Energy Challenge Badge

Bioenergy Supplement

Draft for piloting

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Developed in collaboration with

GBEP Global Bioenergy Partnership

Food and Agriculture Organization of the United Nations

Contents

Introduction

Welcome

You might already know that most energy currently produced in the world comes from fossil fuels. Not only is this resource finite, meaning it will soon run out, but it also has very negative consequences for our climate, as it produces a lot of greenhouse gases. Renewable energies – wind, solar, bioenergy, geothermal, wave, tidal… – are a good alternative to fossil fuels because they can reduce the greenhouse gases emitted for the production of energy.

Bioenergy is an important source of renewable energy. Most people in the world have bioenergy as their primary source of energy for cooking and heating in their homes, and in 2017, bioenergy accounted for 12 percent of the total energy consumed globally and 50 percent of the total energy consumption from renewables. However, bioenergy gets a bad rap because of uncertainty over its sustainability. In this guide we will learn all about bioenergy and how to assess whether it is sustainable.

This booklet is a supplement to the YUNGA Energy Challenge Badge so that you can learn more about the interesting world of bioenergy. Once you have completed the Bioenergy Supplement, you will be able to claim your Energy Challenge Badge with a specialisation in bioenergy!

TAKE this booklet and EXPLORE, PLAY and DISCOVER – and while you're having fun, maybe you can even come up with some clever ways to help save energy in your home! After all: YOUR actions and ideas to save energy today will help you to make a difference in the world. Energy is part of everything we do every day!

Be safe and sound

DEAR LEADER OR TEACHER,

The Challenge Badges are designed to support you in undertaking educational activities. However, as you will be implementing these activities in different contexts and environments, it is up to you to ensure that the activities you choose are appropriate and safe. This document contains a number of suggested activities to help your group learn about energy; however, do not feel restricted to this content – why not see what other things you can come up with in your groups.

Practical activities such as those in the second half of this booklet are a fantastic way to learn about the importance and uses of energy. Nevertheless, it is important to take some precautions to ensure nobody gets hurt. Energy has many uses all around us, but for example electricity is very dangerous. This is why it is important to learn how to properly use and control energy. Plan carefully and make sure you have enough adult support to keep you safe, especially when you are near sources of electricity or fire, and in general to any source of energy. Young children should be supervised by an adult at all times. Please consider the general precautions on the next page and carefully evaluate which other safety issues need to be taken into account before undertaking any activity.

Some general precautions to consider include:

- Look after yourself
    - Be careful when using sharp objects and electrical appliances.
    - Do not touch power lines, nor the insides of electrical appliances and stay away from utility boxes.
    - Always turn off a light at the switch before changing a bulb.
    - Keep electrical appliances away from water and use dry hands to plug and unplug electrical appliances.
    - Pull gently when unplugging electronic appliances and tuck away electrical cords.
    - Do not put metal objects in the toaster or microwave.
    - Do not plug many appliances into one outlet or extension cord.
    - Do not climb on power poles and touch or climb trees that are near power lines.
    - Stay inside during thunder and lightning storms and turn off the televisions and computers.
    - Do not fly kites near power lines or during a lightning storm.
    - If you need to use some type of sharp object or device, always ask an adult for assistance.
- Look after the natural world
    - Treat nature with respect and always leave nature the way you found it.
    - Recycle or reuse the materials used in the activities as much as possible.
    - Do not pollute the environment – if you cannot find a bin, take your rubbish home.
    - Make sure that you have permission from the relevant people to carry out special activities or experiments.

Badge structure and curriculum

This booklet is a supplement to the YUNGA Energy Challenge Badge and is intended for teachers or youth leaders who want to develop a focused curriculum on *bioenergy*. It follows the same structure as the Energy Challenge Badge and should be used in conjunction with it to build a curriculum that suits the group.

The first part of the booklet includes basic background information on relevant educational topics, aiming to help teachers and youth leaders to prepare their sessions and group activities without having to search for the information. The supplement looks at the different types of bioenergy, the sources and uses of bioenergy, and the different sustainability considerations. It also suggests and encourages actions you can take to raise awareness in the community about the importance of renewable energy and bioenergy in particular.

The second part of the booklet contains the badge curriculum: a range of activities and ideas to stimulate learning and motivate children and young people to engage in bioenergy issues. Additional resources, useful Web sites and a glossary explaining key terms (*that are highlighted in the text like this*) are provided at the end of the booklet.

Badge structure

A. Understanding bioenergy
B. Bioenergy sources and impacts
C. Producing and using bioenergy
D. Bioenergy sustainability
E. Take Action

Requirements: To earn the badge, participants must complete one of the two compulsory activities at the beginning of Section A of the Energy Challenge Badge and from each section (B-E) of the bioenergy supplement, plus (at least) one additional activity from each section, chosen individually or as a group. Participants can also complete additional activities considered appropriate by the teacher or leader.

A. Understanding bioenergy

1 compulsory activity (A1 or A2) & at least 1 optional activity (A3 to A6)

B. Bioenergy sources and impacts

1 compulsory activity (B1 or B2) & at least 1 optional activity (B3 to B6)

C. Producing and using bioenergy

1 compulsory activity (C1 or C2) & at least 1 optional activity (C3 to C6)

D. Bioenergy sustainability

1 compulsory activity (D1 or D2) & at least 1 optional activity (D3 to D6)

E. Take Action

1 compulsory activity (E1 or E2) & at least 1 optional activity (E3 to E6)

= Bioenergy Challenge Badge COMPLETED!

Age ranges and appropriate activities

To help you and your group select the most appropriate activities, a coding system is provided to indicate the age group(s) for which each activity is most suitable. Next to each activity, a code (for example "Levels 1 and 2") indicates that the activity should be suitable for five- to ten-year olds and eleven to fifteen-year olds. However, please note that this coding is only indicative. You may find that an activity listed at one level is suitable for another age group in your particular circumstances. As teachers and youth leaders you should use your judgement and experience to develop an appropriate curriculum for your group or class. This could incorporate additional activities not listed in this booklet but that allow you to achieve all the educational requirements.

Level 1 Five to ten years old

Level 2 Eleven to fifteen years old

Level 3 Sixteen plus years old

REMEMBER! The key objectives of the Challenge Badge are to educate, inspire, stimulate interest in learning about energy issues and motivate individuals to change their behaviour and create local and international action. However, most of all, the activities should be FUN! Participants should enjoy the process of earning the badge and learning about energy and its importance.

Background information

The following section provides an overview of key issues relating to bioenergy. It aims to help teachers and youth leaders prepare their sessions and group activities without having to search for the information. Naturally, not all the materials will be required or appropriate for all age groups and activities. Leaders and teachers should therefore select the topics and level of detail most appropriate for their group. For example, you may wish to skip the more complicated issues with younger groups, but will probably wish to conduct further research with older groups, who could also read the background information for themselves.

Section A: Understanding bioenergy

Bioenergy is energy obtained from *biomass*. Biomass is derived from living material in plants and animals, such as wood, dried vegetation, cow manure and food scraps. Biomass contains stored energy from the sun. Plants absorb the sun's energy during *photosynthesis*, which converts the solar energy into *chemical energy*. When the plants die, the chemical energy is trapped inside. However, we can release this chemical energy through different processes to produce *bioenergy*.

What is bioenergy?

All of the different words used to describe bioenergy can be quite confusing at times. Let's check that we understand the different terms:

- **Biomass** is plant and animal material that constitutes the *feedstock* for producing bioenergy – it is the raw material for bioenergy.
- **Bioenergy** is the renewable energy produced. It can be produced in solid, liquid and gaseous forms:
    - Solid: e.g. wooden charcoal, woodchips and pellets
    - Liquid (biofuels): e.g. ethanol and biodiesel
    - Gaseous: e.g. biogas and syngas

Bioenergy is a *renewable energy* because it is derived from living material (biomass) that can be renewed relatively quickly (in the lifetime of a person). This means that it has the potential to reduce the greenhouse gas emissions from producing energy when compared to non-renewable fossil fuels.

Bioenergy is an important type of energy globally. In 2017, bioenergy accounted for around 12 percent of global energy consumption (WBA, 2019) and for around 50 percent of the global energy consumption from renewables (IEA, 2018). Many people around the world use bioenergy in some form. Bioenergy use falls into two main categories – traditional and modern. *Traditional bioenergy* use refers to the burning of solid biomass (such as wood, animal waste and traditional charcoal) using inefficient methods, such as open fires. *Modern bioenergy* use, instead, is more efficient than traditional methods, and it includes efficient technologies for using solid, liquid, and gaseous biomass fuels for modern applications, such as space heating, electricity generation, *combined heat and power (CHP)*, and transport (IRENA, 2018; REN21, 2013). The most utilized type of biomass for bioenergy is solid fuels (such as *woodfuel*), much of which is still used in a traditional way.

Life without electricity

Imagine not having access to electricity in your home or school. Think about all the daily activities that require electricity: lighting, heating, cooking, charging your electric devices such as phones or computers…

Many people in developing countries do not have access to electricity. For example, in sub-Saharan Africa, only 45 percent of the population has access to electricity, and in rural areas the percentage of people with access to electricity is only 23 percent (World Bank, 2020). Therefore, they rely on traditional bioenergy for cooking meals, boiling water and heating their homes. We will see how

traditional bioenergy can have many problems and it is much better to switch to modern bioenergy, where possible. Modern bioenergy can be useful in contexts where other sources of energy are not available to bring modern energy services to isolated rural populations.

In the following sections, we will discuss the different types of bioenergy sources and processes, the benefits and drawbacks of bioenergy – both traditional and modern – and how we can take action to ensure that bioenergy is *sustainable*.

