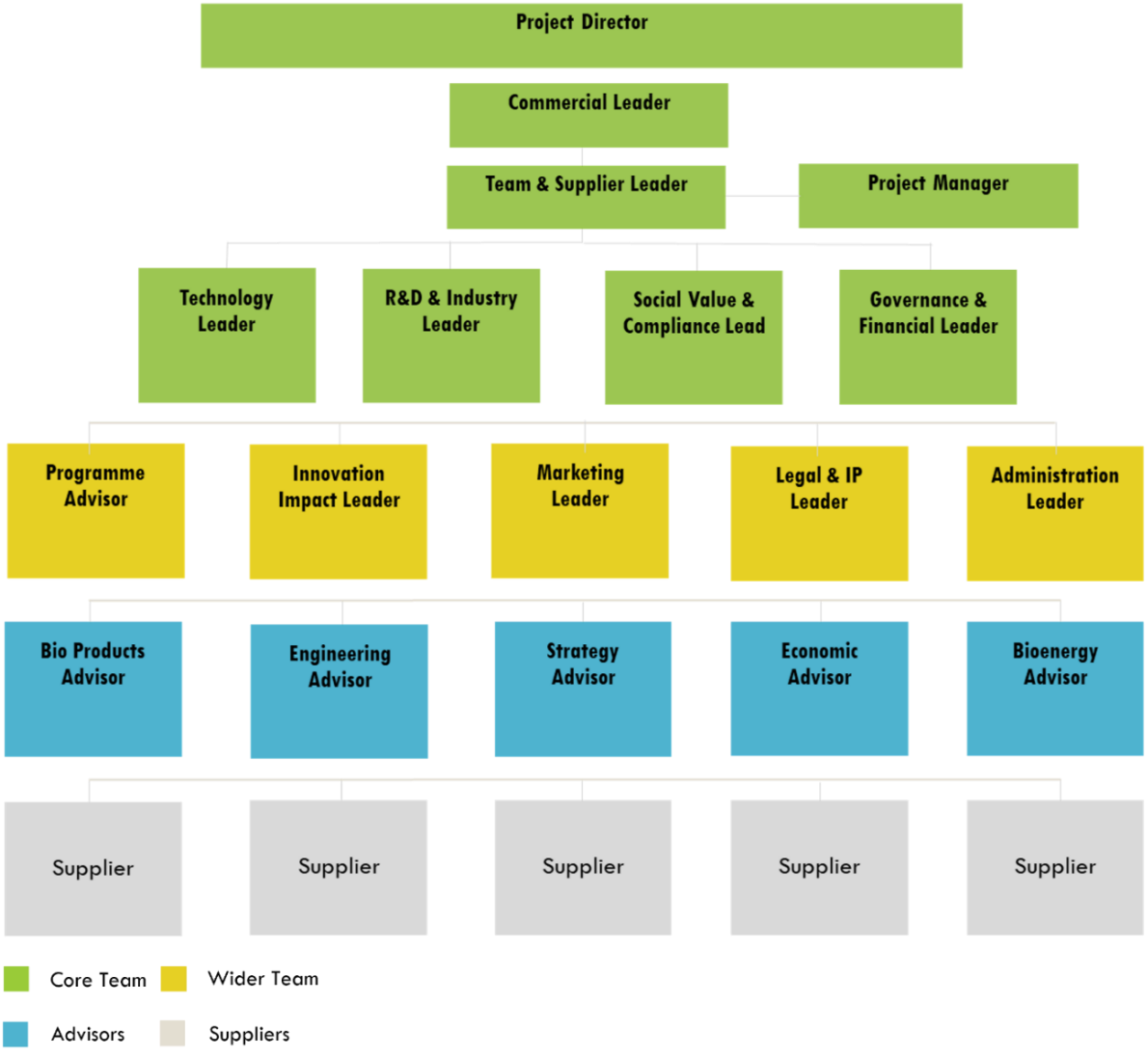
**Year 3**

- Develop commercialisation strategy
- Continual in-field testing of individual components and individual systems
- Dissemination with both Lot 2 winner and also other grower intermediaries
- Deconstruction of non-viable systems or elements
- Final Reporting/Draft/Final dissemination

## 3.2 Project management, including project delivery team, significant collaborators and sub-contractors

The Phase 2 core project team retains the services of five Phase 1 members. An additional four members are added to the core team to recognise the wider skills areas required for the three-year Phase 2 project and the Phase 1 learnings. The Phase 2 project is projected to create three Full Time Equivalent (FTE) permanent roles within ECC.

