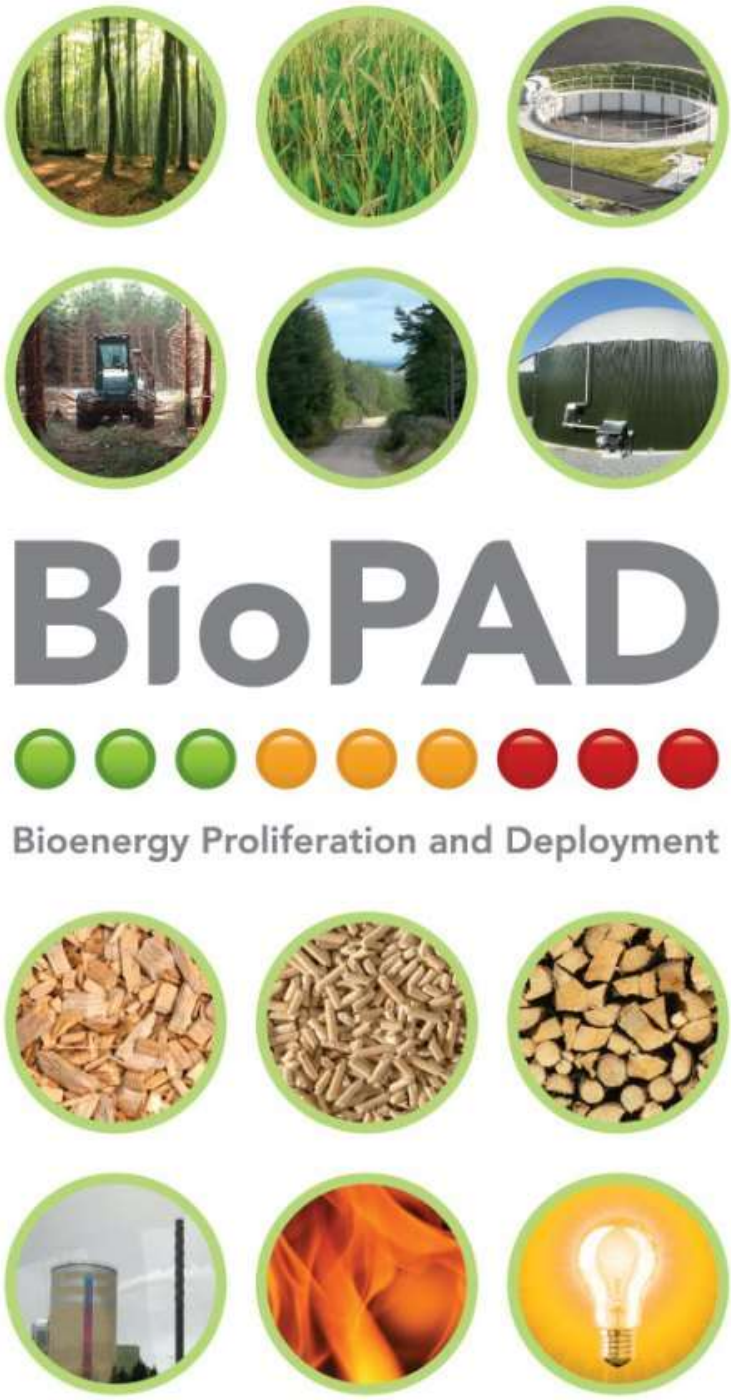
Energy Flows and Carbon Emissions: Combustion of Energy Crops



BioPAD

Bioenergy Proliferation and Deployment

Northern Periphery Programme 2007–2013

Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund

eri environmental research institute

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Preface

Completed by Dr Kenny Boyd (Environmental Research Institute, North Highland College UHI, Scotland) for BioPAD, a project of the Northern Periphery Programme.

