

INTRODUCTION TO BIO-BASED ECONOMY

LESSON OBJECTIVES

Students will be able to:

Understand how crude oil is used to make other valuable items

Understand how biomass may be used to generate these materials or alternatives instead.

Understand that crude oil cannot be used forever

SUMMARY OF TASKS

PART 1 – INTRODUCTION

- Start by brainstorming ideas on a whiteboard in a classroom discussion. Get students to come up with as many ideas as possible in 5 minutes of things which are made from crude oil. Use the factsheet to fill in things that students missed at the end.
- Discuss whether any of these are surprising, and whether the variety of products is greater or less than the students would have thought.

PART 2 – BIOBASED ECONOMY

- Next, ask students to discuss with the person next to them for one minute what some of the advantages and disadvantages are of crude oil. Each pair can share one advantage and one disadvantage with the class. If any are missed from the factsheet, inform them of these as well. Additional ideas given by the class not found on the factsheet may also be relevant.
- Upon completion, the non-renewable and polluting nature of crude oil should have been identified.
- Ask students whether they have any ideas what might happen to all the above products when we run out of oil, which is likely to be in their lifetime. Are there alternative products to use? What are they made from? How do we dispose of the above products? Is there possibility for recycling?
- This is when the idea of a bio-based economy can be introduced. Emphasise how biomass and crude oil are alike in that they're sources of chemicals, and that for both sources we can take a few simple chemicals and diversify them into many complicated ones. Use the factsheet to present the advantages/disadvantages and finish by presenting examples from the factsheet.

RESOURCES/ EQUIPMENT

HOMEWORK/ EXTRA ACTIVITIES

Introduction to Bio-Based Economy
Factsheet

One paragraph on why you think the bio-based economy will/will not be used in the future.

INTRODUCTION TO BIO-BASED ECONOMY FACTSHEET

FACT SHEETS HAVE BEEN DESIGNED FOR TEACHER USE TO AID CREATING OF TEACHING RESOURCES, OR THEY ARE FREE TO BE REPURPOSED FOR STUDENT USE.

PART 1 – INTRODUCTION TO CRUDE OIL

Crude oil is known for being used to make fuel, but much of crude oil goes into making products. Products include clothes, packaging, ink, perfume, shampoo, car parts, painkillers to cancer treatments, cosmetics, furniture... An expanded list is given,¹ although this is still small in comparison to just how many products are made from oil.

PART 2 - ADVANTAGES AND DISADVANTAGES OF CRUDE OIL AS A FEEDSTOCK

Advantages:

- It can be processed relatively cheaply and on huge scale
- Transportation is also straightforward, as crude oil is a liquid that can be moved around through pipes.
- It is an incredibly diverse resource. It can be processed very efficiently, through fractional distillation, hence it is possible to make the wide range of products listed above from one singular resource.
- It has historically been very easy to obtain in large quantities.

Disadvantages:

- It is non-renewable resource. As crude oil is a limited resource it will eventually run out, meaning products like those listed above will not be available, or at least be very expensive to produce, if we do not find a replacement for the crude oil feedstock.
- When crude oil is used as a fuel or when the products based on crude oil degrade, it is converted to pollutant gases. The material that comprises these gases was at one point buried deep underground in the form of oil, where it could not do environmental harm. Using oil as a

1. ¹ <https://www.ranken-energy.com/index.php/products-made-from-petroleum/>

Bio-Based Economy

INTRODUCTION TO BIO-BASED ECONOMY– INTRODUCTION TO BIO-BASED ECONOMY LESSON PLAN + FACTSHEET

feedstock causes a net increase in atmospheric pollution, disrupting the natural balance of the carbon cycle.

PART 3 - THE BIO-BASED ECONOMY

- This is where we make products from plant material (biomass) instead of oil. What the listed products all have in common is that they are made predominantly from the element carbon.
- Large amounts of carbon exist in oil, coal, gas, and all living things - but only plants can make brand new carbon-containing materials (using photosynthesis).



- If we want to continue making these carbon-containing items in the long term, we must utilise the carbon from biomass, as plants can continuously make carbon-containing materials. This has the additional advantage of reducing pollution. As plants grow, they remove carbon dioxide from the atmosphere, and build it into carbon-containing materials. Making materials from plants is therefore an indirect way of making materials from our waste carbon dioxide.
- More able students may recognise the cyclical nature of this process. Creating products from biomass is in theory a carbon neutral process, even if the products are burned at the end of their life.
- We need to make thousands of different chemicals to meet demand, though plants only make a few in large enough amounts to be useful. For a bio-based economy to take off, we need ways of diversifying chemicals such as lignin, sugars and starch into many different chemicals.
- We have successfully done this with the simple few chemicals that exist in crude oil.
- Doing this again with biomass will require scientific research to find out how we can do it and will require heavy financial investment to put the ideas into practice. Oil had the advantage of having very little competition as the industry was set up, products made from biomass now must be able to compete with those from oil in quality and price in order for the industry to support itself, and this will likely take years or decades.²

² <https://link.springer.com/content/pdf/10.1134/S0965544110040079.pdf>

Biobased Economy

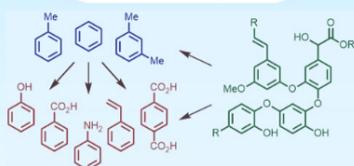
The Biobased Economy is all about making products from renewable resources, like biomass.

Petrochemicals, which come from non-renewable crude oil, are currently used to make the vast majority of important chemicals

Here's a breakdown of some of the important things we can make from biomass instead:

Aromatics and Phenols

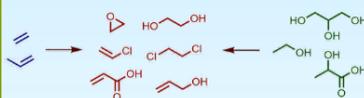
Used to make plastics, dyes, medicines and perfumes



Three compounds from crude oil: **benzene, toluene & xylene**, are the main feed stock for **aromatic chemicals**. Research is ongoing into how to make these or bypass them completely using **lignin**, a component of biomass that's readily available worldwide

2 and 3 Carbon Compounds

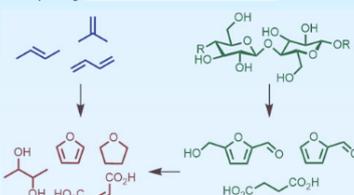
Used to make solvents, polymers and medicines



Ethylene & propylene are two of the most abundant compounds found in crude oil, and form the feed stock for a huge variety of **chemicals**. **Ethanol, glycerol & lactic acid** are incredibly common bio-chemicals that can also produce many of these important chemicals

4 and 5 Carbon Compounds

Building blocks for solvents, polymers and medicines



Cellulose is another major component of biomass, and can be converted to useful compounds like **5-HMF & furfural**. These are used to make **important chemicals**, which are usually derived from **petrochemicals**

Bio-diesel

A renewable alternative to fossil fuels



Bio-diesel is used as a transport fuel to rival non-renewable petrol and diesel. It is made from fatty acids, **triglycerides**, which are abundant in nature. Reacting a triglyceride with methanol gives bio-diesel and **glycerol**. Its use is widespread and it's already a valuable part of the bio-economy

Bio-Based Economy

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FACTSHEET