Section B: Bioenergy sources and impacts

Woodfuel

Wood is the single most important source of renewable energy, providing around 6 percent of the global total energy supply (Source: FAO, 2019). When wood is used for producing energy, it is called *woodfuel*, and includes not only firewood (like you would use in a fireplace) but also charcoal, pellets, chips and sawdust.

Wood fuel

Firewood Charcoal Pellets Chips Sawdust





Woodfuel is a traditional and crucial source of energy that is still the main source of energy in some developing and developed countries, where it provides basic energy for cooking and heating in households. It is also used in industry for heating industrial activities and producing power. However, using wood for biomass has an environmental impact, as cutting down trees at a rate higher than they can grow back result in *deforestation*. Also, people who use wood for cooking every day in their house may suffer health problems from breathing in the smoke.

Can you think of some ways that we could reduce the negative impacts of the use of *woodfuel*? Here are some examples:

- Use the off cuts (or *by-products*) of timber production that cannot be used for any other purpose
- Use sustainably managed plantations
- Use efficient stoves that reduce the harmful smoke produced from cooking
- Use different biomass sources
- Use wood that is properly dried before use

Woodfuel is a renewable resource. This means that any carbon dioxide emitted from the production of energy from woodfuel will be reabsorbed by new plants or trees that grow back in the place of the ones harvested; this is what is known as a *closed carbon cycle*. In a closed carbon cycle, there are no net carbon dioxide emissions and so the forest bioenergy would be *carbon neutral*. However, there are a few important things to remember:

- A closed carbon cycle is only possible when the wood that is harvested for bioenergy is replaced with new wood from growing trees. This is not the case when forestland is entirely cut down and used for another purpose (like agriculture or pastureland).
- Fossil fuels are still usually needed for the harvesting, transporting and processing of the wood; this creates greenhouse gas emissions.

- The way the forest is managed also determines the amount of carbon absorbed by the trees – fertiliser, for example, could increase the growth rate of trees and the amount of carbon absorbed through photosynthesis. When management practices change, so too does the amount of *sequestered* carbon.

So, as you can see, there are lots of things to take into consideration when evaluating the climate change impacts of bioenergy from wood.

As well as *woodfuel*, there are also many other biomass sources that can be used to produce bioenergy. Let's have a look at what they are…

Agricultural crops

Agricultural crops are also used for bioenergy production. Some examples are sugarcane, maize and palm oil. The sugars that are contained in the crops can be converted (and we'll see how later!) into *biofuels* that can be mixed with petrol or diesel for transport.

Some people say that we should not use agricultural crops for producing bioenergy because it reduces the availability of the crops for feeding people or animals, or it may increase the price of the crop so that poorer people cannot afford it. This is called the 'food vs fuel' debate.

Food vs fuel debate

In recent years, increasing commitments to combat climate change have brought a debate on biofuels to the table, which has been especially contentious because it is motivated primarily by political and ethical issues.

This debate covers: increased food prices, land competition, GHG emissions, energy balance and subsidies. Most of the criticism focuses on *first generation biofuels*, which are those derived from biomass that could be used for food. Let's look at the two arguments for and against biofuels...

Arguments against biofuels:

- It is "morally wrong" to use land to produce energy that could be used for food.
- Large-scale production of biofuels may compromise worldwide *food security*.
- Land competition may lead to deforestation and loss of biodiversity.
- Some of the social and environmental benefits of bioenergy are not yet fully proven.

Arguments for biofuels:

- With sustainable modern agricultural management practices, there would be sufficient land available to produce both food and a reasonable portion of biofuels (i.e. 5-20% of transport fuels demand) without affecting food supply.
- Food insecure countries without fossil fuels reserves allocate a significant portion of their national income to pay oil imports. In such cases, bioenergy could be a good alternative.
- Nearly 2 billion people live without access to modern energy systems. Agriculture in developing countries needs more energy in absolute terms, therefore bioenergy availability can actually enhance food production.
- Certain biofuel crops can be utilized to prevent soil degradation and can utilize or reclaim so called "marginal" or "degraded" land.
- The social, economic and environmental benefits of biofuels outweigh potential negative impacts if good management practices are applied.
- Biofuel can play a significant role in modernizing and diversifying agriculture.

Source: Frank Rosillo-Calle, 2012

What do you think about these arguments? The jury is still out on this debate but the focus has now shifted to looking at development of biofuels at the local and national level and how it affects food security, i.e. we need to take each case separately and analyze the pros and cons on an individual basis.

To overcome some of these problems, crops specifically for energy purposes – energy crops – are sometimes grown. These can be specific varieties of food crops that are not used for food (such as energy cane, a variety of sugarcane), grasses (such as switchgrass) or fast-growing trees and shrubs (such as bamboo or poplar). However, these crops still have the problem that the land where they are grown could be used for growing food and so they could still have an impact on people's *food security*. One way to overcome this is to grow bioenergy crops on land that is currently not in use because either it is contaminated or it has low *productivity*. Crops for bioenergy can also be *intercropped* with

food crops, for example, trees or shrubs to be used for bioenergy can be grown alongside food crops in a system called *agroforestry*. Agroforestry can actually increase the productivity of land and food production, provide a more varied income for farmers, and provide biomass for energy in integrated food-energy systems.

Another bioenergy feedstock that is being investigated comes from biomass from the sea – algae. Algae are oil-rich and the liquid fuel produced from them can be used as an alternative to liquid fossil fuels. *Algaculture* has a number of benefits: algae can grow up to five to ten times faster than crops on land, and can also be grown using saline and wastewater so requiring limited fresh water resources. However, you won't find algal fuel at the fuel pump; it is not yet commercially available because it is very expensive to produce. Research and development are under way to reduce the costs and make it competitive with other fuels.

Residues and wastes

Residues and wastes are good for producing bioenergy because – as their name suggests – they mostly do not have any alternative uses (although see below for when this might not be the case)! Organic residues and wastes include:

Agricultural residues, such as rice husks 	Forest residues, such as sawdust 
Animal wastes, such as manure and urine 	Urban waste, such as organic household and garden waste, and sewage 

Currently, residues in agriculture, livestock and industry are sometimes left to naturally decay, and municipal solid waste is sometimes illegally abandoned, even though these are potential energy sources! Unfortunately, this happens due to the high transportation cost and the undeveloped market for these materials.

Although most residues are left, we need to be careful because some are already used for other purposes, for example:

- Agricultural residues are oftentimes kept on the field for *mulching* and land cover to recycling nutrients, improve soil health, or as feed for animals. For example, in developing countries, at least 30 percent of residues from agricultural fields are used to feed livestock animals.
- Forestry residues can be important for the health of the forest.
- Animal wastes can be used for composting and as fertiliser.
- The organic fraction of the urban waste or other organic waste from agro-industries (e.g. fruit peels) can be used for composting.

Section C: Producing and using bioenergy

Now we have seen what types of biomass can be used as energy sources, we are going to look at the processes needed to convert them into bioenergy and how that bioenergy can be used.

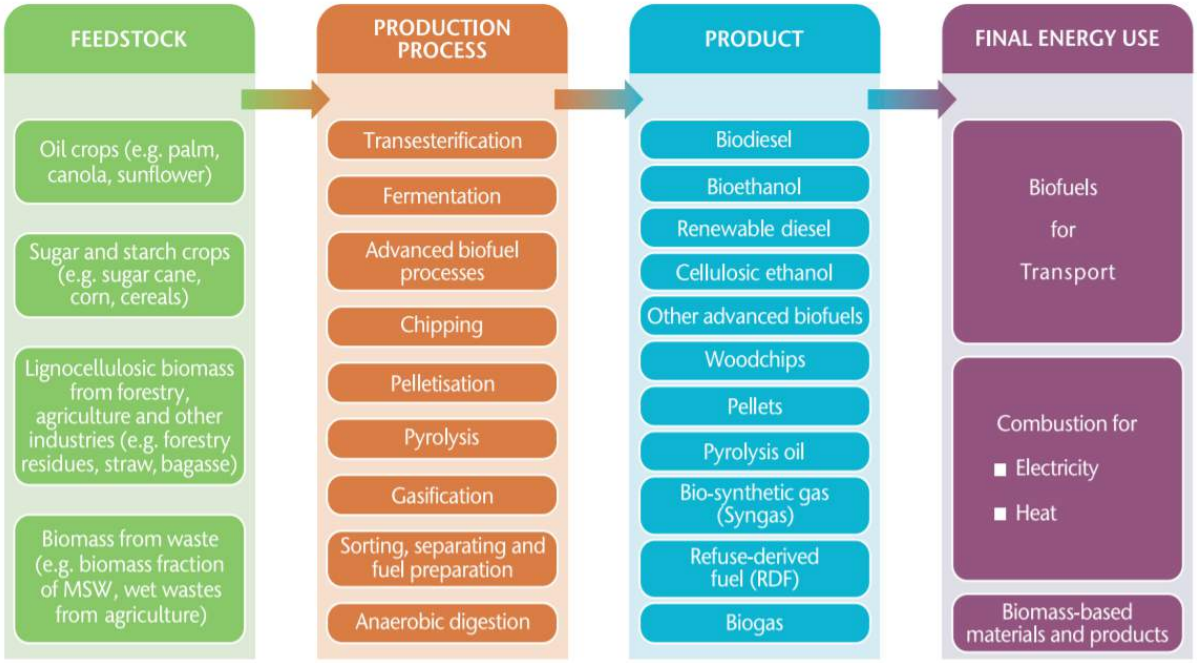
Bioenergy production

There are two main chemical processes to produce energy from biomass.