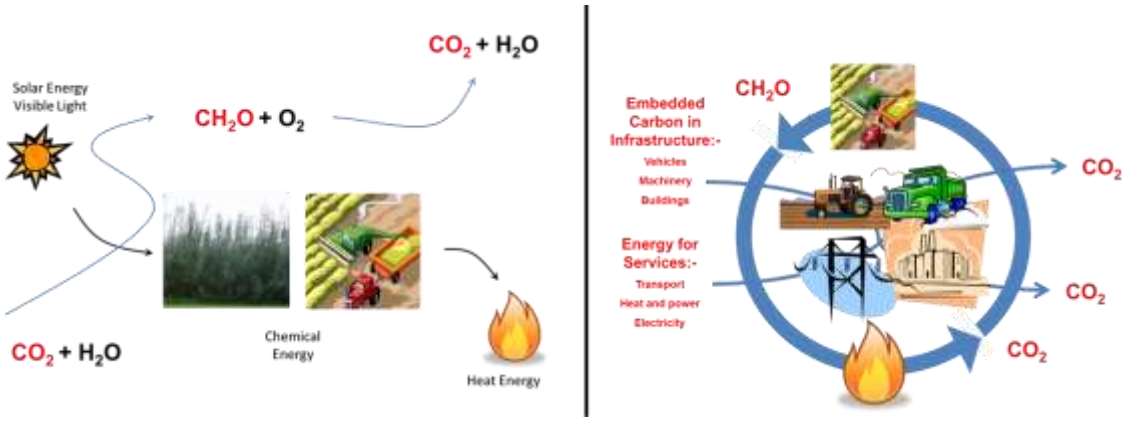
The BioPAD project aims to improve our understanding of the links between supply and demand by looking at supply chains for a variety of bioenergy fuels and different ways of converting these fuels into sustainable energy. Understanding the supply chains and the ways bioenergy moves from fuel source to energy provision will help the establishment of robust and efficient supply services which can match local demand.

BioPAD is led by the Western Development Commission www.wdc.ie (Ireland) and is funded under the ERDF Interreg IVB Northern Periphery Programme (NPP) http://www.northernperiphery.eu. It has partners in Scotland (Environmental Research Institute, UHI http://www.eri.ac.uk/), Northern Ireland (Action Renewables http://www.actionrenewables.org/) and Finland (Finnish Forest Research Institute, Metla http://www.metla.fi/).

Energy Flows and Carbon Emissions: Combustion of Energy Crops

Synopsis

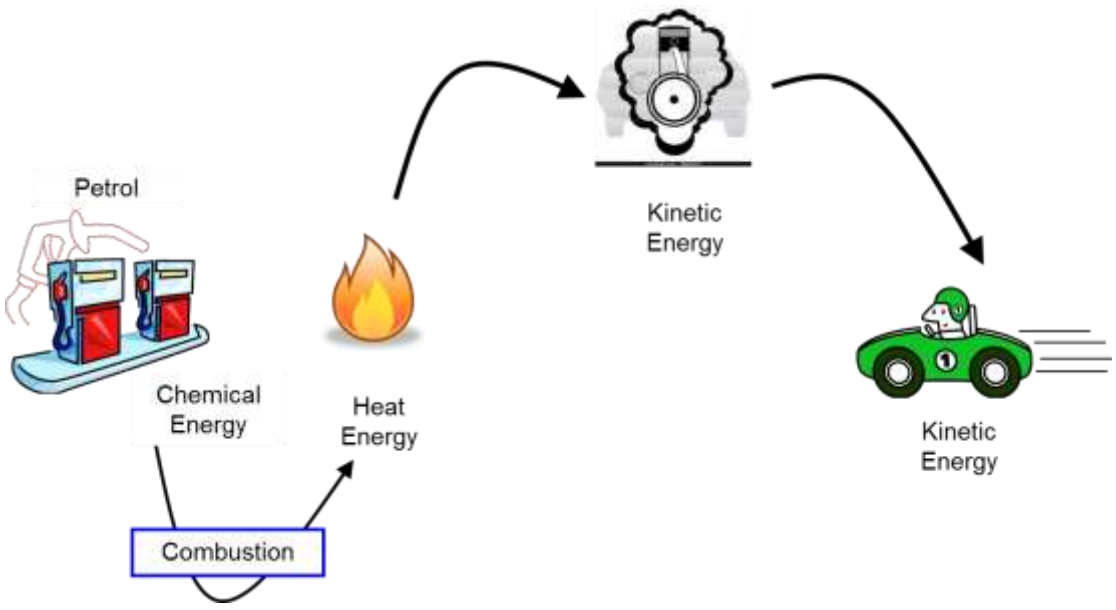
In the production of energy using energy crops (such as short rotation coppice willow) both energy and carbon "flow" through the entire process. Initially carbon dioxide, from the atmosphere, is utilised by plants to build complex molecules, predominantly carbohydrates. In harvesting and processing the biomass into a product for combustion (i.e. chips) the carbon remains stored within the product in essentially the same form. However, when burned, to release heat energy, the molecules that make up the fuel are broken down and the carbon is released back into the atmosphere as carbon dioxide, completing the cycle. The production of energy from energy crops can therefore be considered renewable as it is a closed carbon loop. However other operations in the energy crop supply chain which emit carbon dioxide, such as the production of vehicles and buildings and the use of fuel for transport and energy requiring processes, result in the emission of some carbon dioxide to the atmosphere.



