Analysis of spent coffee grounds as a feasible feedstock to meet bioethanol production demands

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Our goal to the reduce the environmental impact of energy demand and waste simultaneously, while contributing to EU's 2020 goal to reduce fossil fuels use in transport by 10%. Utilising spent coffee grounds we have designed a process to produce sustainable and economically viable bioethanol. Our proposal uses the oil free coffee residues from *bio-bean* as our feedstock for bioethanol production, which amounts to *50,000,000* kg per year. By collaborating with bio-bean, we would save on carbon emissions, as transportation would not be required to every coffee shop around London.

Scope: We are considering everything from the growth of the coffee beans to collection of the 95% (by purity) bioethanol. This is our cradle to gate process. As part of our process, we are not participating in the growth of the coffee. The first stage under our control is collection of the coffee residues (oil free) from bio-bean.

Limitations: Our process relies on bio-bean supplying us with their waste coffee residue. This is currently limiting the scalability of our process. However, bio-bean are planning to expand their process to accommodate for larger supplies of coffee and have already initiated the expansion process; they are now collecting from Manchester and Birmingham.
Additionally, when considering the LCA and the coffee growth and manufacturing process, the transportation process of the coffee by cargo ship to the UK would contribute greatly to climate change - generally more than most other processes.

Able to produce 107,000,000 litres of E10 a year

Power a small passenger car for 1,070,000,000km

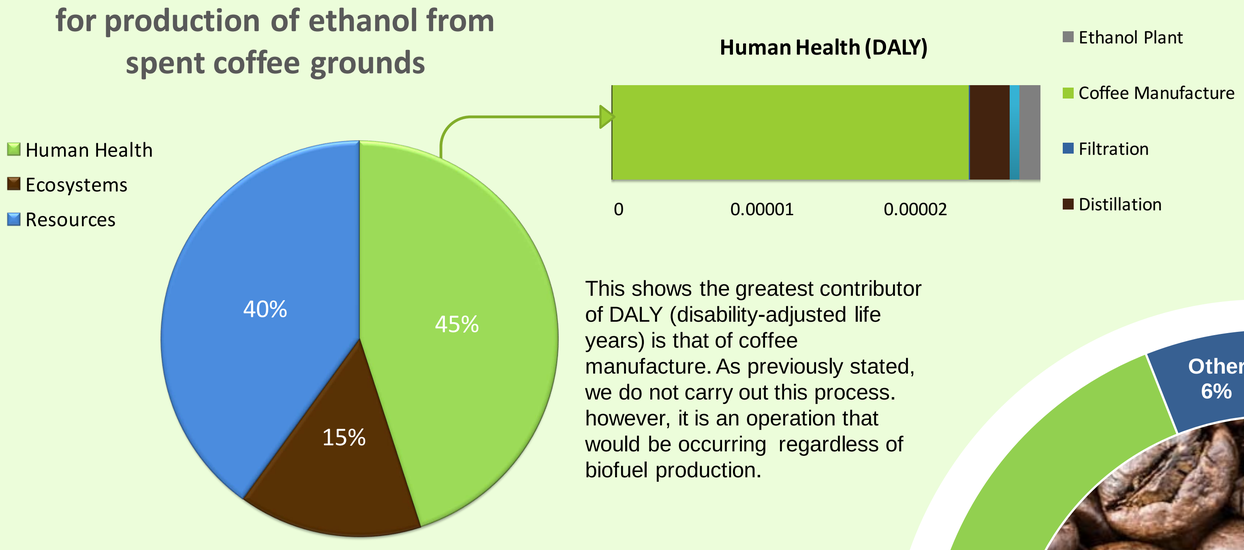
Or 94,000 small passenger cars for a year (6% of cars in the UK)

Abstract
With the world's continuously increasing need for energy, new environmentally and economically sustainable fuels must be developed in order to meet global demands. Bioethanol has become one of the most popular alternative forms of vehicle fuel. Whilst use is becoming increasingly popular in warmer climates (where there is a variety of crops available), the UK doesn't have this advantage, meaning that alternative feedstocks must be found.

