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Future 4 Fuel Is Solid (FFIS)

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A new solid ethanol technology offers a low cost, safe and practical alternative to wood, charcoal and liquid ethanol as an eco-cooking fuel; which will work with existing cookers.

1. Executive Summary

BCB International has developed, and holds the worldwide patent for, an innovative ethanol-based cooking fuel which it supplies to British and European defence forces. Unlike other ethanol cooking fuels, FireDragon is solid ethanol blocks making it a lot more practical and safer to use, store and transport.

Most past clean ethanol projects in Africa have focused on changing the cookers to liquid ethanol cookers. As liquid ethanol is dangerous and expensive to distribute and use and with the high cooker cost (approx. \$40 to \$50 per ethanol cooker, compared to approx. \$2 per charcoal cooker), these have all been barriers to widespread adoption of ethanol.

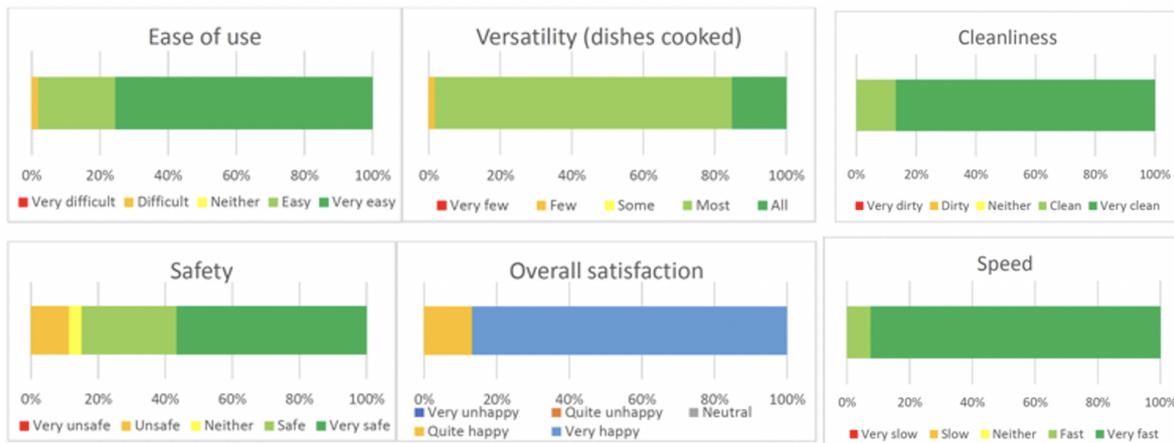
This project is ready to prove at scale, that there is a latent demand for a clean low cost fuel; but one which is solid. As a solid eco fuel, FireDragon has been proven as a practical and safe clean alternative to wood or charcoal. Importantly, FireDragon can be used in the households existing cookers, like the Jiko or Chitetezo Mbaula stoves, with a very slight modification. Hence no high capital cost to the users. It is also much easier to light, compared to the other solid fuels and can be lit with a low cost flint striker, also developed. FireDragon will be available in a small purchase sizes.

Based on initial trials in refugee settings in Bangladesh, and in 2021 in low income households in Malawi, BCB is now looking to expand and take this exciting new eco-technology to scale up in a developing market.

This follow-on FFIS project is looking to conduct a broader study of 3,000 households for FireDragon in an African or SE Asian country, leading hopefully directly onto the establishment of local manufacture under license, in a sustainable way for the long term good of the users, local businesses and of enormous benefits to the climate.



The very successful feasibility study conducted in 2021, in Malawi, clearly demonstrated that 98% of users thought FireDragon was “easy to use”, while 87 % were “very happy” and 13% were “quite happy” using FireDragon, see below. Building on this success we want to gather more data by extending the user trial, to include the wet season (when wood and charcoal prices rise while their performance decreases) and to finalise the business case for establishing production of FireDragon for the longer term (work package 3).



The aim would be to provide a clean cooking alternative fuel to wood and charcoal in urban, peri-urban and rural areas, with the view to reaching large scale adoption by low- and middle-income families and maybe even higher income households.

This follow on project can be easily undertaken in Malawi; utilising the local partners and knowledge we have already. This project is based on this as it is estimated that the informal charcoal market in Malawi is worth up to \$620 million annually; the majority of which is illegally produced. And less than 5% of Malawi's population have access to clean cooking according to the WHO 2016 report entitled “Burning Opportunity”.

However, it could just as easily be undertaken in another African or SE Asian country, depending on finding the correct local partners and finance.

The FFIS project will cover three main components:

- (1) Follow up on the feasibility trial done in 2021 and to build on this successful study.
- (2) Conduct a more comprehensive Market Assessment of this large and polluting charcoal market.