Introduction – Conservation of Energy

Before we consider the carbon emissions and energy transfer steps involved in the production of energy using energy crops it is important to remember that energy can neither be created nor destroyed but can be converted from one form to another. As an example we can consider the energy transformations which take place in order for us to drive a petrol powered car.

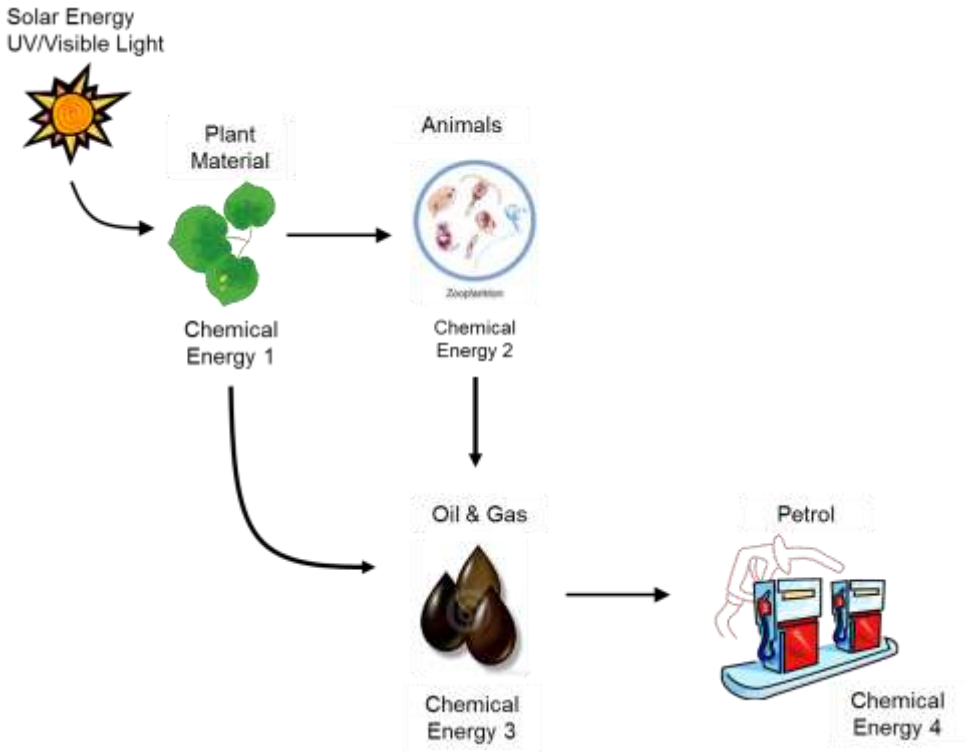
When we drive a petrol powered car we are releasing the chemical energy stored in the molecules that make up petrol to first produce thermal energy, by combustion of the fuel, which is converted into kinetic energy, a rapidly expanding gas, which drives the moving parts of the engine and the car itself.



The energy transformations taking place when burning petrol to power a car.