Biochemical processes	**Thermochemical processes**
These processes use wet biomass. Biochemical processes are processes that occur thanks to the presence of living organisms. Therefore, these processes use microorganisms, such as bacteria or yeast, to produce bioenergy. There are many different types of biochemical processes that involve different biomolecules... One biochemical process is *anaerobic digestion*, which just means digestion without oxygen. The wet biomass is put into a big container called a biodigester, along with water and bacteria. The biodigester works like a stomach that processes food: the bacteria decompose the waste to produce a mixture of gases called *biogas*. Another biochemical process is *fermentation*, where enzymes are used to break down the sugars in the biomass into alcohol, such as *ethanol*. We also use another biochemical process called *esterification* to make *biodiesel*.	These processes use dry biomass, such as wood, to generate heat energy. When biomass is burnt in the open air, it works much like your fireplace at home: it creates thermal energy. This heat can be used to heat water or spaces, and for cooking. Alternatively, it can heat water to steam that can then be used to power a turbine to make electricity. Biomass can also be 'burnt' in absence or with limited presence of oxygen; in this case a gas is produced called *syngas* that can be used for cooking and heating, or for electricity production. One of these processes is called *gasification* (and we'll see how it works later).

In fact, the list of biochemical and thermochemical processes (along with a few other processes for preparing biomass) is very long! You can see in Figure 1 the great variety of feedstock and products that characterize these processes.

Figure 1 Examples of bioenergy pathways



Source: IEA and FAO How2 Guide for Bioenergy

Bioenergy use

In Figure 1 we saw types of final energy use for bioenergy – biofuels for transport, and combustion for electricity and heat. Have a look below for some examples this. Can you think of any more? What kinds of bioenergy do you use?

- Electricity produced from biomass has many uses! For lighting, cooking and other electric appliances in the home, public buildings, industry and workplace.
- Heat from thermochemical processes can be used to drive turbines and motors in factories and industry.
- Biogas can be burnt for use for cooking in houses, schools, restaurants and hotels or in boilers for heating.
- Biofuels (such as ethanol and biodiesel) are used in transport, such as cars or aeroplanes.

The specific biomass-to-energy process, with its distinct technology, is called a pathway. Let's examine some of the different bioenergy pathways we saw in Figure 1!

Biofuels for transport

When we talk about biofuels, you might hear lots of different terminology used to describe them: conventional biofuels; advanced biofuels; first generation biofuels; second-generation biofuels; and even third-generation biofuels! This seems very confusing but they simply describe the different types of technology or feedstock used:

- The term *first-generation biofuels* is usually used interchangeably with *conventional biofuels*. They refer to biofuels produced using established technologies that are widely used and commercially viable.
- *Advanced biofuels* include second- and third-generation biofuels. It can refer to a number of different things:
    - Biofuels that are produced from specific feedstocks, for example, dedicated energy crops, wastes and residues (second-generation) and algae (third-generation).
    - Biofuels that are produced through specific technologies, e.g. new technologies that are not yet well-established
    - Specific types of new biofuels e.g. *'drop-in' fuels*
    - Biofuels that have high greenhouse gas emission savings compared with fossil fuels

Ethanol and diesel are the most common types of biofuel for transport. Both types can be used in their pure form to power vehicles but usually they are mixed with the fossil fuel equivalent in small proportions so that they can be used in regular engines. Let's take a closer look:

Ethanol

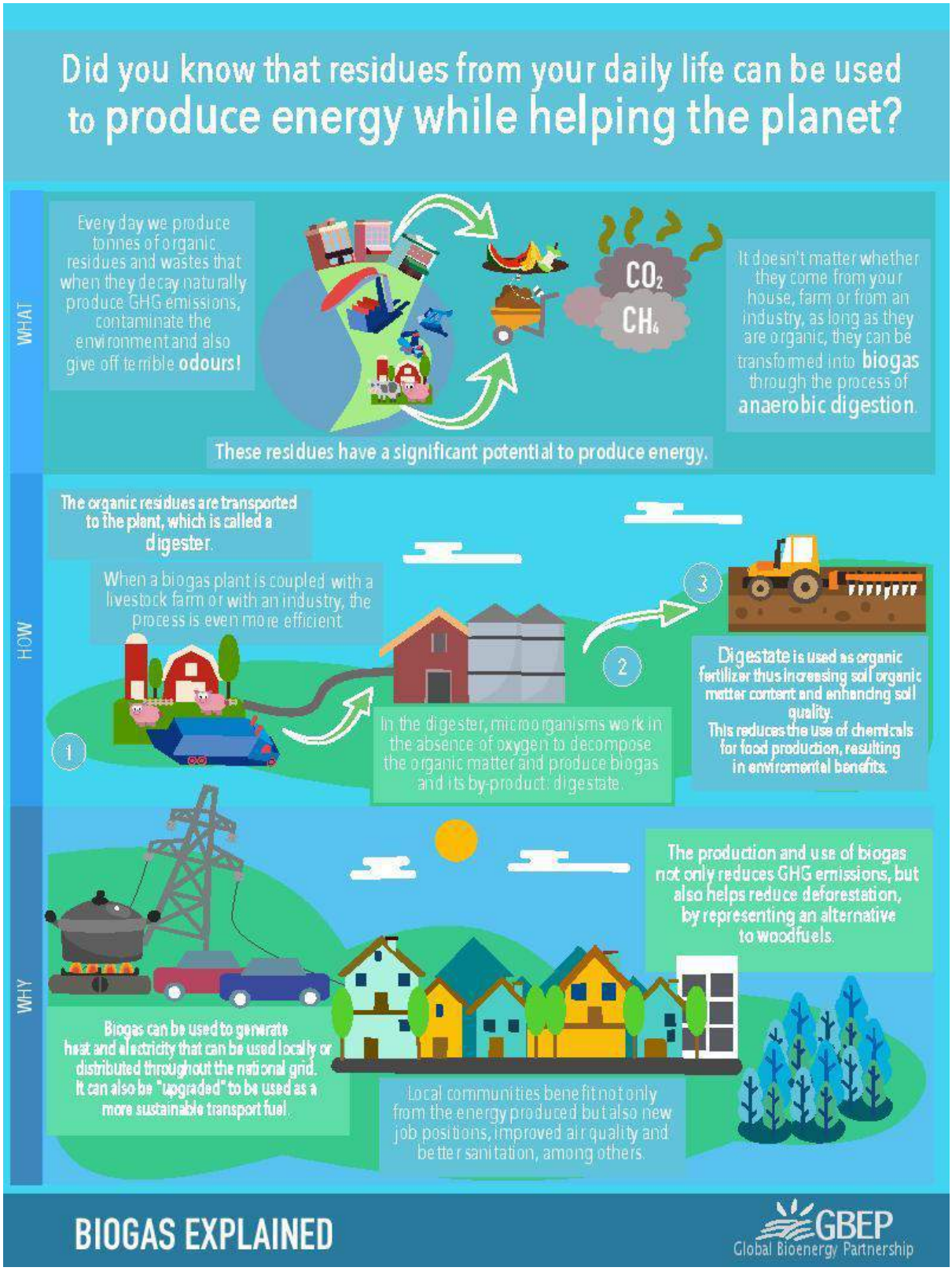
Ethanol, as we have seen, can be produced from the fermentation of sugars. It can be blended with gasoline in regular vehicle engines up to a low percentage (e.g. a 10 percent blend is called E10). However, some vehicles – called *flex-fuel vehicles* – can run on both gasoline and pure ethanol (called E100). These vehicles have one fuel tank that can contain any mixture of gasoline and ethanol. Flex-fuel vehicles, both cars and motorcycles, are very popular in Brazil, making up around 82 percent of all of the light-duty vehicles in the country in 2017.

Biodiesel

Biodiesel is made by esterification of vegetable oils, fats or greases. It is usually blended with fossil fuel diesel up to 20 percent (B20). It is usually not used on its own (B100) because it contains less energy per litre of fuel and so a full tank will not get you as far. It can also create problems with engines that are not refitted for the purpose.

However, there is another type of renewable diesel – called Hydrotreated Vegetable Oil (HVO) or Hydroprocessed Esters and Fatty Acids (HEFA) – that can be used in its pure form (called HVO100) without making any changes to a regular engine. HVO is produced from the treatment of oils and fats, ideally wastes (such as used cooking oil or animal fats). HVO, if produced from wastes or residues, is considered an *advanced biofuel*.