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(3) Develop a financial model to establish a solidifying plant for the production of FireDragon under license for the longer term. This model can then be rolled out into our countries in Africa and SE Asia.

This will have a significant impact on air pollution, reduce deforestation, improve the users health especially for the mainly women who use charcoal and wood as their primary fuel. Burning wood and charcoal have significant negative health and environmental impacts.

This model will lay the foundations for FireDragon to be rolled out to other countries, so hopefully reaching as many of the 2.9 billion people whom still use wood and charcoal as their primary fuel, as possible.

2. Meeting the energy Trilemma

One of the key development needs in Malawi is an excessive reliance on biomass to meet cooking energy needs, resulting in deforestation and poor health outcomes. This project will promote social welfare by increasing access to a clean cooking fuel, which will improve the cooking environment, as well as helping to better manage natural resources.

Furthermore, introduction of a modern cooking fuel to Malawi will promote economic development through local manufacture, which will create jobs and result in technology and knowledge transfer from UK to Malawi. Additional income generating opportunities will be created along the value chain, including distribution and retail. In addition to job creation the fuel will be subject to Government taxes and levies, unlike charcoal, and will therefore increase the Governments budget.

This project will allow BCB to complete the business case for the long term the production and enduring sale of FireDragon in Malawi. If so, BCB will be in a position to expand into a new markets and increase sales revenues by licensing production. Building from this platform additional new markets could be explored. The introduction of a sustainable and modern cooking fuel is in line with the UN **sustainable development goals 1, 3, 5, 7, 9, 10, 13 & 15** strategy to increase energy access, reduce energy poverty, improve health and climate change.

The project is likely to benefit a range of other stakeholders.



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Firstly, findings from the feasibility study will be shared with policy makers to help inform the Governments strategy on cleaner cooking and biomass.

Secondly, the findings will be widely shared with members of the National Cookstove Steering Committee and the Clean Cooking Alliance which includes representatives from Government, civil society, academia, private sector, and the donor community. This will help to build capacity on ethanol cooking and contribute to future strategy development.

Thirdly, the end product of the study will be a business case for production and sale of FireDragon in Malawi. This will be made available to the private sector in Malawi to encourage them to enter the market, leading to increased revenues and new employment opportunities.

Fourthly, current users of charcoal will benefit from a clean, modern, easy to use fuel that is cost competitive with charcoal, which will create a healthier cooking environment. This will impact women and children who are most at risk from indoor air pollution.

Finally, reduced charcoal consumption will slow deforestation, which will reduce soil erosion, leading to better quality soil for farming, as well as less siltation of hydroelectric.

The objective of the project is to develop the business case for the private sector to enter production and distribution of FireDragon solid ethanol in Malawi, as an alternative to wood and charcoal in urban and peri-urban areas.

In Malawi 95% of all 3.9 Million households use firewood and illegally produced charcoal for cooking. Availability of legal (sustainable) charcoal production is very low and it is relatively expensive. Accessibility and affordability of cleaner alternative cooking fuels remains low. LPG is available but not used by most low and middle income households due to its perception of being dangerous and due to its high upfront costs of stove, canister and gas.

It has been long recognised that ethanol, when produced from waste vegetation, is a clean, efficient and effective fuel. However, until recently it has only been available in liquid forms, which are difficult and dangerous to use, transport and store. A Welsh company BCB International Ltd (BCB) working with Cardiff University has designed and developed a low-cost way of solidifying ethanol into a practical solid form which makes it a safer fuel. BCB has perfected this method for large-scale production, without significant loss of heat output from the ethanol.



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In meeting the energy trilemma our project aims to introduce a new cooking fuel which is affordable and cost competitive with wood and charcoal. Currently, FireDragon retails in the UK at GBP 1 (US\$ 1.3) per kilogram, whereas charcoal in Malawi sells at approximately GBP 0.8 (US\$ 1.04) per kilogram. We believe that production in Malawi will be more cost efficient than in the UK, and we anticipate that the cost of charcoal will continue to rise steeply over the coming years, therefore closing the price gap. Furthermore, cooking with FireDragon has an approx. 60% lower specific fuel consumption than charcoal. Meaning households can achieve the same result with less fuel. FireDragon also has approximately twice the heat output, per kilo when compared to dry hardwood.

By switching to FireDragon, emissions from cooking will be greatly reduced as ethanol is a renewable fuel, which burns a lot more cleanly. Not only will this mitigate global climate change, but it will also reduce indoor air pollution, which will result in better health outcomes for users. Local production of FireDragon, from locally produced ethanol, will greatly increase the supply and security of cooking energy access in Malawi, especially given that Malawi is predicted to enter a wood supply -- demand deficit before 2030.

The attached presentation details the emissions savings from FireDragon.