The energy which is stored in the petrol has its origins in the sun. The sun provides energy directly for the growth of plants which transform this energy into chemical energy, stored in complex molecules such as carbohydrates, fats and proteins. The plants can in turn be eaten by animals which act as another store of chemical energy. The decomposition of animal and plant material over long periods of time produces oil and gas which are themselves a store of chemical energy. Petrol is

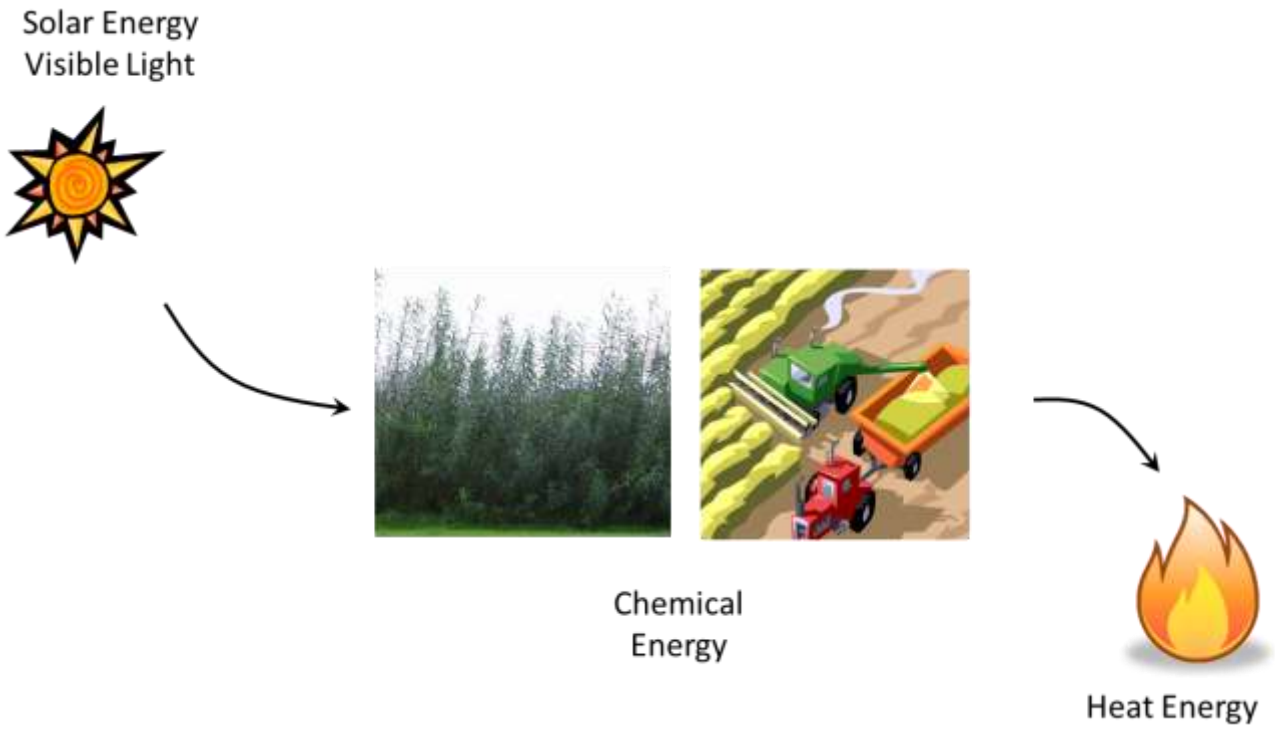
then produced by processing the crude oil to give a product with properties that allow it to be utilised in an internal combustion engine. Petrol is another form of stored chemical energy.



The energy transformations taking place in the formation of oil and gas and in the production of petrol.

Energy and Carbon Flows Associated with Energy Crops

If we examine the energy flows associated with the combustion of energy crops to produce energy we can see that the energy in the crops was originally supplied by the sun. The sun provides the energy to drive photosynthesis, building plant material and storing the energy as chemical energy which holds the atoms within the complex molecules which make up plants together. The plant material is then modified to form product suitable for transportation and combustion e.g. chips, pellets etc., which acts as another store of chemical energy. Finally burning this product releases the chemical energy, stored in the bonds holding together the complex molecules, as heat energy.



Energy flow associated with using energy crops to produce heat. We can see that biomass acts as an energy accumulator absorbing energy from sunlight.