**Core Project Team Organogram - for 'Proving low ground pressure harvesting equipment in the field to extend SRC Willow and Poplar wood crops harvesting season and open up more marginal land for SRC Willow and Poplar crop planting'**



The core team is supported by a wider team who will bring additional skills from time to time, throughout the 3-year project cycle. These roles include:

- Programme Adviser
- Innovation Impact Leader
- Marketing Leader
- Legal and IP Leader
- Administration Leader

The team is further strengthened by the addition of the key suppliers who will have committed to the 3-year project term by providing Letters of Support.

## 3.3 Risks and risk management

A ground rule that the core project team will be following is ‘no surprises’. This is to ensure that all actions have an opportunity and risk attached to them and the team consider the risk factors alongside the positive effect the action could have. An example of this is where is where a mutually exclusive major design component delivery is tracked to ensure it reaches each section of its journey rather than seeing whether it turns up when expected or not, which leads to a hold-up for the next planned action.

There are 11 key risks identified across the areas of:

- Commercial
- Governance and Compliance
- Environmental
- Financial
- Technology

## 3.4 Quality assurance

Speed with quality is a primary project team ground rule for Phase 2. This is designed to ensure that the pressure to produce quickly does not outweigh the quality of what is produced. The project uses Six Sigma and Lean Sigma standards[8] at the core, along with the resolve to remove all points of failure. This approach includes:

- Setting the quality expectations
- Measurement of current performance against the standards set
- Expected results and outputs
- Project deliverables and process status
- Creating project management quality procedures
- Decision making from a quality perspective
- Quality validation of the project outputs

[8] Six Sigma and Lean Sigma https://asq.org/quality-resources/six-sigma

Regular meetings and team decision making, especially for the machinery design, will include. involvement from machinery users as well as designers, to ensure quality assurance of the product design and the end solution product is sellable to the market.

## 3.5 Project controls and governance

The aim for this area is to assure the highest quality framework of consistency across the day-to-day operations, whilst delegating responsibility to local levels to give a practical way for people to complete their tasks.

The project uses a secure cloud depository facility that gives128-bit or higher Advanced Encryption Standard (AES) encryption. The project also protects Personal Data by following the Data Protection Act 2018 standards. There are 3 primary pillars of governance the project follows:

- The organisational and decision-making structure
- The people within the structure
- The information which informs the people within the structure

A governance officer has been appointed as a member of the core project team and oversees the way the team operates through the assurance of written rules and training that covers:

- Policies
- Regulations
- Functions
- Processes
- Procedures
- Responsibilities

## 3.6 Reporting plans

The reporting side of the project is critical to keep an auditable trail of the actions and activities that take place over the 36-month period. The format includes the recording of the ‘what to achieve, how to achieve it and when it will be achieved’ for each project section, giving a historical timeline of what is considered best practice, the lessons learned and leaving legacy for future project teams to follow.

Reporting will be led by the project Team and Supplier Leader;

- On a weekly basis for the core team
- A formalised monthly basis with key partners
- Use a quarterly formal report meeting for BEIS and other stakeholders
- Publish bi-annual strategic updates for any wider interested parties.
- Daily reporting will be introduced if and when there is a backlog of activities required to bring the project back on its forecasted timeline.

The reporting content includes:

- Creating a library of findings for future reference and best practice sharing
- Data collection, analysis and interpretation for experimental activities
- Report writing by work package (technical design, environmental etc)

- Project reporting to give a regular overview of progress towards milestones

## 3.7 Any other relevant material to demonstrate good practice in project delivery

The Social Value team will be a part of the project agenda. This is to ensure Social Value thinking is included within all activities, including:

- Carry out Social Value testing for all investments
- Working with sub-contractors to consider Social Value applications
- Ensuring green technologies are considered at all development stages
- Managing internal and external Social Value communications
- Quarterly BEIS and stakeholder reviews, and feedback on achievements

# 4 Commercialisation plan for innovation

## 4.1 How will the innovation be commercialised in 2025?

By the end of Phase 2 in 2025, the ECC partnership will have created best practice in terms of creating machinery which was part deconstructed, added to and then made fit for purpose. This is in line with the ambition of extending the growing season and enabling commercial growing of woody perennials to take place on a wider range of currently inaccessible land. This will be achieved through LGPM giving better traction and lower ground pressure than current available machinery offers.