Firedragon can be made from differing grades of ethanol, including lower grade ethanol associated with micro - distilleries.

3. Needs & Challenges

Gender equality is vital in all countries especially in Africa. This project will make important strides in mainstreaming gender equality.

This apply the lens of the 'Gender Asset Gap' in their design and implementation, and explicitly contribute to closing the gap in some or all of its dimensions.

Cooking is traditionally undertaken by women who are most impacted by the negative health outcomes related to indoor air pollution. These negative health consequences also extend to children, as they are mostly cared for by female household members, and therefore, exposed to particulate matter and emissions from cooking. Furthermore, the introduction and use of FireDragon will improve social inclusion, as the fuel will be targeted at poorer households who cannot access modern cooking energy, such as LPG and electricity, due to the high upfront cost barriers that these alternatives present.



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The motivation behind the project (apart from obviously reducing deforestation and reducing greenhouse gases) is to develop the business case for licensing the production of an ethanol cooking fuel (FireDragon) to the Malawian market, with the aim of capturing a portion of the existing charcoal market, while creating jobs, reducing deforestation, improving local ethanol production with micro-distilleries and in turn encouraging local farmers production, and resulting in healthier cooking environments. All this will encourage local businesses and maybe even exports of FireDragon and so in turn Government revenue.

BCB, working with Cardiff University, has designed and developed a low-cost, effective way of solidifying ethanol and has perfected this method in large-scale production. The primary market for the fuel has been the British Army, who have entered into a second 4 year contract with BCB. Subsequently, BCB have trialled the fuel in refugee camps and are in discussions with IRCR, UN and WHO about further tests. Building from this, the business need is to expand FireDragon into new markets with large numbers of potential customers, through a licensing agreement with a Malawian private sector company.

Until recently ethanol has only been available in liquid or gel forms, which are dangerous to use, transport and store. Kenyan company KOKO have made strides to bring the fuel to market through an integrated stove and fuel dispensary system. However, for this to be safe and effective, the fuel needs to be paired with a \$40 to \$50 stove, which is a significant barrier to adoption for most low-income households. In Malawi there is only one other company (BluStove) promoting ethanol cooking and it is still at the start-up stage. However, unlike BCB, BluStove focuses on the stove technology, rather than the fuel, as it uses liquid ethanol. BluStove is based in South Africa. As such, the technological challenge will be to successfully produce solid ethanol briquettes in Malawi by transferring knowledge plant and technology.

Malawi has a population of 17.5 million people, of which 19% (758,000 households) live in the main urban areas. Reliance on solid fuels to meet cooking energy needs has remained exceptionally high at 95%. However, there has been a concerning shift from wood to charcoal, with increasing urbanisation, with wood use falling to 70% and charcoal use increasing to 24% nationally. This means that approximately 512,000 urban households are currently cooking with charcoal, consuming approximately 584,806 tonnes each year, at a retail value \$620 million annually. Currently, accessibility and affordability of BLEENS (Biogas, LPG, ethanol, electricity, natural gas and solar) as alternative cooking fuels remain low and limited to urban areas. Therefore, the market opportunity is gain a share of existing charcoal market in major urban areas such as Blantyre and Lilongwe.



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This number is only set to increase with growing population (3%) and urbanization (3.7%) rates, coupled with a shift from wood to charcoal in urban areas (3.9% annually) has resulted in the increase of charcoal use in Malawian households from 44.6 % in 2011 to 76 % in 2018 (2018 Malawi population census).

Charcoal use is estimated to be increasing by 10% pa in Malawi. Ethanol based cooking in Malawi is not widespread. Electricity is in short supply and unreliable. LPG use is limited to about 15,000 households.

Charcoal production is mainly from illegal produces. Charcoal cost have been rising rapidly, due primarily to demand and reduction of wood availability due to deforestation. In the 5 years to 2019, charcoal prices have tripled and electricity prices have doubled.

In total there are 406,723 households in the main two cities of Malawi, which would form the key target populations for FireDragon. These areas generally have high literacy rates (>87%) and high population densities (>2455 capita/Km). A study by the USAID PERFORM project in Lilongwe, segmented households into Low (\$150 / month), Middle (\$475 / month) and High (\$1500 / month) income groups. It found that Low income groups spent \$16 a month on energy and 91% used charcoal as their main cooking fuel. Middle income households spent \$30 a month on energy, with 60% cooking using electricity and 29% using charcoal. For high income households 75% used electricity and 10% used charcoal, spending on average \$60 per month on energy. It is anticipated that the target market for FireDragon would be low-to-middle income households.