Production of Biogas via anaerobic digestion Pathway

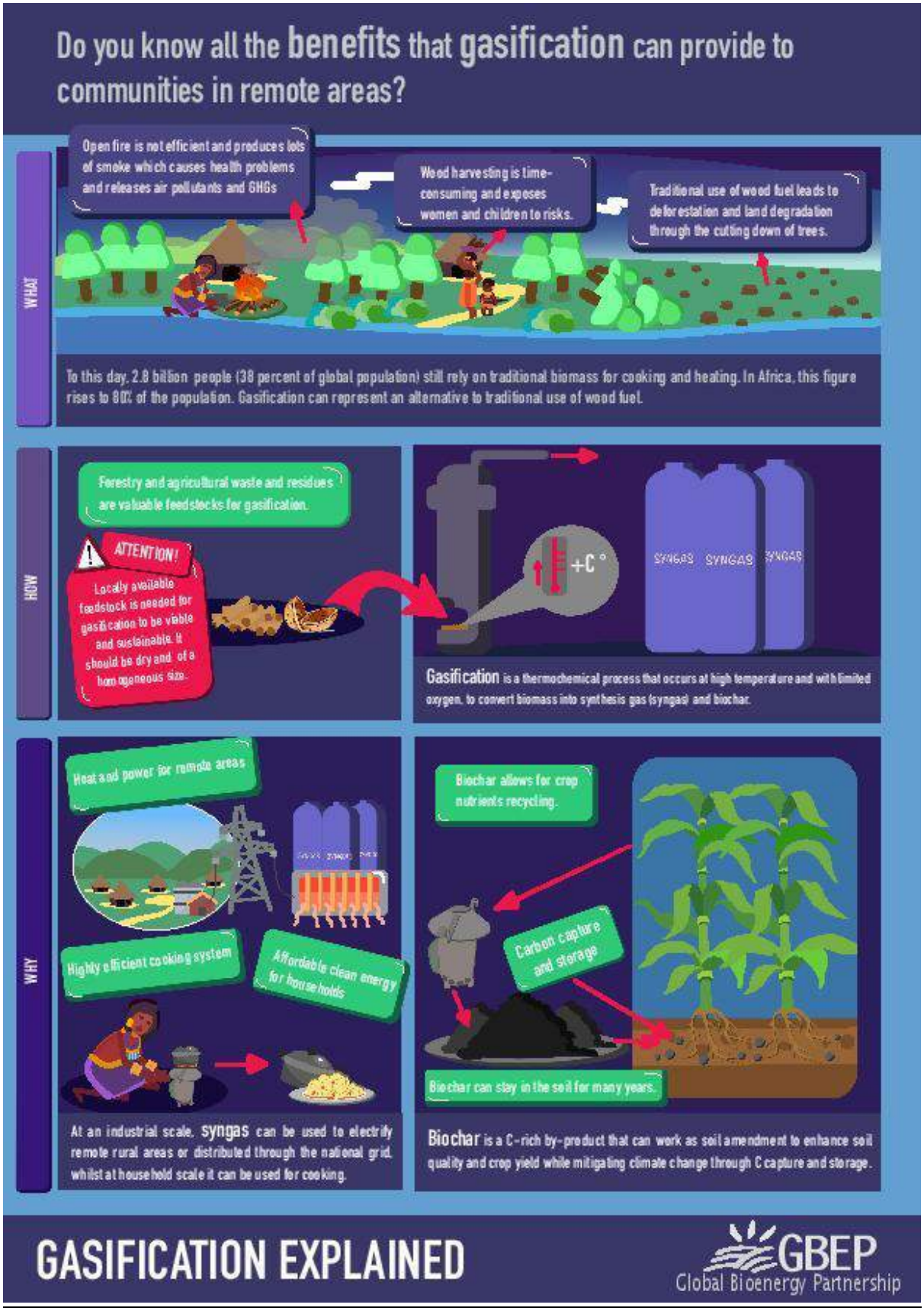


Ethanol Pathway (the case of Sugar Cane)

Description (text to be included in the infographic)	Graphic Presentation
1. Ethanol can be produced from various types of feedstock, as long as they contain starch or sugar. Typical biomass from ethanol production are sugarcane, maize and cassava.	Sugarcane, maize and cassava plants.
2. Sugarcane is harvested and transported to the mill to be processed.	A graph of a sugarcane plantation along with a tractor to highlight the harvesting process.
3. Once in the mill, sugar cane is washed to remove any debris.	A graph with a conveyor belt with cleaning equipment will be displayed.
4. The clean sugar cane is then ground to extract the juice. This juice is used to make sugar. The **residue** that remains is called bagasse and can be used to produce additional energy, usually power!	It will be presented the graph of a little grinder, highlighting the two outputs, juice and bagasse.
5. The sugar solution (both from the juice and the bagasse) is then fermented (a biochemical process) using yeast to produce alcohol.	An industrial graph containing a graphic representation of the whole ethanol production process.
6. After fermentation, a process called distillation is needed to get a pure alcohol output. This alcohol is called **ethanol**. The by-product of this process is called **vinasse** and can be used as an organic fertilizer for the sugar cane or other crops!	A distillation tower and an agricultural field with a truck to emphasise the use of the vinasse.
7. There are many possible uses for ethanol: it can be used for cooking, heating, to produce power or even as a **fuel** for cars, thus replacing the use of gasoline!	Cars, buses, cook stoves and an arrow pointing down into a fossil fuel dispenser, in order to represent its reduction.
8. **Hydrous ethanol** (92 %) is used directly in "special cars" such as E100 vehicles and flex-fuel vehicles; whilst anhydrous ethanol is blended with gasoline to	

make the E20–25 fuel, that can be used in traditional vehicles	

Gasification Pathway



Biodiesel Pathway (the case of soybean)

Description	Graphic Presentation
Oilseeds (e.g. soybeans) are harvested and transported to the industrial plant.	
Once in the industrial plant, soy oil is extracted from the seeds. Part of it can be used for cooking but it can also be used to produce biodiesel. Biodiesel is an alternative to existing fossil fuel, but it comes from a renewable source!	
In order to obtain biodiesel, the refined oil is mixed with alcohol and *esterification* occurs to produce biodiesel. Glycerine – used to make soap – is produced as a *by-product*.	
Low percentages of biodiesel are blended with diesel and used as fuel in cars, buses and trucks, thus partially replacing the use of fossil fuels.	

Section D: Bioenergy for a sustainable world

What are some of the advantages of bioenergy?

- It is constant and storable (we can store it, for example, by making a wood stack!)
- We can produce it even if there is not much sun (needed for solar) or wind (needed for wind power) or water (needed for hydropower)
- It usually produces less greenhouse gases than using fossil fuels
- It can be produced from organic wastes and residues that otherwise would be unused and contaminate the environment through their natural decay

However, we have to be careful that the biomass that we use for our energy is produced and used *sustainably*! That means that we have to observe, evaluate and manage the impacts of bioenergy on the environment, on the society and on the economy. For example, to be able to harvest it cheaply, without causing damage to the environment or affecting people's health and *livelihoods*.

Bioenergy and the fight against climate change

In 2015, 196 countries around the world came together to develop the Paris Agreement, which is a dedication towards combating climate change and adapting to its effects. The main aim is to keep a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels. This is an ambitious but necessary target to ensure that dangerous climate impacts are limited. It requires the reduction of emissions of GHGs and an increase in 'carbon sinks' that can remove carbon dioxide from the atmosphere.

Unfortunately, it appears that we are currently not on track to meet this target unless we take drastic action. GHG emissions continue to rise and carbon sinks, such as forests, continue to be reduced. So, what do we have to do to turn it around?

Because energy makes up a big part of GHG emissions (about two thirds of global greenhouse gas emissions are linked to burning fossil fuels for energy), it is an area where we can do a lot. We need to increase the efficiency of energy production and increase the use of renewable energy technologies.

International organizations agree that bioenergy is extremely important for meeting the goals of the Paris Agreement. Not only will we need to scale up the use of 'mature' bioenergy technologies but we will also need to work fast to deploy new bioenergy technologies as well. However, we always need to consider the other impacts of bioenergy on people and the environment (its sustainability), as we will see in this Section…

If you are interested in finding out more about climate change, why not complete the YUNGA Climate Change Challenge Badge! You can also find out about the ways bioenergy can help to tackle climate change in the IEA 'Technology Roadmap: Delivering Sustainable Bioenergy', where you can also find out more about other sustainability considerations that we will look at in this Section.

There are many considerations that affect the sustainability of bioenergy, and we have already mentioned some in previous sections. Usually, these are split up People (social), Planet (environmental) and Profit (economic) aspects. We saw in Section B that there is a 'food vs. fuel'

debate that discusses the impacts of bioenergy on food security. Some other considerations to think about are the 3 Ps:

- **PLANET** – Environmental considerations
    - Bioenergy production can have an impact on **greenhouse gas emissions** and on emissions of other pollutants when it replaces other types of energy (e.g. fossil fuels)
    - The production of bioenergy may have impacts on the **soil or water quality** of an area. This could be negative (e.g. if the production of bioenergy causes contamination) or it can be positive (e.g. if the biomass used is a waste and so contamination of the environment is avoided or if the by-products of the bioenergy process can be used to fertilise the soil).
    - When biomass for energy is grown on land that was previously natural vegetation or used for a different purpose, this can have negative environmental impacts, such as **deforestation** and **loss of biodiversity.**
- **PEOPLE** – Social considerations
    - Some bioenergy is produced from biomass that comes from food crops or it is grown on land that could be used for food. It is important to ensure that using this biomass for energy does not impact people's **food security**.
    - **Access to land, water and other natural resources** needs to be taken into consideration where biomass is grown or harvested.
    - **Labour conditions** and also **human health and safety** at work are also considerations. This can be positive where the bioenergy sector improves conditions for workers or can be negative when harvesting of biomass or converting biomass into bioenergy are potentially unsafe activities.
    - **Rural and social development** should also be considered. The bioenergy value chain can have an impact on people's livelihoods – it may increase **jobs** available or improve **wages** for workers, and it may lead to more **skilled jobs** as workers gain **training** in bioenergy.
    - Bioenergy can have a positive impact on people's **access to energy**, for example in remote areas where the national electricity grid is not available.
- **PROFIT** – Economic considerations
    - We need to ensure the **availability of adequate resources** for producing bioenergy in a particular location and that they are used **efficiently**.
    - We need to be able to ensure *energy security*. Therefore, that there is sufficient **infrastructure** for the supply of bioenergy and that **capacity** of bioenergy production can meet demands.
    - Bioenergy needs to be economically sustainable and **competitive with other energy options**.
    - For bioenergy to be produced sustainably, there needs to be access to adequate **technology and technological capabilities**.