In terms of the scale of the wider market, UK-produced SRC Willow and Poplar wood chips provide an opportunity to substitute imported pellets at scale and pace – providing enhanced environmental benefits as well as local jobs. SRC Willow and Poplar grows quickly even on wet land that may not be suitable for other agricultural purposes – allowing a rapid growth in domestic bioenergy supply. However, achieving this requires improved planting and harvesting methods that the Low Ground Pressure Machinery (LGP) innovations will unlock.

There are around 230 UK power stations utilising biomass of varying forms to produce electricity, of which c. 80 are burning wood from various sources. Bioenergy accounts for about 12% of the country's electricity[9], with 7% of this coming from a single site – Drax. It is estimated that 15% of the UK's energy could be provided by biomass by 2050[10]. This trend is not restricted to the UK, and it is estimated that 20% of EU power is derived from biomass. In addition to power generation there is increasing demand from smaller scale private consumers using wood chip as a source of clean fuel for heating.

The majority of feedstock for these plants is currently imported as wood pellet from other countries - using energy to both form the pellet and then transport to the UK for incineration. This view is

[9] Figures from the Ricardo Energy - Sustainable Bioenergy Feedstocks Feasibility Study & Environment report for the UK Department for Business, Energy and Industrial Strategy (BEIS) - https://www.contractsfinder.service.gov.uk/Notice/Attachment/b00cdc78-cb91-4b21-8104-d6b1e706748f

[10] Renewable Energy Association - https://www.biomass-uk.org/

further supported by the Climate Change Committee (CCC) call for an increase of energy crops in the UK from around 10,000 hectares in 2020 to 720,000 hectares in 2050 and the Environmental

Land Management Schemes (ELMS)[11] that changes farm subsidies from size of land to environmental land management.

In the publication 'Natural flood protection. Reducing downstream flood risk', the Forestry Commission use Manning's n value[12] to rate dense willow as giving the greatest tree surface resistance to slow flowing water and reducing downstream flood risk. Willows also outrate cultivated areas and pasture with no brush in the n index.

The ECC Phase 2 proposal supports the CCC drive to rapidly grow energy crop hectares by extending the harvesting season up to a multiplier of three and accessing land that otherwise would be inaccessible using traditional methods.

After the initial 3-year planting to first harvest timescale, farmers and landowners can expect a 30-year to 40-year return as the plantation continues to grow and mature. No fertilisers or growth hormones are required. This is pure nature in action.

Given these factors, the Low Ground Pressure innovation provides a credible and commercially viable alternative to existing import market.

## 4.2 How will the wider market be engaged?

The project has planned engagement with interested industry organisations from Phase 1 of this project. This includes:

- Continuing to build the large SRC grower group established in Phase 1
- Advancing the current dialogue with the UK's largest power stations who are the largest importers of wood pellets.
- Employing the project team's existing networking relationships that include National Farmers Union, Newcastle University, Energy & Bioproducts Research Institute, Forestry Commission and the Climate Change Committee
- Connecting with Members of Parliament and the relevant ministers and government departments to maximise the existing routes to market

The drive for post project commercialisation of the new Low Group Pressure technology innovation, includes working with the machinery manufacturers and the wider market, through:

- Targeted press releases and engagement with industry media outlets
- Demonstration events at various milestones throughout the project.
- Exploiting existing relationships within the industry to promote the effectiveness of the LGP system.
- Events at dedicated demonstration sites where the full advantages of LGP system can be compared against existing techniques. Demonstration will focus on the skills and techniques required to operate the equipment to a level that will optimise output and ensure

[11] ELMS - https://www.gov.uk/government/publications/environmental-land-management-schemes-overview
[12] Manning's n Value http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

the crop is quickly and cleanly despatched from the field into road going vehicles to be transported to end users and the many advantages achieved.

## 4.3 How will it be promoted and distributed in order to maximise its impact

The Lot 2 process and the collaboration with the project's primary partners gives a solid platform for promoting and distributing the technical innovative solutions.

As the sales saying goes 'Don't tell them, show them!' The project carries this philosophy forward by utilising the experience within the team to demonstrate the solution in the live farming environment. Launch, trial, and end solution demonstrations are scheduled to show the capabilities of the LGPM technology. These events will be used to create a whisper campaign (where one person tells another, who tells another and so on), as used by Apple Inc., to spread the word and to produce an extensive video library, including testimonials, to exploit the growth of social media in giving direct access to decision makers. The project will also avail existing news and media contacts to promote and educate growers on the benefits of creating and/or extending their current SRC Willow, Poplar and other energy crops.

The post-project commercial plan includes opportunities in international markets, that Phase 1 research demonstrates a growth market opportunity, including franchising and the use of local agents.