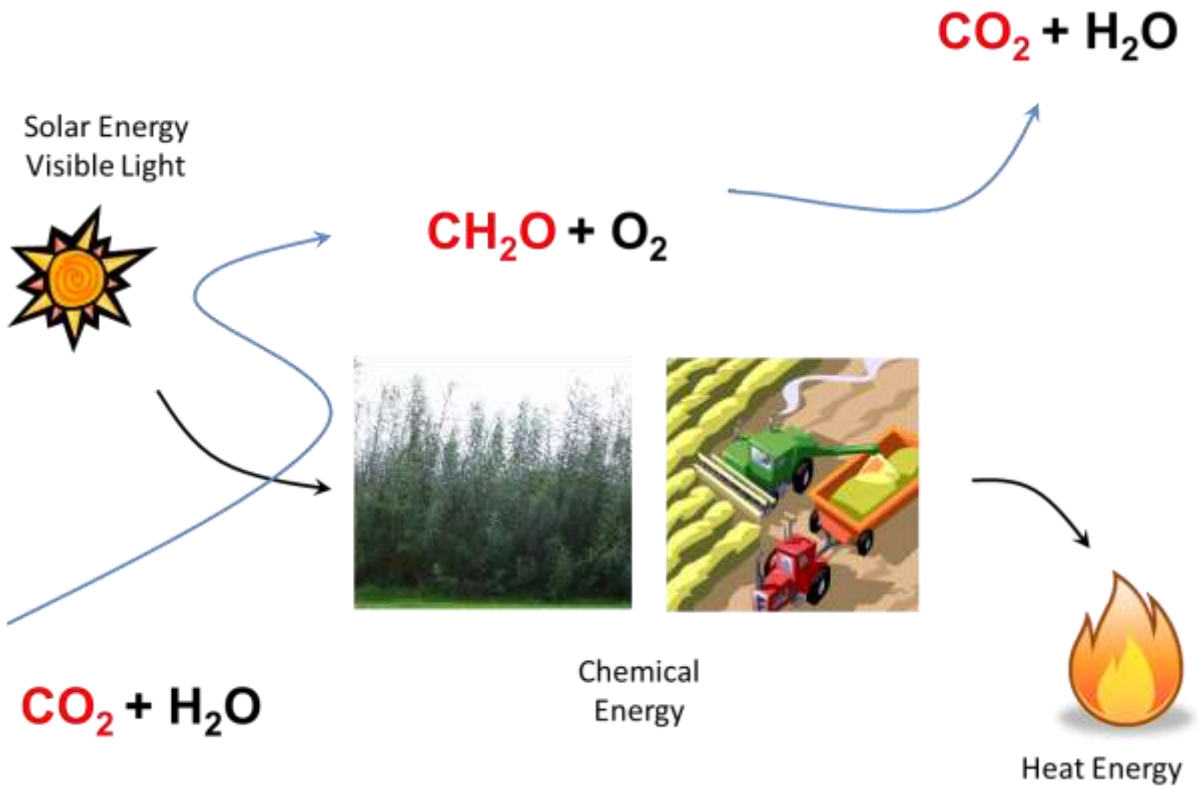
As well as energy flowing through the process carbon also flows through the system. In the case of the carbon, carbon dioxide is utilised by plant materials during photosynthesis to build complex molecules, predominantly carbohydrates, as follows.

$$nC0_2 + nH_20 \rightarrow (CH_2O)_n + nO_2$$

In transforming the crops into a combustible product, such as wood chips, little is actually done to change how the energy within the material is stored. The chips are just wood in another form. However when burned, the molecules that make up the fuel are broken down and the carbon transformed into carbon dioxide according to the following equation.

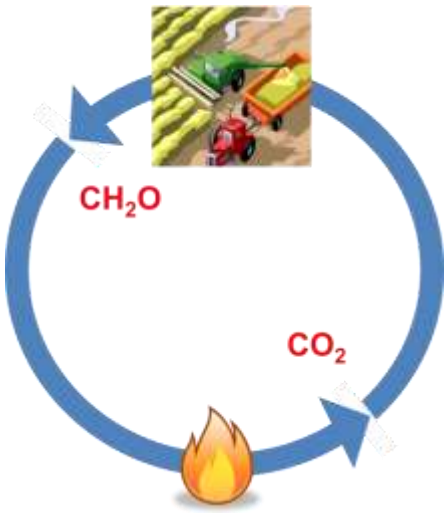
$$nO_2 + (CH_2O)_n \rightarrow nC0_2 + nH_20$$

The flow of carbon within this system is therefore as depicted as follows.