As you can see, there are lots of things to consider and it can be complicated because some impacts will be negative and some will be positive; this is what we call *trade-offs*.

One way of analysing and quantifying all of these sustainability aspects is to use *indicators*. In a specific context, indicators can show us which aspects are positive and which aspects are negative, and also

how they change over time. Indicators can also help us decide which type of energy is the most sustainable; it can help us make choices between different energy sources and different conversion technologies.

The most widely recognised set of indicators to assess the sustainability of bioenergy were devised by the Global Bioenergy Partnership (GBEP) in 2011 and can be seen below.

Environmental	Social	Economic
1. GHG emissions	9. Land tenure	17. Productivity
2. Soil quality	10. Food security	18. Net energy balance
3. Harvesting of wood resources	11. Change in income	19. Gross value added
4. Emissions of air pollutants	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training
6. Water quality	14. Access to modern energy services	22. Energy diversity
7. Biodiversity	15. Disease attributable to indoor smoke	23. Infrastructure and logistics
8. Land use and land-use change	16. Injuries at work	24. Capacity and flexibility of use

Global Bioenergy Partnership Sustainability Indicators for Bioenergy

One of the best ways to ensure the sustainability of biomass for energy is to use residues or wastes that are not needed for other purposes (although not always – remember that sometimes residues are used for other things!). That way, not only are we producing energy that improves people's lives, we are also reusing wastes that would otherwise contaminate the environment – it's a win-win! This process of reusing wastes is called the *circular economy*.

Section E: Take Action

Actions for governments and decision makers

It is important to ensure that decision-makers are promoting *sustainable* bioenergy and taking into consideration all of the different positive and negative factors and trade-offs with other energy sources. Decision-makers can do this at different levels:

Global level

At a global level, international organisations can promote collaboration and information sharing to ensure all countries have access to up-to-date information and technologies.

International targets are also important for ensuring that all countries are working towards the same goal and to monitor progress towards that goal.

Bioenergy and international targets

Climate change

As we have mentioned in previous sections, bioenergy can have a positive impact on climate change (although we have also seen how this is not always the case) by reducing the greenhouse gas emissions compared with alternative energy such as fossil fuels. This means that it can be deployed by countries to reduce their emissions and help them meet their internationally-agreed targets for *climate change mitigation*. Countries have drawn up plans on how they will reduce their emissions in order to comply with the Paris Agreement; these plans are called Nationally Determined Contributions (or NDCs) and many of them include bioenergy.

Sustainable Development

Bioenergy can also form part of each country's *sustainable development* agenda and help them meet the targets of the Sustainable Development Goals (or SDGs). In particular, bioenergy can be important for SDG7 on ensuring access to affordable, reliable, sustainable and modern energy. As we have seen, bioenergy can be a good *off-grid* solution for remote rural communities who do not have access to electricity.

Regional level

Some regions of the world have policies on bioenergy (or renewable energy more generally). These can help to promote bioenergy through incentives (such as subsidies).

Examples of regional policies

Economic Community of West African States (ECOWAS) Regional Bioenergy Strategy

Adopted by the ECOWAS Ministers of Energy in 2012, the ECOWAS Bioenergy Strategy aims to increase food and energy security in the ECOWAS Region though sustainable production and utilization of bioenergy resources.

European Union: Renewable Energy Directive

The Renewable Energy Directive (RED) is the EU policy for the production and promotion of energy from renewable sources in the EU so that it can fulfil its greenhouse gas emission reduction targets. The RED was revised in 2018 and the REDII has a binding renewable energy target for the EU for 2030 of at least 32 percent. In terms of bioenergy, the REDII sets out biofuels sustainability criteria for all biofuels produced or consumed in the EU to ensure that they are produced in a sustainable and environmentally friendly manner.

National level

Many national governments have policies to promote the use of bioenergy. One example are biofuel mandates.

Biofuel mandates

Biofuel mandates are government policies, programs or actions that promote the use of biofuels. They set targets for a certain percentage of biofuels blended into normal fossil fuels (such as gasoline and diesel) and attempt to achieve this by providing incentives (e.g. subsidies, regulations, laws, feed-in tariffs).

Mandates are expected to raise the level of bioenergy production and consumption above levels that would not have been supported by a free market.

Brazil is a country with a strong biofuel mandate. The legislation states a mandatory blending of up to 27% of ethanol in gasoline.

However, it is important that policies promote only sustainable bioenergy. We can work towards this by using national-level indicators to evaluate and monitor the national bioenergy production and use (e.g. GBEP Sustainability Indicators) and use the results of evaluations to form sound policies that promote sustainable forms of bioenergy.

One problem with increasing bioenergy (and renewable energy in general) at the national level is that is struggles to be competitive with fossil fuels, which generally cost less. There are a few ways to overcome this:

- **Remove subsidies on fossil fuels** – this is the most direct way to increase the price of fossil fuels compared with renewable energy. However, we need to be careful that increases in prices of energy do not negatively impact poor people living in the country, who may no longer be able to afford energy.
- **Subsidies for renewable energy** – this means that the government pays a part of the cost of producing the renewable energy, thus lowering the price to consumers. Some examples of these policies are:
    - *Feed-in tariffs* (FITs) – a feed-in tariff promotes renewable energy production by promising a guaranteed price for the energy produced that is usually higher than the market value. They reduce risks to investors and so increase development of renewable energy projects.
    - Tax exemptions – governments can decide to lower or eliminate tax on renewable energy or the equipment needed to produce it. This reduces the overall cost of production and makes it more profitable.

Project/plant level

At the plant level, certification schemes can help understand which bioenergy production is sustainable and create a market for it. To be certified, a certain production pathway has to pass a number of principles (for example, impacts on the environment and local communities) all the way from feedstock production to biomass production and trade.

In some cases, certification is required to be able to qualify for a certain market or for specific incentives. For example, in the European Union, bioenergy production has to be certified by a recognised certification scheme to show that it complies with the region's sustainability criteria.

International Organisations and Initiatives

There are a number of international organizations and initiatives that seek to promote renewable energy and bioenergy more specifically.

biofuture platform Kickstarting a global, advanced bioeconomy	The Biofuture Platform is a 20-country effort to promote an advanced low carbon bioeconomy that is sustainable, innovative and scalable.
CLEAN COOKING ALLIANCE	The Clean Cooking Alliance works with a global network of partners to build an inclusive industry that makes clean cooking accessible to the three billion people who live each day without it.
Food and Agriculture Organization of the United Nations	The Food and Agriculture Organisation (FAO)'s work on energy involves enhancing knowledge and supporting countries to move towards using energy-smart agrifood systems. FAO, in collaboration with partners, has developed the FAO Support Package to Decision-Making for Sustainable Bioenergy.
GBEP Global Bioenergy Partnership	Global Bioenergy Partnership (GBEP) brings together public, private and civil society stakeholders in a joint commitment to promote bioenergy for sustainable development.
IEA Bioenergy Technology Collaboration Programme	IEA Bioenergy is an organisation set up in 1978 by the International Energy Agency (IEA) with the aim of improving cooperation and information exchange between countries that have national programmes in bioenergy research, development and deployment.
IRENA International Renewable Energy Agency	The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy.
REN21 Renewable Energy Policy Network for the 21st Century	REN21 is a global renewable energy community of actors from science, governments, NGOs and industry. They provide up-to-date and peer-reviewed facts, figures and analysis of global developments in technology, policies and markets, with the goal to enable decision-makers to make the shift to renewable energy.
RES4AFRICA RENEWABLE ENERGY SOLUTIONS FOR AFRICA FOUNDATION	RES4Africa's mission is to create an enabling environment for renewable energy investments in African countries to meet local energy needs for sustainable growth.

	As a private sector and member-driven organization, RES4Africa acts as a bridge between members and partners to exchange perspectives, expertise and initiatives.
RSB Roundtable on Sustainable Biomaterials www.rsb.org	The Roundtable on Sustainable Biomaterials (RSB) is a global, multi-stakeholder independent organization that drives the development of a new world bioeconomy through sustainability solutions, certification, and collaborative partnerships.
SUSTAINABLE ENERGY FOR ALL	Sustainable Energy for All (SEforALL) is an international organization working with leaders in government, the private sector and civil society to drive further, faster action toward achievement of Sustainable Development Goal 7 (SDG7), which calls for universal access to sustainable energy by 2030, and the Paris Agreement, which calls for reducing greenhouse gas emissions to limit climate warming to below 2° Celsius.
WORLD BIOENERGY ASSOCIATION	The World Bioenergy Association (WBA) is the global organization dedicated to supporting and representing the wide range of actors in the bioenergy sector. It aims to promote the increasing utilization of bioenergy globally in an efficient and sustainable way and to support the business environment for the bioenergy companies.
WCRE World Council for Renewable Energy	The World Council for Renewable Energy (WCRE) is a non-profit and non-governmental globally working organisation that is focused on developing policies and strategies for Renewable Energy.

Actions for YOU!

There are many ways that we can integrate the use of bioenergy, along with other renewable energies, into our daily lives, thus reducing our *carbon footprint* and our environmental impact. You can find out more about your carbon footprint, and other ideas for how to make a difference, in the main Energy Challenge Badge.

Here are some more ideas you could think about:

Using biofuels

Most vehicle engines are able to use petrol and diesel that is blended with small amounts of ethanol and biodiesel, respectively. Blending biofuels with the fossil fuels can have air quality benefits and reduce greenhouse gas emissions ultimately helping the environment. Why don't you find out whether there are blended fuels in your country? Your family could even buy a flex-fuel car to be able to use pure ethanol as well as petrol, thus reducing your carbon footprint even further. (But even better to use your bicycle instead!)