# 5 Conclusion

ECC is established to support farmers and landowners maximise their energy crop yield, whilst minimising carbon and other environmental impacts. This includes engaging with growers and government departments to produce UK grown renewable energy feedstock.

Phase 1 of the Low Ground Pressure innovations has witnessed huge interest and take-up from the growing community as new techniques substantially extend the UK harvesting season and access land that would otherwise be inaccessible.

ECC will continue to work with the growing community, government departments and UK power stations to continuously improve harvesting techniques, delivery efficiencies, improve the environment and the overall viability of the biomass supply chain.

During Phase 1, the project team engaged with a cross-range of growers who are passionate about being a part of expanding SRC Willow and Poplar farming.

We gratefully acknowledge and thank the growing community and partners for their support in making the Phase 1 aims a reality and for the funding from the UK Department for Business, Energy & Industrial Strategy (BEIS) for assessing this innovation opportunity. Without this support, the results obtained would have taken far longer to establish or not happened at all.

# 6 Appendices

## 6.1 Appendix 1

### 6.1.1 Practicalities of land managers assessing their own land

Since the BEIS Biomass Feedstocks Innovation programme started it has been reassuring that two other Lot 1 projects have been looking at the mapping of land which supports:

1. Evidence to take aa app decision – this report was designed to scope out the need for farmers on land that has perhaps had limited options to recast their thinking by evidencing that their land under management could be utilised for the growing of woody perennials or agroforestry
2. Evidence to qualify for accreditations or payments – ever since the IACS Integrated Administration and Control System (IACS), setting up of the Rural Payments Agency and Rural Land Registry there has been a need to digitise maps and utilise applications to help decision making. For bioenergy there will be many reasons to have methods of researching and deciding and subsequently recording via electronic devices connected to the World Wide Web.

An example of the drive for online and app technology is the 'Land App'[13] shown below as Figure 1. The Land App example has links to the land management changes announced to align with the two Oxford Farming Conferences in January 2022