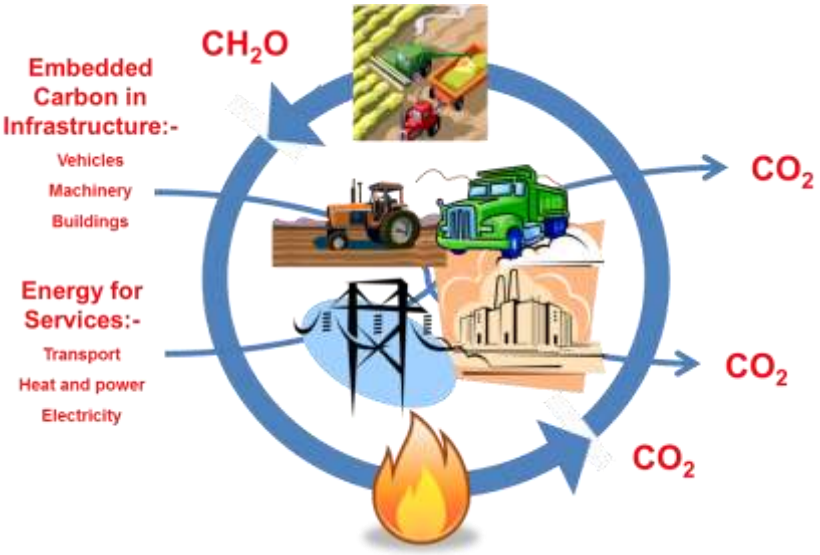
Energy and carbon flows associated with the combustion of energy crops to produce heat.

Biomass is considered renewable as it is a closed carbon loop in which carbon dioxide is continually cycled through wood. In the case of energy crops the carbon is stored within the biomass as it grows and is released at the end of the growing cycle. If crops are replanted to provide a sustainable supply of fuel then the integrity of the cycle is maintained.



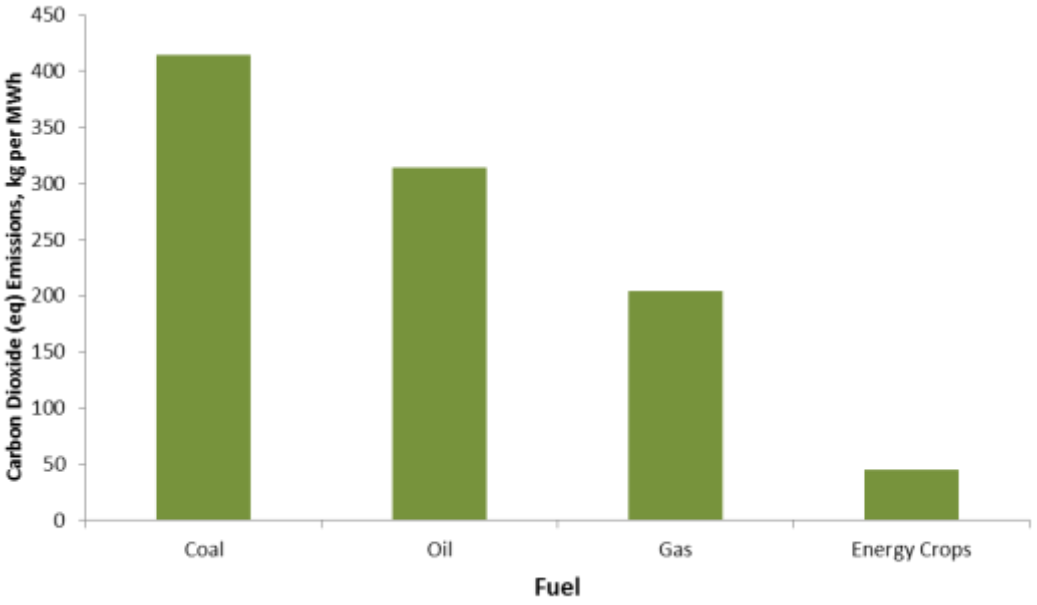
The closed carbon loop, associated with obtaining energy from energy crops

Processing operations in the energy crop supply chain (planting, harvesting, transportation, chipping etc.) can result in the emission of carbon dioxide to the atmosphere. This can be from the direct use of fossil fuels for transportation or providing heat. The use of electricity within the supply chain can also be responsible for carbon dioxide emissions where electricity production is dependent on fossil fuels. The fabrication of the physical resources needed for the supply chain (vehicles, harvesting equipment, storage facilities, computers) is also likely to be a source of carbon dioxide emissions which are attributable to the supply chain.