These households are predominantly using illegally produced charcoal and cook using the locally produced, and widely available, Kenyan Ceramic Jiko (KCJ); both stove and fuel value chains are informal. Wood is harvested from areas surrounding the cities (i.e. Dzylanama in Lilongwe) and converted into charcoal using inefficient earth kilns. It is then transported on bicycles and trucks to the city in large bags, before being broken down into smaller portions and sold by retailers. Low income customers often purchase fuel on a daily basis in small quantities. This is a highly unregulated market with no formal taxes and is the lowest cost option.

The Government of Malawi had an initiative to increase the number of efficient cookstoves. Their target has not unfortunately been met, primarily due to the high initial upfront cost of the stoves. These stoves can be as much as a months income for low income families. Most ethanol stoves in Malawi are imported, though some are assembled in Malawi. With small modifications to the commonly used wood



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and charcoal stoves, Jiko and the Chitetezo Mbaula stoves (thought to number over 2 million), FireDragon as a solid fuel can be practically and safely used with them. FireDragon produces very little ash and so the ash collector is unnecessary, but they will need a waterproof receptacle as FireDragon liquifies when burning.

Firedragon, like all ethanol, can be ignited very easily with a flint spark, single match or lighter. This was well liked by the participants in the 2021 feasibility study as charcoal and wood are a lot more difficult to light. BCB also make a small fire flint, which retails for about GDP 1.40 (US\$ 1.80), and will strike over 3,000 times and works in the rain.

According to WHO 2016 report Burning Opportunities.... *“studies demonstrate that households are often willing to spend more on clean energy, if they have access.”*

4. Approach & Innovation

Our approach to meet the need will be to develop the business case for the production and distribution of FireDragon in Malawi, to reach large scale adoption as an alternative to charcoal and wood by low- and middle-income households in urban and peri-urban areas. Our innovation, FireDragon, will be cleaner to use, more sustainably produced and safer than the current cooking fuel used by 95% of Malawians. The focus will be on applying an existing technology (FireDragon) to a new area (Malawi) for BCB. We are free to operate as BCB holds the patent to FireDragon and intends to grant a license for local manufacture.

Previously most projects in Africa have recognised ethanol as a fantastic eco fuel, but it has only been available in liquid form. As such it is expensive and dangerous to distribute, store and use, especially in low income households. It also relies on needing a specialist ethanol cooker which typically costs \$40 to \$50. As such this is a barrier to most low and middle income households adoption, though small numbers of liquid ethanol cookers are imported from South Africa, some part and others fully assembled. Liquid ethanol is also though very dangerous, as it has a low flash point. Would you store petrol in your house? There have been lots of uncontrolled fires and burns, especially of children.

This project will focus on the fuel and not the cooker as with most previous projects. Solidifying ethanol makes it;

- Safer and more practical to handle and cook with, and it is actually an advantage to get on your hands as FireDragon is a proven hand sanitiser.



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- It can be used in most of the existing Jiko stoves, which are widely used in cooking, and most other types of charcoal and wood stoves, with a slight low cost modification we perfected during the feasibility study.
- Safer and easier to distribute, and store. Hence reducing the transport costs, as we can rely on the existing local wood and charcoal distributors and resellers.

Most of BCB's products are associated with lifesaving, protection, or survival. Historically our primary customers have been the UK MoD, a UK manufacturer of life rafts and latterly the MoJ. The company also exports 45% of its turnover to military, security and marine services around the world and has a well-established network of international sales distributors. BCB have been an occasional supplier to the UN, NGOs and Red Cross agencies for over 35 years. So, exploring the feasibility of supplying FireDragon to the humanitarian aid sector is a logical fit with its current portfolio. Establishing an overseas licensing model that targets household use of FireDragon has the potential to open up a market of 3 billion new customers which can be capitalised on through first mover advantage. Our fuel innovation will improve on the current state-of-art by licensing BCBs patented technology to solidify liquid ethanol into a safe and low-cost cooking fuel, which can be used in existing cooking stoves.

This project will be split into three Work Packages (WP) as detailed in 8. Project Plan.

The expected outputs will be:

- The market system is mapped, over a wider 3,000 user group, during the wet season and with any barriers identified and corresponding interventions proposed.
- The target market and partners will be identified, profiled and potential size determined.
- Imported FireDragon will be used during WP1 and WP2, to prove the latent demand for a clean, readily available, eco fuel, which fits and works with the existing cookers, modus operandi of the households and utilises the existing distribution and retailers structure. This will become increasingly easy to achieve in the wet season and as wood becomes more scarce with the continued wanton deforestation.



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- A financial model and plan will then be developed to prove the viability for the establishment of FireDragon production and distribution in country. FireDragon can be made from lower grade ethanol, typical of production from smaller micro distilleries, (1 to 3 million litres pa) so helping to increase the ethanol production in country, and in turn use waste vegetation and feedstocks from smaller rural farms.