Making biogas at home

One great way to know that the energy that you are using is produced sustainably is to make it yourself at home! Producing biogas at home can be quite simple – you just need to 'feed' your biodigester with household waste (such as food scraps or even toilet waste) or farm waste (such as manure).

If you are particularly adventurous then you could try making a biodigester yourself (but make sure that you check with the adults in your family first!!). Either that or there are many companies that sell small biodigesters that are quick and easy to install[1]. Not only will you produce compost for the garden but you will also produce biogas for cooking.

Switch to sustainably-sourced woodfuel or more efficient technologies

If you use woodfuel (e.g. wood or charcoal) in your house for cooking or heating, think about whether the woodfuel is sustainably sourced and whether the technology used to produce the energy is efficient. It might be possible to switch to a more sustainable alternative or improve the efficiency of burning the woodfuel so that less is used – this is good for the environment but also reduces the cost of fuel!

[1] The HomeBiogas technology is one example. You can find out how it works by watching this video: https://www.youtube.com/watch?v=m0kvJmsughQ

Activities

Section A

Do one of the two compulsory activities below:

A1: Energy through the ages

Age level: 1, 2 and 3

Research the history of energy use in your country. You can go back as far as human history! Draw a timeline to show the main types of energy used throughout history, with pictures for each type of energy. Has there been an energy transition from traditional bioenergy to modern bioenergy or fossil fuels? If so, when did this happen?

A2: How is biomass produced?

Age level: 1, 2 and 3

How do plants grow and produce biomass? We are going to find out!

Take 4 plant pots (you can use the bottom part of bottles of milk cartons, cleaned and with holes pierced in the bottom – ask someone to help you!). Fill all four pots with soil and then plant a seed in each one. Place the first two pots in the sun and the second two pots in a closed dark space. Keep the pots in the same place for two weeks, watering them each day as necessary and checking how much they have grown. At the end of the two weeks, bring all the plants together and notice the differences in growth. Which plants are taller and why? Take the plants out of the soil and weigh them on accurate scales. Which plants produced the most biomass?

Choose (at least) one additional activity from the list below:

A3: Biomass song

Age level: 1, 2 and 3

Write a song about how the sun's energy gets converted into bioenergy. You can sing about all the different types of energy and biomass. Make sure it's *energetic*!

A4: Bioenergy acrostic

Age level: 1, 2 and 3

Make up an acrostic for some of the words you have learnt in Section A, for example BIOENERGY, BIOFUEL, FEEDSTOCK, etc. Make your acrostics fun but also try to link them to the topic of energy. Here's an example to get you thinking:

Richard **E**ats **N**othing, **E**ats **W**afers **A**nd **B**ears **L**ack of **E**nergy

A5: Investigating traditional bioenergy

Age level: 2 and 3

38 percent of the global population relies on traditional bioenergy. Investigate some of the problems with this traditional use of biomass – not just the impacts on the environment but also on people's health and livelihoods. Make a short news video (or written article for a newspaper) to show these impacts. Maybe you can even include some of the ways in which people are trying to overcome these

problems. Share the video with people outside of your group to get them thinking about these problems.

A6: My daily energy needs

Age level: 2 and 3

Think about all the things you do each day and whether they require energy. Make a list of the activities that you do each day that need energy and what kind of energy is used (electricity, petrol, natural gas, wood, etc.). Do any of these activities require bioenergy? If not, how could you switch to using bioenergy? How many of these activities require electricity? Think about how your life would be different if you didn't have access to electricity.

Do any other activity approved by your teacher or leader.

Age level: 1, 2 and 3

Section B

Do one of the two compulsory activities below:

B1: Explore your neighbourhood

Age level: 1, 2 and 3

Ask an adult to accompany you for a walk around your neighbourhood. Your mission is to identify different types of biomass and collect some of them. (Place them in a plastic bag and clean them when back home!) Once you are done cleaning them, make a collage using your collection. Let your creativity flow to create cool designs using the different shapes and colours!

B2: What is it used for?

Age level: 1, 2 and 3

Take a piece of paper and draw a picture of an agricultural crop in the centre. Draw a spider diagram around the picture to show all of the things that can be produced from that crop – food for humans, feed for animals, bioenergy and other products. What would happen if more bioenergy was produced from that crop?

Choose (at least) one additional activity from the list below:

B3: Experimenting with oils

Age level: 1, 2 and 3

In this experiment you will investigate the properties of different oils and why they are used for different purposed. You will need two toy metal cars, vegetable oil (such as sunflower or rapeseed oil), car oil and a ramp. Put the vegetable oil on the wheels of one of the cars and the car oil on the wheels of the other car. Then place each car on the ramp one at a time and let it roll down, noting down exactly how far it goes. Keep the cars safe in a box and repeat the experiment again after a week. Which car went further? If you were a racing driver which oil would you use?

B4: Classifying biomass residues

Age level: 2 and 3

There are many different types of residues and wastes. For each one, draw a picture on a small piece of paper or card, and write the name. For example, for cow manure you could draw a cow. In your group, think about how each of these residues fits in to the four categories of biomass residues explained in Section B: urban waste; animal waste; agricultural residues; and forest residues. You can then use these cards to play a game where the objective is to have three cards that come from the same residue category.

Cow manure

How to play: Each player takes three cards from pile. One player draws a card from the pile, and either discards it or exchanges it with a card from his hand, passing it to the player on his left. Subsequent players do the same, in rotation, except for the last player, who discards his card to the bottom of the pile. As soon as a player has a triplet, he shouts 'BIOMASS' and is given a letter 'B' (you should all check together that the cards come from the same category!). The first person to spell BIOMASS wins the game.

B5: Where in the world

Age level: 2 and 3

What types of biomass does your country have? Draw or print a map of your country. Design a symbol for each type of biomass, for example, wood energy could be a stack of logs. Then add your symbols onto the map in the locations where the biomass is produced. Do you notice any patterns? Does it correspond with the climate or geography of your country?

B6: Food vs. fuel

Age level: 3

Read the box on the 'food vs. fuel' debate in Section B. You can also do further research to understand the arguments in more depth. Pick a country of your choice and investigate the potential for using biomass for biofuels in that country – are they already making biofuels and if so what from? Have there been questions about food security? Write a newspaper article detailing your findings and making recommendations.

Do any other activity approved by your teacher or leader.

Age level: 1, 2 and 3

Section C

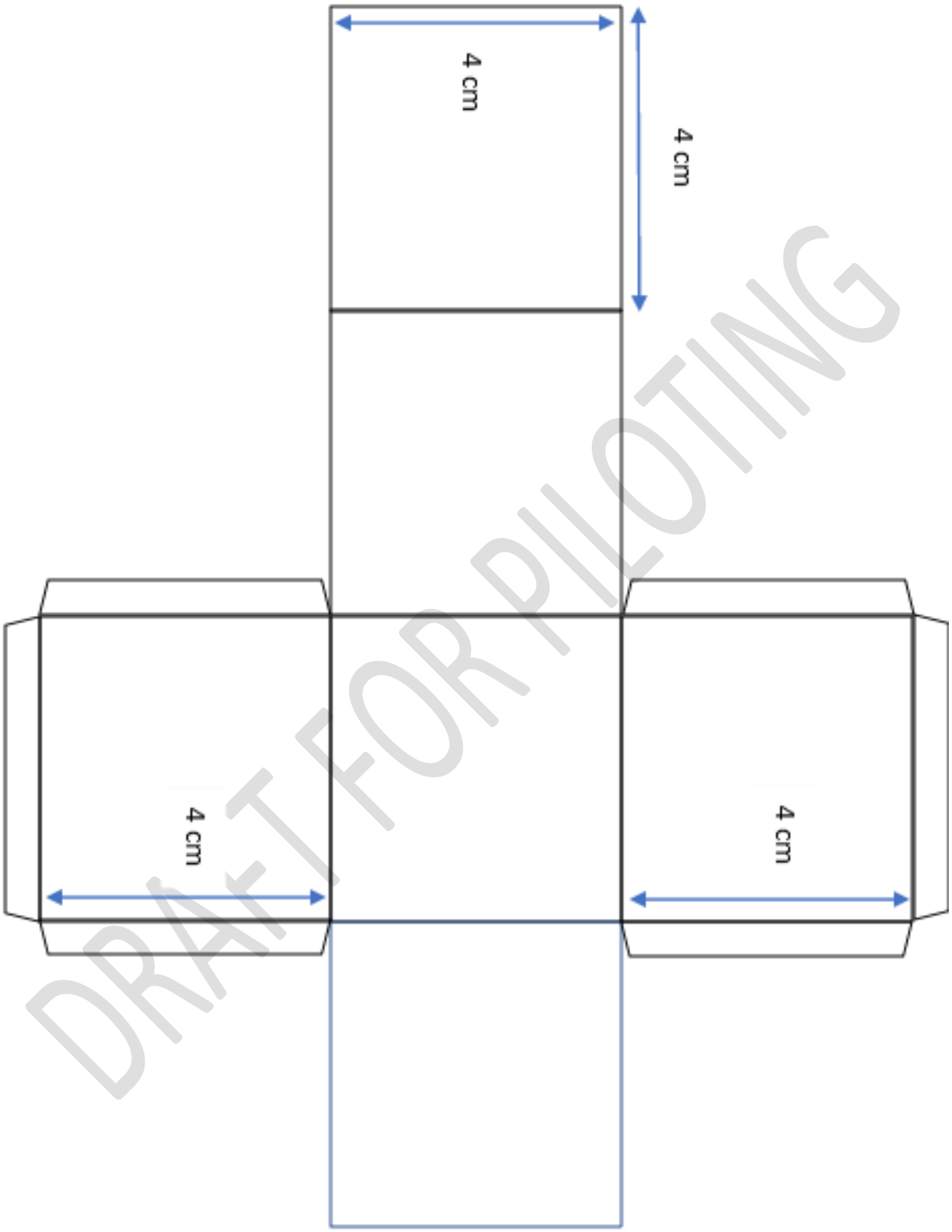
Do one of the two compulsory activities below:

C1: Bioenergy dice

Age level: 1, 2 and 3

Preparation: In the following page you can find a dice blueprint you can use to make your personalized dice. For each of the 6 sides of the dice, draw a bioenergy pathway.