An abundance of coffee goes to waste each year - 500,000,000kg each year in the UK alone. Utilising this coffee would prevent its disposal via landfill, which can be detrimental to the environment in terms of global warming potential - release of methane (far more potent as a greenhouse gas than carbon dioxide).

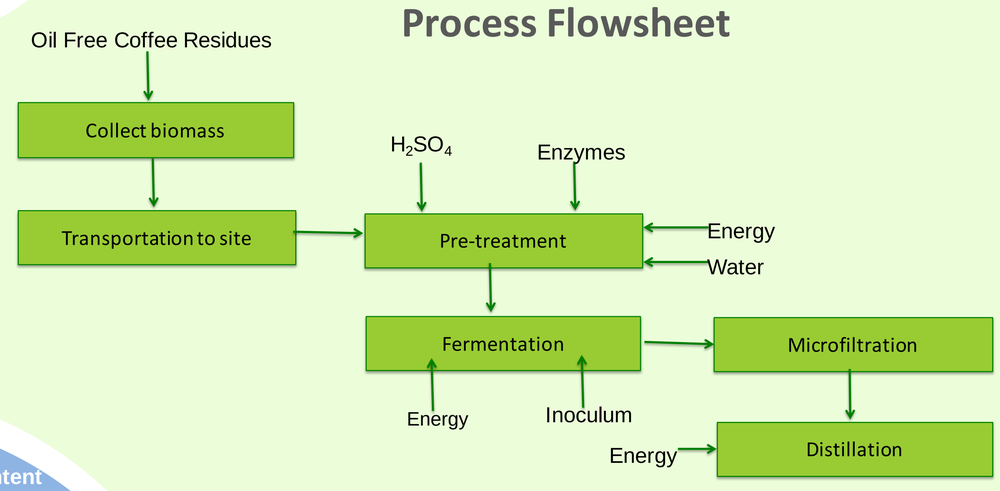
Process summary	
Yield ethanol per kg coffee waste	0.17kg/kg
Total mass of ethanol produced per year	8,470,000kg
Total volume of ethanol produced per year	10,700,000L
Total volume of E10 produced per year	107,000,000L

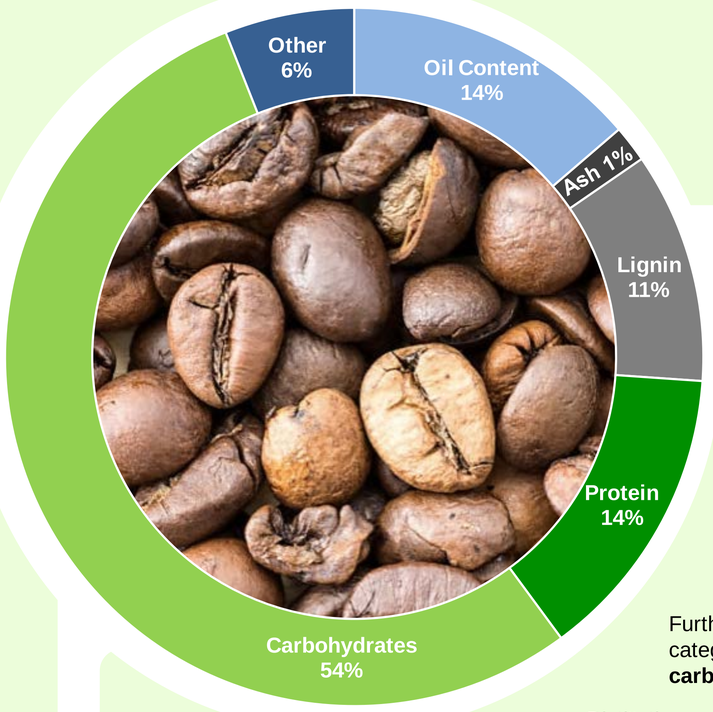
Endpoint damage assessment for production of ethanol from spent coffee grounds



This shows the greatest contributor of DALY (disability-adjusted life years) is that of coffee manufacture. As previously stated, we do not carry out this process. however, it is an operation that would be occurring regardless of biofuel production.