5. BCB Capability

BCB International Ltd, established in 1979, is a designer, manufacturer and supplier of innovative and life-saving equipment primarily to the outdoor, defence and marine markets. The company has a well-balanced and capable management team with good financial control and proven production, quality control and distribution structures. Key personnel involved with the project will be Andrew Howell, Managing Director and Fahmid Uddin, R&D Chemist. Fahmid is qualified to Masters (Hons) level in Chemistry, graduating from Swansea University in 2015. He has significant focus on gelation polymers and hydroalcoholic gels, and can actively apply this knowledge to new product development and regulations.

The core markets for FireDragon are security and outdoor adventure, which BCB are already heavily involved with, deemed to be relatively low risk and well established. The search for new markets has taken BCB to the humanitarian and Aid sectors with some initial traction, but scale has not been achieved to date. This project marks the next evolution in market expansion by exploring developing country markets, where demand is potentially very high due to almost universal use of biomass for household cooking. However, these markets can be high risk, carry a significant amount of certainty and are not well understood by BCB.

BCB invested £700,000 in new FireDragon automated machinery in 2020. Further information on BCB is attached.

External funding support is needed for this project so the fuel will be competitive in the market compared with charcoal and wood, to cover the high transport costs, especially as Malawi is a land locked country, cover the establishment costs, to ensuring availability of employees and local consultants. With the funding the velocity of the project will be increased and the projects outcomes would have a high likelihood of success. With a project such as this, in a relatively new territory for the lead applicant, there is higher risk and lower financial reward for the costs that are required to undertake this project. The lead applicant would be less able



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to devote time and resource to the project and data collected may be less reliable than with greater financial input.

BCB will engage with local governmental and NGO's already established who we have identified who have experience working in cleaner cooking initiatives and carbon finance in East and Southern Arica and will lead data collection for the Market Assessment and trials of FireDragon with a typical Malawian cooking stove

BCB will also engage local consultants to lead the financial modelling activities for work package 3, as well as provide inputs into work packages 1 and 2. We will use the same consultants used on the feasibility study.

6. *Routes to Market*

BCB owns the patent for FireDragon Fuel and is the exclusive producer, primarily targeting British and foreign militaries. Secondary and tertiary markets include the camping industry, as well as use in humanitarian settings, such as refugee camps. This feasibility study aims to develop the case for entering new markets in sub-Saharan Africa, with an initial assessment conducted in Malawi.

The target market is urban users of illegal and unsustainable charcoal, currently cooking on the Kenyan Ceramic Jiko. This is a large and growing market, with prices set to increase further over the coming years due to fuel scarcity. Estimates from informal data collection over the last 5 years (2015 -- 2020) suggest that the price has increased by nearly 400%. As this customer segment is highly price sensitive, they will be more willing to explore alternatives as prices continue to rise. As well as being price sensitive, these customers have limited cash flow and tend to purchase fuel in small amounts on a frequent basis, sometimes daily. FireDragon is ideally suited to this type of customer behaviour, as it is produced in small blocks which can be sold individually.

Initial tests indicate that FireDragon is competitive with charcoal when used for cooking, as it requires 53g to boil 1 litre of water, compared to 67g for charcoal. In the UK, FireDragon retails at GBP 5 (\$6.50) for 5 Kgs, equating to GBP 1 (\$1.30) per kilogram. In comparison, the price of charcoal is currently approx GBP 0.8 (\$1.04) per Kg. Not only does FireDragon represent a financially attractive option for customers, but it is also a cleaner, more modern fuel, that is quicker to use and will provide more flexibility for users when cooking. Liquid ethanol from South Africa costs approx. \$1.30 per litre ex works.

BCBs objective is to identify a Malawian company that can produce the fuel under license within Malawi, paying a royalty to BCB which will increase revenues. The



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exact amount and structure of the royalties will be determined as part of the feasibility study. In turn, the Malawian manufacturer will be responsible for marketing and retailing to end users. Most charcoal users purchase their fuel through informal sales channels, often located along roadsides in busy areas. Therefore, to reach them it will be necessary to ensure FireDragon is available in the same areas. To achieve this, FireDragon should ideally be stocked in small independent roadside grocery shops that are common throughout urban areas in Malawi.

7. Wider Impacts

Sale of FireDragon in Malawi will increase government tax revenues, unlike the current practice of charcoal use. If 30% of the 406,723 households in Blantyre and Lilongwe adopt FireDragon and consume 333 grams per day, it will generate an additional \$3.5 million in VAT per year. Manufacture of FireDragon will increase demand for liquid ethanol in Malawi, encouraging producers to scale-up operations. Currently, ethanol production in Malawi stands at about 30 million litres per year, (2018/2019) with capacity to produce up to 40 million litres. The 10 million litre spare capacity is sufficient to reach 25% of the households in Blantyre and Lilongwe. End users of FireDragon will see energy savings due to the increasing price of charcoal and the higher energy output of FireDragon. Existing wood and charcoal distributors and retailers will be able to maintain their revenues through the sale of FireDragon, which will help to cut off the supply of wood and charcoal.