How to play: For each round of the game, a judge must be chosen. Each player throws the bioenergy dice and gets a bioenergy pathway. Each player has 2 minutes to explain everything he/she knows about the pathway and the judge should choose a winner for each round. The winner gets one bioenergy point. When the game is over, the player with most bioenergy points wins the game.



C2: Making energy

Age level: 2 and 3

Preparation: Have a look at the cards needed for Activity B5 – you will need them for this activity! These are the biomass cards. Think of all the processes that can be used to transform these wastes and residues into bioenergy. Draw or describe each process on a card and put each card face down in the middle of the table; these are the 'process' cards.

How to play: Deal out all the biomass cards to the players. Turn over the first process card and go around the circle taking it in turns to put biomass cards on top of the process card that can be used to transform that biomass into bioenergy. The first person who cannot place a biomass card must pick up all the cards and uncover a new process card. The first person to place all their biomass cards is the winner.

Choose (at least) one additional activity from the list below:

C3: Pass the process

Age level: 1 and 2

Get your group into a circle and give one person a ball or beanbag. The person with the ball says out loud the name of a biomass (for example, animal manure) and throws the ball to someone else in the circle, who has to say a type of bioenergy that can be produced from that biomass (in this case, biogas). If the person cannot think of anything, they are eliminated from the circle and the game continues until there is one winner.

C4: Biogas Experiment

Age level: 1, 2 and 3
Source: https://www.clearwaycommunitysolar.com/blog/science-center-home-experiments-for-kids/creating-biogas-from-your-pantry/
In this experiment, we will create our own biogas using household food items. The materials you will need to complete this experiment are:

- Basic Kitchen Scale
- 5 Empty plastic bottles
- Duck or packing tape
- Marker
- Pouring Funnel
- Small blender or food processor
- 5 different types of food or food waste (e.g. orange peel, banana, etc.)
- (1 cup) Water

Prepare your bottles for the pureed food waste. Wash and label your plastic bottles with the food items, and mark a water line ¾ of the way up each bottle.

Gather all of your food/organic matter and puree each of the food items separately in the blender or food processor, and then weigh out each of your food items so that they are all the same weight in each bottle. (For example, if you place 60 grams of onion into your first bottle, you must be consistent

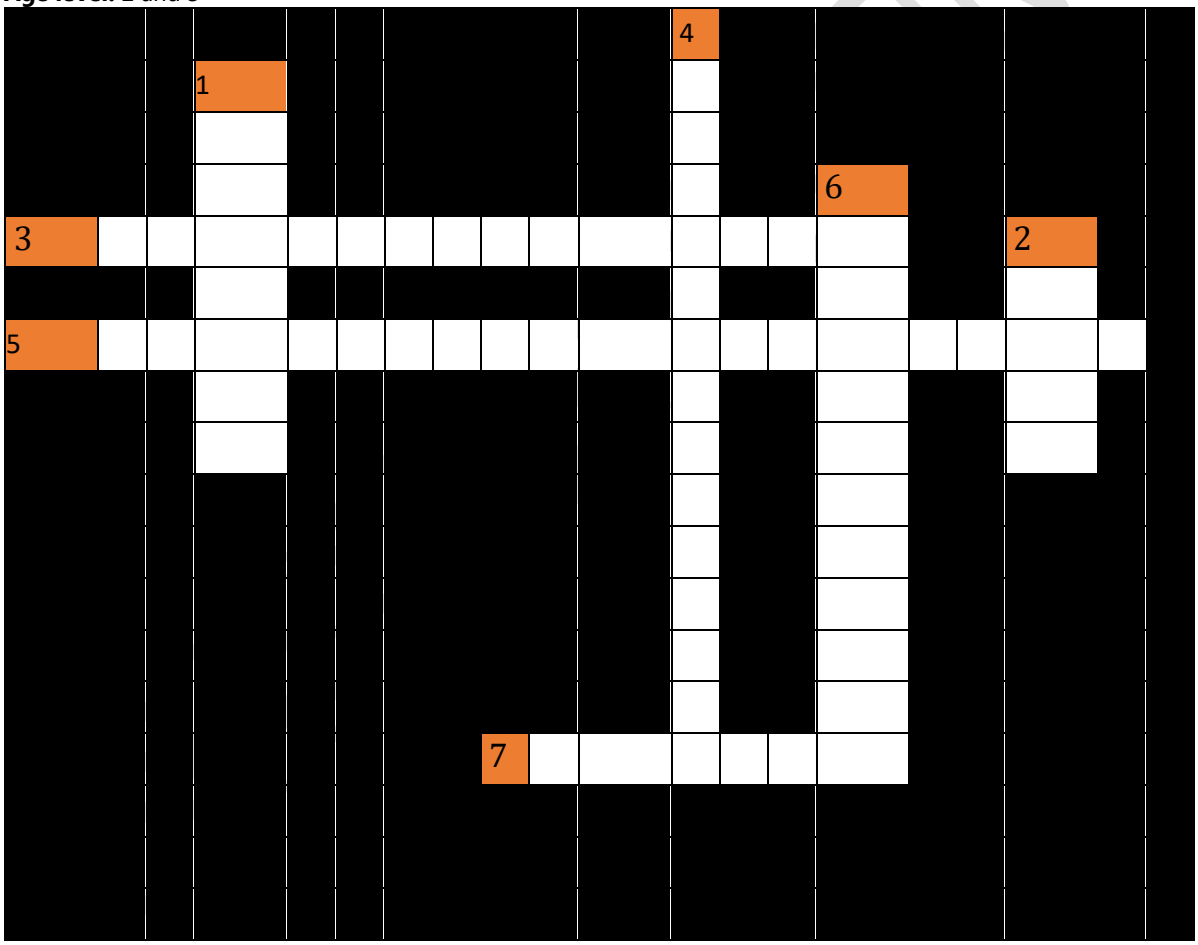
and do the same weight for each of the other food items.) After weighing, place the food into the correct labelled bottle and fill each with water up to the water line; you may need a funnel.

Place a balloon on the top of each bottle and secure it with tape so that it is airtight. Place all of the bottles in the same place and observe for the next week. When you are tracking the balloons over the next week, think about the following:

- What did you notice today about the bottles?
- What did you notice about the balloons and food waste?
- Based on what you have learned. What do you think is happening inside the plastic bottles? And the balloons?

C5: Crossword

Age level: 2 and 3[2]



1. A living material that comes from plants and animals, such as wood, dried vegetation, cow manure and food scraps. It contains stored energy from the sun.
2. The single most important source of renewable energy, providing around 6 percent of the global total energy supply.
3. Process in which plants absorb energy from the sun.
4. The biochemical process used to produce biodiesel.
5. Is a biochemical process that involves digesting without oxygen.
6. The word we use to describe bioenergy production that can be maintained over time.

[2] ANSWERS: 1 Biomass; 2 Wood; 3 Photosynthesis; 4 Esterification; 5 Anaerobic Digestion; 6 Sustainable; 7 Manure

7. The waste produced by animals used for producing biogas.

C6: Bioenergy pathway comic

Age level: 2 and 3

Choose one type of bioenergy pathway that exists in your country (for example, sugarcane-based ethanol, or wood energy for industry). Identify all the steps along the pathway, starting from the raw biomass and ending with the use of the energy. Draw a comic strip showing each stage in the process and explaining what is happening in each picture.

Do any other activity approved by your teacher or leader.