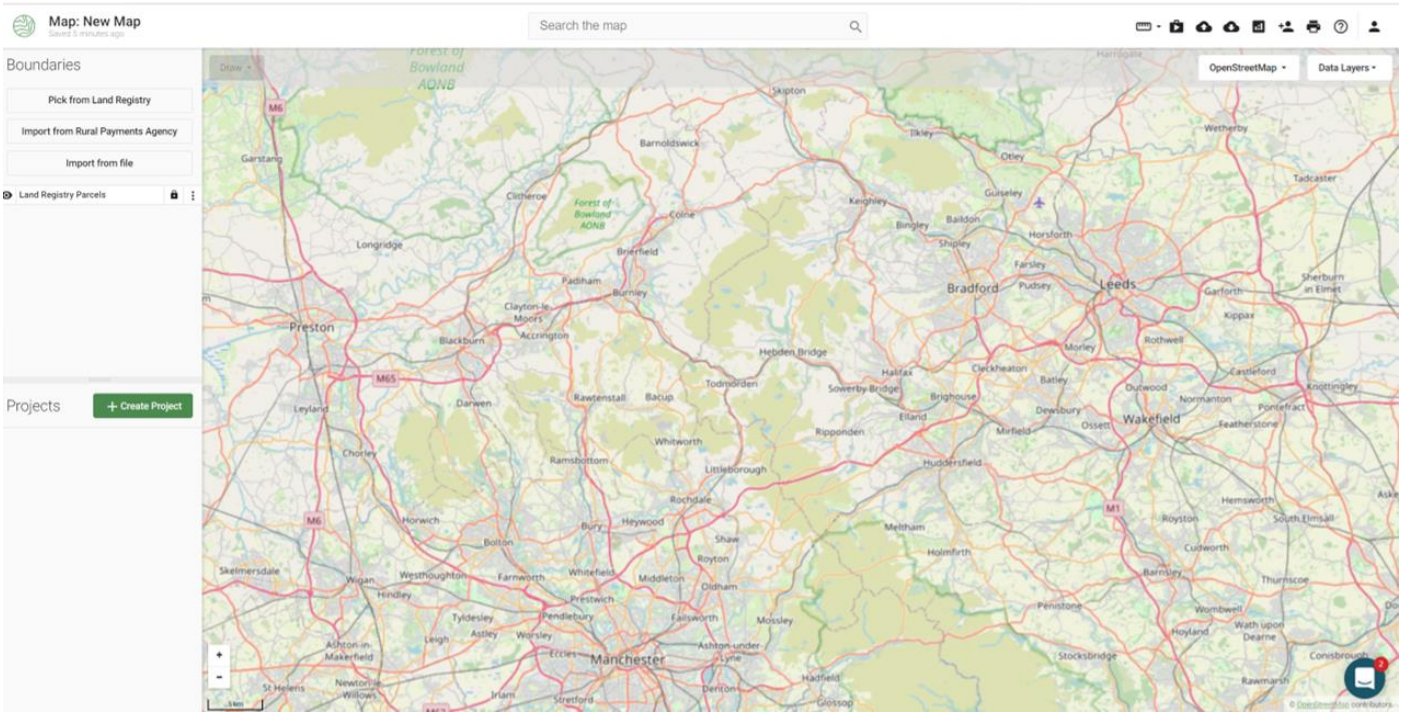



*Figure 1*

[13] Land App https://go.thelandapp.com/

There are several mapping programmes already available, and the advent of Google Earth and Google maps is that we can see land from above. Drone technology has added to innovation and is adding speed to mapping roll out.

This is an exceptional area of agricultural innovation and has several drivers. The land-based economy is benefitting from other sectors who have had a more urgent need or perhaps were better incentivised to create new tools.

There is a new reason to have real time telemetry from land management systems as the way that farming, and land management raises money. Accuracy of mapping was important when the farming payments system moved to a Hectarage basis under devolved Common Agricultural Policy (CAP) regulations. Land then had to be mapped and registered on the IACS system, so payments could be calculated and paid. This caused many disputes and the exercise proved both complicated for Defra and the RPA and other agencies. Later, non-agricultural land (such as horse grazing paddocks) became registered. meaning that most land was recorded that could be linked to payments from DEFRA. At the same time, the Land Registry was encouraging full registration and digitalisation of their systems.

Today there is a major agrarian/land use revolution happening for a range of reasons:

1) CAP ending, transitional systems such as ELMS being designed
2) Biodiversity crisis and climate change emergency – COP26 outcomes
3) Brexit and trade deals and food security reviews following the pandemic
4) Building/development changes with ‘net environmental gain’ embedded in them
5) Nature recovery plans being implemented and schemes with landscape recovery at their centre – Environment 25-year plan and Environment Bill and Climate Change Committee
6) ESG (Environment, social and Governance) impacts on private investment into so called ‘Impact Investments’ such as Hadrian Bond
7) Natural Capital being used as a metric for “public money for public goods” carbon sequestration has been the first area but others will follow
8) The weather climate becoming changeable impacting some land uses, and to make adaptation necessary to continue on other potential land sites

There will also be a need to train people in this technology and ensure it is open to all, the digital divide has closed in many areas, but our most rural areas can still be disadvantaged.

### 6.1.2 Perennial Energy Crops Decision Support System (PEC-DSS)

Led by Agri-Food and Biosciences Institute.

The Perennial Energy Crops Decision Support System (PEC-DSS) is envisaged as a central source of impartial information in an easy to access, free or low-cost, user-friendly format, that will enable farmers and land managers to make an informed decision about planting perennial energy crops (PEC).

The PEC-DSS will assemble a wide range of knowledge and expertise that will provide answers to questions such as:

- what type(s) of PEC will grow on my land?

- what profit will it make?
- what are the environmental benefits and impacts?

The PEC-DSS may take the form of an interactive website portal or a downloadable app available on a smart device. This advice will help UK farmers make sound business decisions and de-risk their investment, giving them the confidence to participate in the rapid upscaling of sustainable domestic bioenergy feedstock production.

### 6.1.3 Using geospatial data science to identify optimal planting sites for forestry-based biomass production

Led by Forest Creation Partners (FCP) with support from Forest Research (FR)

FCP's ForestFounder system (Fig.2) combines a wide range of geospatial data to identify optimal sites for productive forestry. ForestFounder can scan almost unlimited areas algorithmically and provides a unique capability to unlock investment in biomass production, by helping landowners decide where and what to plant within their estates and advising investors on optimal sites to acquire or lease for planting.

This project will expand ForestFounder's geographical coverage from England to Great Britain and broaden its species coverage (currently limited to Long Rotation Forestry) to include SRC and Short Rotation Forestry (SRF). This approach improves the ability to account for future climate change in its species recommendations. This could greatly enhance the potential for GB biomass production through increasing the number, variety, and productivity of the sites available.

As part of this project, Forest Research will update its open species suitability datasets to use the UK Climate Projections 2018 and will publish the first ever datasets on the climatic suitability of SRC and SRF species across Great Britain.