The findings of this project will be shared with the Government of Malawi to inform policy and practice. If the feasibility determines that large scale production and sale of firedragon is viable, then the GoM can increase their support to the sector.

This FFIS project will contribute towards the following Sustainable Development Goals:

SDG 1: No Poverty - by supporting local, sustainable businesses to produce improved cookstoves for use with the fuel, as well as income generating opportunities in retailing the fuel

SDG 3: Good Health and Wellbeing -- FireDragon can be used as a hand sanitiser. Over 2.2 million children in the developing world die each year from diarrhoea. Hence, helping hygiene in these households, just before cooking and eating, will help to save lives

SDG 5: Gender Equality -- Livelihoods and health of women are improved, helping to save some of the 13,000 lives that are lost directly as the result of in-door air pollution in Malawi each year. Also the countless hours lost to gathering wood or making charcoal.



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SDG 7: Affordable and Clean Energy -- as a clean and renewable fuel it will displace unsustainable charcoal and wood use, increasing energy access and security in country. The WHO in 2016 estimated in "Burning Opportunities" report that 4.3 million people die globally from indoor air pollution annually, just from the smoke from fires lit for cooking alone.

SDG 9: Industry, Innovation and Infrastructure -- Knowledge and technology transfer allows local manufacture of a modern cooking fuel. Proving the market demand will demonstrate to the current two distilleries to encourage them to increase their production and so in turn their farm suppliers to increase their production. It will also encourage smaller micro distilleries to start, in rural locations, near farms. So the ethanol will be transported to the FireDragon production site and not the bulky feedstocks. Such micro distilleries could typically produce 1 to 3 million litres pa.

SDG 10: Reduced Inequalities -- Increased access for poor households to modern cooking fuels

SDG 13: Climate Action -- FireDragon will reduce carbon emissions by 26% and nitrogen oxides by 40% (compared to dried hard wood).

SDG 15: Life on Land -- Reduction in deforestation for cooking energy resulting in healthier ecosystems and improved biodiversity.

This project will also help prove the market, and release the latent demand for a clean fuel we saw during the 2021 feasibility study.

8. FFIS Project Plan

The project will have three main Work Packages (WP's). Findings from work packages 1 and 2 will feed into development of the financial model in work package 3

We are looking to fund this project in a number of ways. Initially, to start the project by obtaining direct grants, subsidies and sponsorships to scale up our 2021 feasibility study, into this larger project which will finalise the business model. Hence it will then be self-sustaining and so to last in perpetuity, by then using resourced based financing, carbon credit offsets, by selling FireDragon and the stoves through the UN, and selling the fuel and cookers to the users in pay-as-you-go (PAYG) schemes.

Many government organisations and large companies now have an obligation, legal, moral or contractual, to buy carbon offsets. This project will hopefully meet the gold standard for carbon offsets, due to the charities involved. Over 11,000 UK businesses must report their emissions from 2020, under the EU Emissions Trading System. Following COP 26 green



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financing and an appreciation by all businesses of the climate and biodiversity crisis we are all facing is slowly replacing the past greenwashing. It is important to get the private sector involved both from the West and in the benefiting country, as early as possible. This will help build durable capability and capacity.

BCB have previously donated our FireDragon fuel for the pilot feasibility trial in 2021. Going forward we will supply our parts to this project at a low cost. With funding, we will be able to start the project in three Work Packages (WP), starting Q1 2022.

BCB will supply FireDragon solid fuel in 5 litre re-sealable buckets, for WP 1 and 2. A deposit will be charged on the bucket, so it will be returned and be reused in WP3. Also, the buckets can be used then for other purposes once the fuel has been used; perhaps as toilets, water gathering and washing, waterproof storage etc. For the longer term, beyond WP 3, the buckets can be refilled at the local village, when they need to buy more fuel.

As the first pilot feasibility trial has already demonstrated successfully in Malawi, it will help to create new micro businesses locally, to make and sell the stoves in the villages. The majority of these being women owned and run. This in areas where there was no previous understanding of business at all. Hence, PAYG schemes. So, as the beneficiary pays for something, (depending on their capability to pay), so they know the fuel and stove are of value. If there is no cost, then the user will not value it. This will help to ensure self-reliance, fuel will not be wasted and that the project will be enduring.