Process Flowsheet





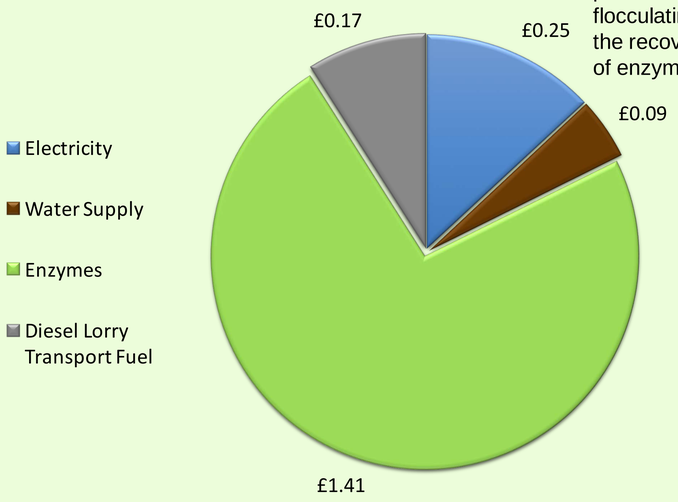
Impact Assessment

Coffee is one of the most popular beverages in the world, making it the second most traded commodity worldwide and the demand is ever increasing. This graph shows that the majority of the contribution to the individual impact categories is from the process of growing and processing coffee. This will happen regardless of whether the spent coffee is used for biofuel production or not. In our process, the main contributor to negative environmental impact is the electricity usage in each unit operation.

Furthermore, whilst coffee manufacture is a large contributor to the varying impact categories, our process could potentially prevent the emission of **340,000 tonnes of carbon dioxide per year.**