Additional carbon emissions from the supply chain

The production of useful energy from bioenergy crops can therefore be sustainable; however it does result in the emission of carbon dioxide, especially where electricity generation is not decarbonised. However compared to other energy sources emissions are much reduced.



Emissions of carbon dioxide associated with the combustion of different fuel types. From 2012 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting.

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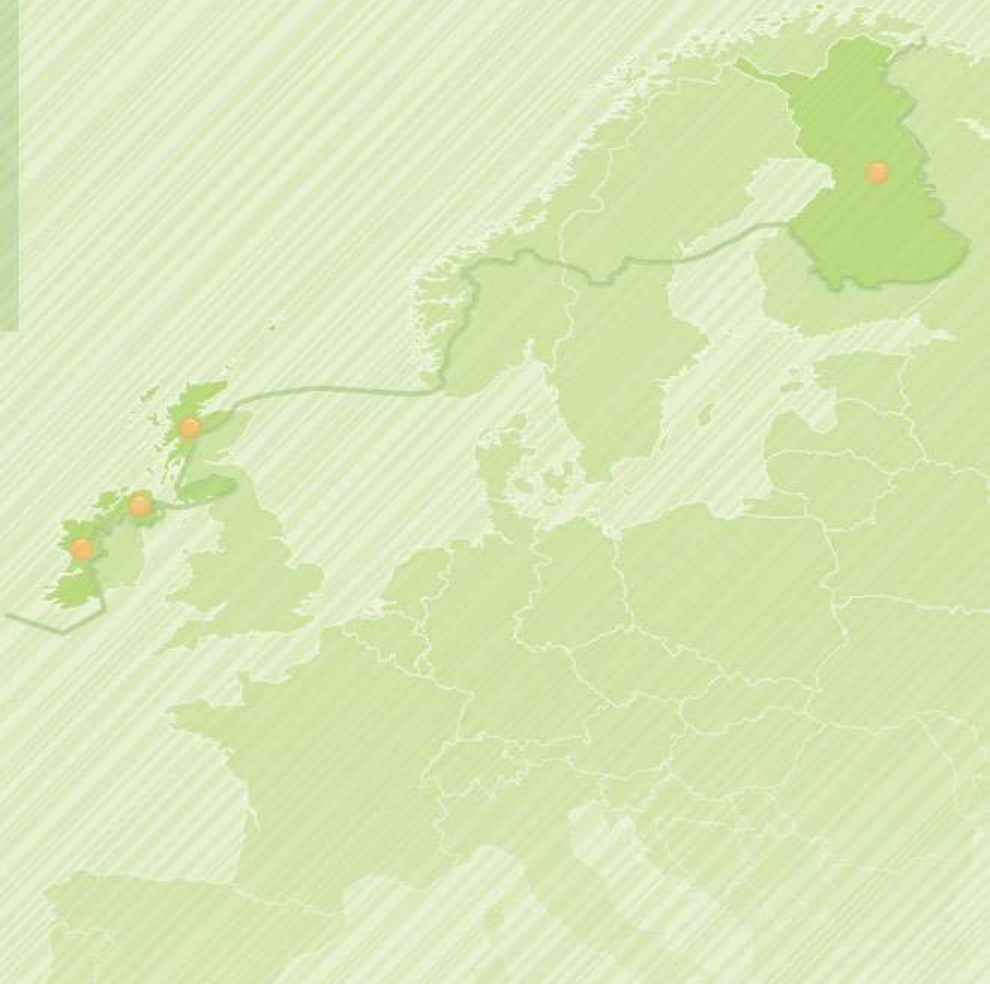

BioPAD is promoting the wider use of bioenergy and developing applications targeting the whole process from supplying fuel to producing energy.

The project is led by the Western Development Commission (Republic of Ireland) and brings together partners from Northern Ireland (Action Renewables), Scotland (Environmental Research Institute) and Finland (Finnish Forest Research Institute, Metla).

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