Local partners will distribute the fuel teaching, normally on a 1 to 1 basis in the rural villages of Malawi, and urban households, how to modify their existing Jiko or other solid fuel cooker. And to promote and then sell the modification. It is hoped these first two work packages (WP`s) will concentrate on both, urban households where the greater opportunities to make a difference are, but also rural villages, to prove the project plan in all settings. So also sharing out the benefit.

However, FireDragon will need to be competitively priced for the longer term, compared to wood and charcoal locally; hence why we need to establish local production in WP3. Educating the users of the eco benefits of FireDragon to the health and their families health as well as its efficient use, in WP1 and WP2 is important to the long term success of the project.

8.1 WORK PACKAGE 1

The cost for WP 1 is based on the following assumptions;

- a) Local clay and earth or metal/ceramic cookers are used in a similar way to the current modified stoves and the improved new modifications from our 2021 feasibility study can be carried out locally. FireDragon does not produce ash and also liquifies to burn.
- b) Demonstrating in each village how to make and then sell the multifuel cookers and how best to use the FireDragon, while conveying the dangers of wood and charcoal smoke.



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- c) Each household comprises of on average 6 people and they cook 3 substantial meals per day and should use approx. 2 kilos of FireDragon per week per household.
- d) That approx. 500 households will participate in the trial for 26 weeks.
- e) That 5 litres of FireDragon is packed in a resealable bucket, labelled with pictorial instructions for use, which will last a typical household (6 people) for 2 weeks. The bucket should have a handle so it can be carried on a bike.
- f) 20 foot containers will be purchased in the UK, painted and filled with the 5 Litre buckets of FireDragon which will be shipped to Malawi. As the containers will be the property of the project, they can stay in country for the project and then will be available to help store safely the fuel produced under WP3.
- g) A deposit will be charged for the bucket, which will be repaired to them when returned empty in a good condition so it can be used again in WP3. It can also be swapped for free for a full bucket if available.
- h) Our previous local partners will participate also to help secure, educate and distribute FireDragon, monitor and report on the project which will help to , prepare the business case and look to setting up local manufacturing, WP3.
- i) map the market/supply chain to develop a production, distribution and retailing overview
- j) Identify the necessary inputs, services and finance required to supply the supply chain
- k) Identify key barriers and risks

8.2 WORK PACKAGE 2

- a) Better understand the existing urban cooking situation in Malawi through customer surveys
- b) Identify and define customer segments
- c) Identify channels the target market currently uses
- d) Assess customer ability and willingness to pay
- e) Determine potential market size based
- f) Provide fuel to users for extended trials
- g) Continuation of WP1 and extended to an additional 2,500 households, for another 26 weeks, plus all other associated items upscaled accordingly, with the continuation of the original 500 households in WP1 for this second 26 weeks.

8.3 WORK PACKAGE 3

Transfer and assistance in establishing all appropriate FireDragon machinery and plant in order to be able to solidify the locally produced liquid ethanol. It is envisaged this will be nearby or be part of the local ethanol producer Ethco, who are located in Dwangwa, next to the primary sugar factory. Alternatively with PressCane.

This WP will involve all of the freight, transfer of production technology, and establishment of the plant.

- a) Using information gathered under WP 1 and 2 develop a financial model for production of FireDragon in Malawi, WP3.
- b) Estimate value addition across the supply chain and determine comparative costs for the different fuels



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- c) Identify and engage suitable Malawian private sector actors who would be interested in taking the business opportunity forward.
- d) Look for additional funding sources, carbon credits, pay as you go schemes, resource based financing.

To effectively manage the project, we will develop an annual workplan based on the work packages and logic model. Activities will be broken down and assigned to specific partners, as well as staff members. The higher level annual workplans will be broken down into more detailed quarterly workplans, against which monthly progress reports will be submitted. The partners will also hold monthly conference calls to update on progress with BCB. Financial reports will be produced on a monthly basis to track spending. Financial expenditure will only be authorised in line with the relevant Delegation of Authority Frameworks of each partner. Overall responsibility for delivering the project will sit with BCB International.

Then with any additional funding we can hopefully extend this project into other countries, to encounter differing environments and hopefully depending on funding to SE Asia. Differing countries also have differing needs and conditions (rural, urban, wet, dry, displaced and non-displaced people, positive and negative governance etc); so differing scenarios to test the fuel and stove in.

9. Project legacy

It is anticipated that this project will finalise and self-sustainable practical business and we believe that a significant opportunity exists to take a share of the \$620 million charcoal market in Malawi. As such, we anticipate using the results of this project to lobby private sector actors to engage with the business opportunity for other countries.

As well as private sector engagement, the results of the market system assessment will be used to identify barriers to adoption of the fuel. In turn, these will be used to engage with policy makers to create a more supportive enabling environment that will benefit all organisations interested in working with ethanol cooking fuel.