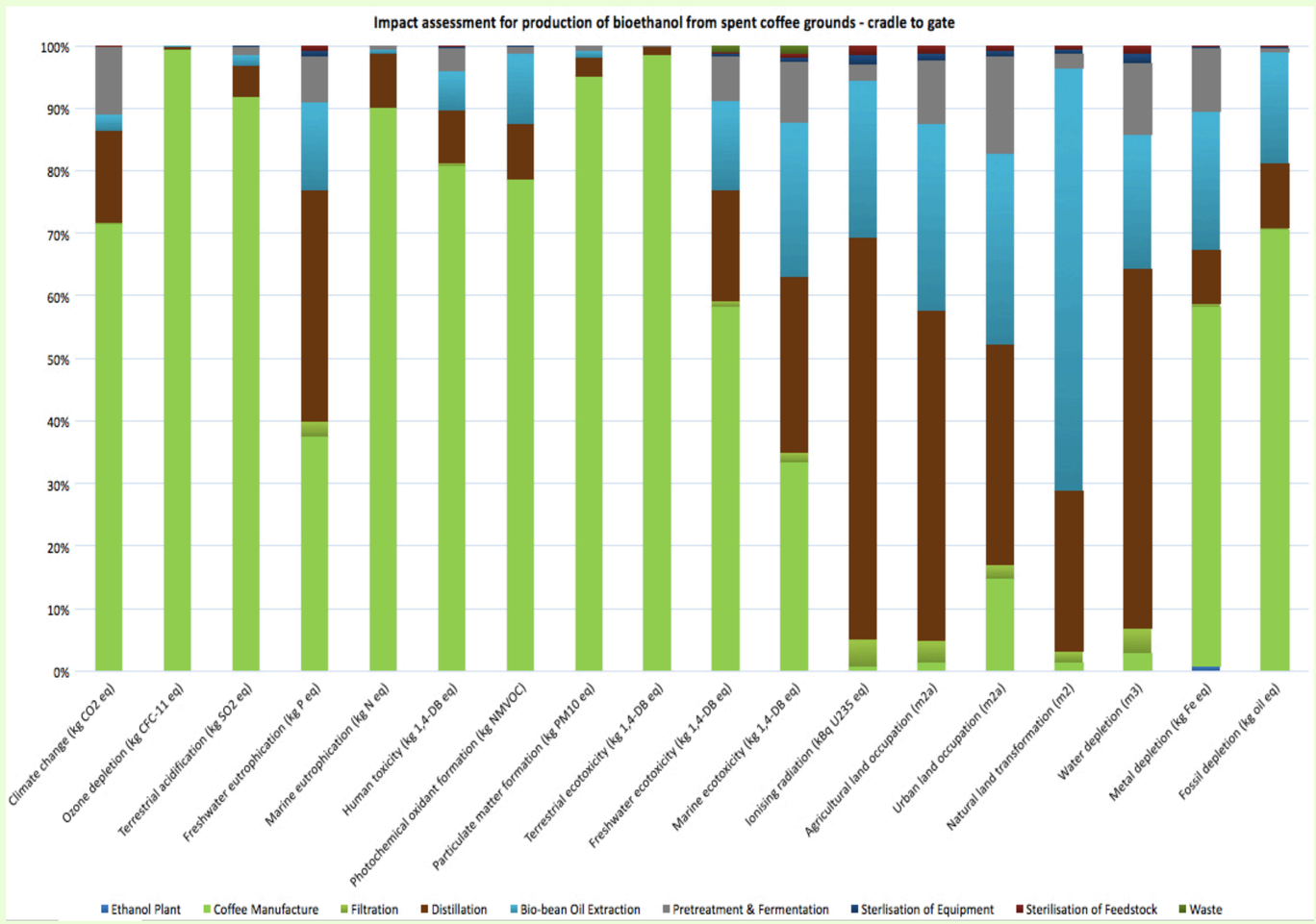
Distillation use heat exchanger to increase efficiency and reduce energy impact and cost.

Operational cost contribution per kg of ethanol



The majority of the cost of the process is due to enzymes, this is due to the necessity for specialised enzymes.To reduce this cost we could potentially use self-flocculating yeast, enabling the recovery and thus reuse of enzymes.

Ethanol Production Cost per kg	£1.92
Ethanol Production Cost per litre	£1.51
E10 Retail Price per litre	£1.07



Future Considerations

- Widely used resource available all year round
- Hard to obtain given the country wide spread of coffee shops.
- Current process relies on the use of bio-bean's leftover waste therefore expansion is reliant on the growth of bio-bean.
- Sell bi-product, lignin (priced as high as £650 per kg) would require process design reconsideration and additional economic and environmental analysis.
- Distillation alternative methods such as pervaporation as a dehydration method would greatly reduce the energy intensity of our process.
- Produce enzymes on site

Conclusion
Coffee is a widely used resource available all year round, which makes it a very attractive feedstock for bioethanol production. Whilst using spent coffee grounds is a practical and exciting way of producing sustainable transport fuel, there is currently not enough utilizable feedstock to meet our stated challenge of producing 5% of the UK's road transport fuel. Furthermore, the cost of ethanol production is noticeably higher than the cost of petrol production and therefore would not be able to compete in terms of retail price, however bioethanol is .

For coffee bean waste to be truly competitive, further research needs to be undertaken to reduce the cost such that it is comparable to petrol/diesel. Should this research be successful, it could have a significant impact in ensuring the UK meets its emissions reduction goals; the EU has stated a requirement that all road fuel should contain 10% biofuel by 2020 and coffee waste could help reach this goal.

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