If successful, the widescale adoption of FireDragon would contribute towards increasing the proportion of the population with primary reliance on clean fuels and technology (SDG 7.1.2), by moving them away from unsustainable and illegally sourced charcoal. Furthermore, adoption of FireDragon fuel would increase the renewable energy share in the total final energy consumption (SDG 7.2.1), as the feedstock for ethanol production is from a renewable source. Finally, introduction of FireDragon production into Malawi will result in



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knowledge and technology transfer from the UK to Malawi, which will build the capacity of the country to address its sustainable energy challenges.

10. Risks

With the feasibility study already completed, few risks are envisaged other than the critical project input of data being insufficiently available in Malawi to carry out the market and technical assessments and financial modelling.

There are possible Managerial risks that project activities are delayed or not completed, and grant funds are not spent as planned. These will be mitigated by close monitoring of expenditure vs budget on a monthly basis, regular re-planning, and phasing of budgets and plans. The project will be subject to travel restrictions also consider risks to its longer-term aims:

10.1 Technical -- cooking stoves in common use by households in the target markets in Malawi are not compatible with FireDragon fuel. Mitigation by the 2021 feasibility study testing any adaptations required. Manufacturing capabilities in Malawi are not able to produce FireDragon to sufficient quality. BCB will engage with existing ethanol producers there. Locally available feed stocks and Molasses a down stream bi-product of the sugar mill in Dwangwa Central Malawi.

10.2 Commercial risks such as locally produced FireDragon not being competitive with current fuels; viable supply chains are difficult to establish; and the prevailing business environment in Malawi is not supportive e.g. manufacture under licence, technology transfer. Assessing these will be part of this project

10.3 Environmental risks are unlikely because the project is designed to have a positive impact. BCB will ensure that the assessment of local manufacture, storage and use of the fuel adhere to the relevant standards.

The project will assess any regulatory requirements around ethanol production in Malawi (currently from sugar and blended with petrol for transport) and its use as a domestic fuel, so may increase the price for ethanol in the region. Hence why we WP1 and WP2 will be imported.

The main ethical issue is diversion of food crops as feedstock. So the project will focus on the feasibility of using common waste vegetation such as maize cobs.



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10.4 Covid

A lot of the communication between the partners and countries will be by regular teams meeting. So virtual not physical. This will also reduce our carbon footprint, costs and will speed up the project and make everyone more efficient.

10.5 Taxes

The Government of Malawi (GoM) has stated its desire to encourage clean fuel to replace wood and charcoal. Accordingly they have allowed a VAT wavier on LPG in 2019. We hope they will consider a similar measure for ethanol as a cooking fuel.

11. Costs and value for money

The more financing we can raise the wider the distribution of the FireDragon can be. But it is thought the minimum to get meaningful data will be the 3,000 households.

Capital items under this project will be fully utilised during the implementation period and 100% covered by the grant. Sub-contractor costs will be for consultancy services in Malawi, who have been used in the 2021 feasibility study, who have solid experience in the local market and financial modelling for off-grid energy products and services in developing countries. They are based in Malawi and know the sector well. Their knowledge and skills will be essential in bridging the gaps between BCB and Malawi.

BCB will also work with Cardiff University for additional laboratory comparative burn tests. Any additional funds raised will be used to extend WP2 by increasing the volume of imported solid ethanol, so as not to push up the price for locally produced ethanol, until capacity is built with micro-distilleries. A study in Nigeria in 2019, by Project Gaia, demonstrated that initially importing 300 million litres of ethanol, helped to prove the market and so encourage the investment to scale up production locally. This example in Nigeria shows imports do not hold back local development of the sector, but rather encourage it.

Establishing production of FireDragon in Malawi will then provide opportunities to export the solid fuel to other countries in the region.

12. Conclusion

Without this project funding BCB will stick to their core business and markets, providing FireDragon for security and outdoor adventure use. Therefore, it is unlikely that FireDragon would be brought to market in Africa and further afield, missing a potentially significant opportunity that could have major environmental,



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social, economic and health benefits. For this small initial outlay, there is a tremendous opportunity to achieve considerable wide ranging development impact for this innovative new technology.

Our vision for this project is to demonstrate the viability of FireDragon for impoverished households (and later for displaced persons), by expanding the very successful project in Malawi to benefit a great sample of households, to include the wet season and use these findings to prove that solid ethanol, FireDragon, is an easy clean, low cost, safe, practical eco solution immediately available. This project will also offer excellent value for money, as it works with the existing well established cookers, which are expensive to replace. And from this the detailed business model will be finalised, to locally produce and distribute solid ethanol at scale, in the selected country and then other countries.

Thank you for your anticipated support!

Attached:

- a) Feasibility study into solid ethanol 2021 Malawi
- b) FireDragon Presentation VH3
- c) Time to clear the air review.