Age level: 1, 2 and 3

Section D

Do one of the two compulsory activities below:

D1: Two Worlds

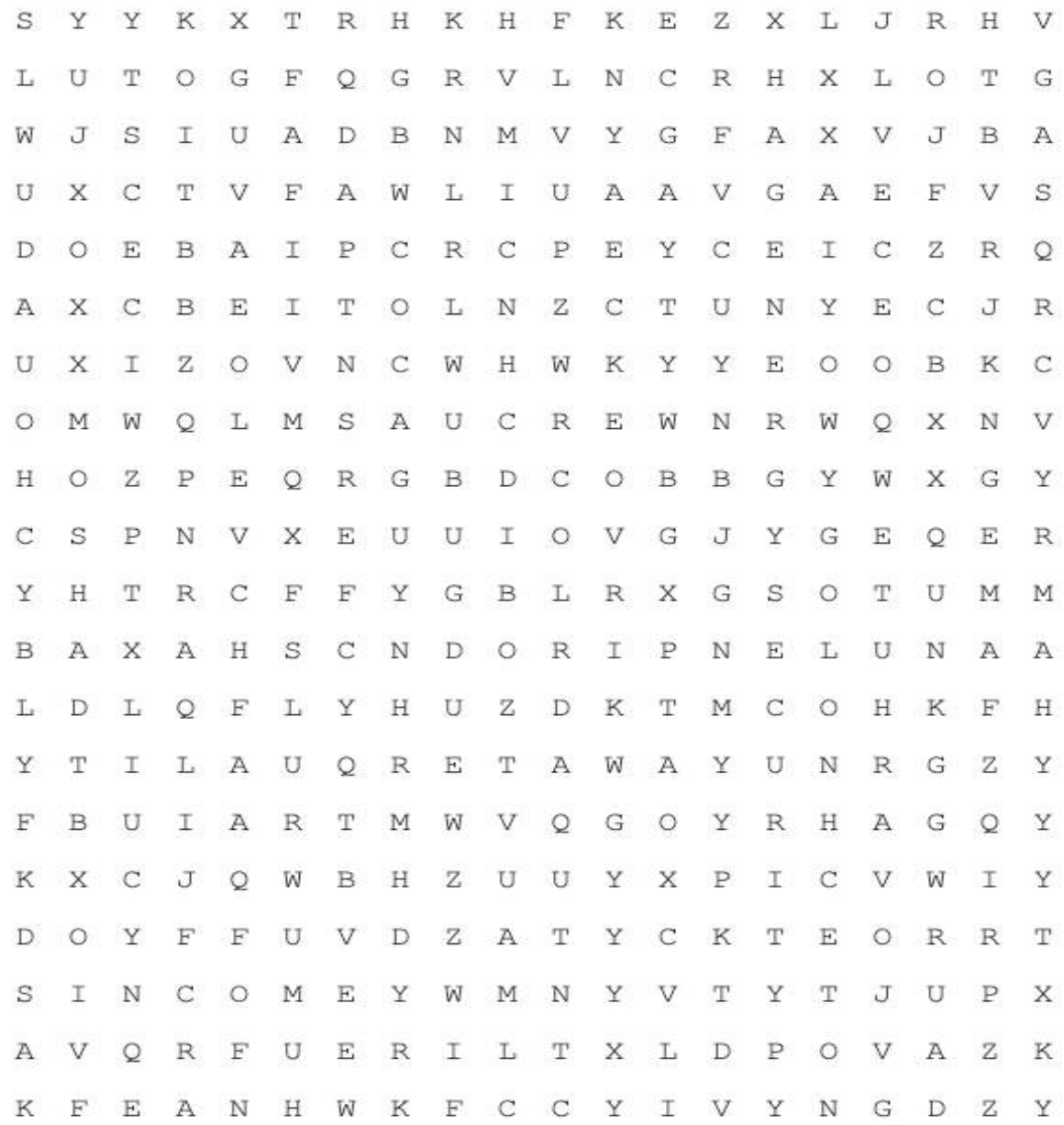
Age level: 1, 2 and 3

Take a large piece of paper and divide it in half. You are going to draw two worlds: on one side of the paper draw a bioenergy plant that is unsustainable and on the other side draw one that is sustainable. You can show all the different processes – where the biomass comes from, local communities, air and water quality, animals and plants. Which world would you like to live in?

D2: Sustainability Word Search

Age level: 1, 2 and 3

Look for some key terminologies from Chapter D. (If you need a hint, take a look below but try to find as many words as possible before you consult to the hint table!)



S Y Y K X T R H K H F K E Z X L J R H V
L U T O G F Q G R V L N C R H X L O T G
W J S I U A D B N M V Y G F A X V J B A
U X C T V F A W L I U A A V G A E F V S
D O E B A I P C R C P E Y C E I C Z R Q
A X C B E I T O L N Z C T U N Y E C J R
U X I Z O V N C W H W K Y Y E O O B K C
O M W Q L M S A U C R E W N R W Q X N V
H O Z P E Q R G B D C O B B G Y W X G Y
C S P N V X E U U I O V G J Y G E Q E R
Y H T R C F F Y G B L R X G S O T U M M
B A X A H S C N D O R I P N E L U N A A
L D L Q F L Y H U Z D K T M C O H K F H
Y T I L A U Q R E T A W A Y U N R G Z Y
F B U I A R T M W V Q G O Y R H A G Q Y
K X C J Q W B H Z U U Y X P I C V W I Y
D O Y F F U V D Z A T Y C K T E O R R T
S I N C O M E Y W M N Y V T Y T J U P X
A V Q R F U E R I L T X L D P O V A Z K
K F E A N H W K F C C Y I V Y N G D Z Y

ENERGYSECURITY
JOBS
SUSTAINABILITY
ENVIRONMENTAL
PRODUCTIVITY
TECHNOLOGY
INCOME
SOCIAL
WATERQUALITY

Choose (at least) one additional activity from the list below:

D3: Field visit

Age level: 1, 2 and 3

Are there any bioenergy plants in your local area? You can take a field visit to a nearby plant to see exactly how bioenergy is produced there! Before you go, write down some questions that you want to ask the plant manager about how they deal with sustainability issues. Here are some example questions to get you started:

- What biomass is used and where does it come from?

- How do you ensure the sustainability of biomass production, such as soil quality, and water quality and efficiency?
- Does the energy produced replace fossil fuels or traditional fuels?

D4: The circular economy

Age level: 1, 2 and 3

The circular economy is a way to improve the sustainability of our economy through the reuse and recycle of materials for as long as possible so as to not create wastes that lead to pollution. Think of a production chain (for younger groups, the group leader may propose a chain), for example, the production of fruit juice, and list all of the 'wastes' along the chain. How we reuse those wastes to create the circular economy? Draw your circular economy showing all the links in the chain and how the wastes can be reused.

D5: Benefits of bioenergy

Age level: 2 and 3

Preparation: Think of all bioenergy pathways you remember; you can use those from Activity B3 and do some research to add extras. For each one, draw a small picture on a piece of card and write the name. Once finished you can start with the game.

How to play: The dealer will deal one card to each player along with a piece of paper. For each bioenergy pathway, the player should write as many benefits as possible, considering all the social, economic and environmental aspects. Failing to provide at least one benefit for each pillar implies the automatic disqualification of that participant. If the player has provided at least one benefit for each pillar, he/she should read all his/her benefits aloud, and all players discuss the benefits together to see if they agree. Once the round is finished, the player with the most benefits approved by the rest of players will gain one sustainability point. When the game is over, the player with the most sustainability points wins the game.

D6: Is it sustainable?

Age level: 2 and 3

Choose a bioenergy pathway. On your own, or in pairs, for each stage in the process, list the different sustainability considerations – environmental, social and economic. For example, for the raw biomass, you could ask: Is the biomass used a food crop? Are fertilisers needed to produce the biomass? How much does it cost to obtain the biomass?

After you have discussed each stage in the process, decide which sustainability considerations are the most important for the bioenergy pathway and which indicators you would need to use to monitor the sustainability of your pathway (you can use the GBEP Sustainability Indicators as a basis).

Do any other activity approved by your teacher or leader.

Age level: 1, 2 and 3

Section E

Do one of the two compulsory activities below:

E1: Helping people with energy

Age level: 1, 2 and 3

First, watch this video produced by the FAO: https://www.youtube.com/watch?v=ZdF57mAghBc

The video shows how energy is extremely important for people's lives. On a large piece of paper or a whiteboard, draw a table like the one below. Whilst you watch the video, take it in turns to write down all the ways that lack of modern energy can be bad for people's lives and how providing energy can help. For younger groups, you can draw a picture of one problem and one solution that you see in the video.

Problem caused by lack of energy	**How providing modern energy services can help**
e.g. burning wood in the house produces a lot of smoke	e.g. modern energy does not produce smoke and so people's health is improved

E2: Bioenergy in my community

Age level: 2 and 3

What is the potential for bioenergy in your community? What biomass could be used and how much is there? What could be the impact on the community and the environment of using biomass instead of other sources of energy? Draw up a proposal for using the biomass in your community for bioenergy that you could send to your local constituency. Make sure to include all the benefits that producing and using bioenergy could bring, and don't forget to show that you have also thought about the potential negative points and how to overcome them.

Choose (at least) one additional activity from the list below:

E3: Carbon footprint tree

Age level: 1

Draw and cut out some footprints (your group leader can also do this before the session). On each footprint write down one thing that you do that requires energy (e.g. turning on the light in the evening, watching the TV or charging your phone). How much energy is used and what effect does it have on your carbon footprint? Colour in each footprint based on the impact on your carbon footprint – very high-energy activities will be red (e.g. taking a plane) and low-energy activities will be green (e.g. riding a bicycle – it only requires your own energy!). Make a tree with your footprint leaves on the wall in your classroom.

E4: Trivia Overview

Age level: 2 and 3

Prepare some flashcards with as many questions and answers as you can find in the bioenergy supplement (write the question on one side and the answer on the other). You can play

a game in pairs or as a group, taking it in turns to ask each other trivia questions. When you answer correctly, you keep the card, otherwise the card goes back to the pile. The player with the most cards at the end of the game wins. After you have played in your group, why not play your trivia game with you family and friends to help them learn about bioenergy!

E5: Bioenergy targets

Age level: 2 and 3

Find out exactly how much energy is produced from biomass in your country. What is the percentage of the total energy consumption? Does your country have any targets to increase this percentage? Make a poster to show the change in bioenergy over time and the percentage of total energy consumption from bioenergy. How do you think your country could do more to promote bioenergy?

E6: Become renewable energy champions

Age level: 3

Investigate the energy consumption of your school or youth group. What energy is used and how much does it cost? Design a plan to include more renewable energy. This could range from changing energy providers that commit to certain renewable energy percentages or you could think about investment in solar panels or a biodigester. How much will each of these options cost? Make a proposal to your group leader or teachers detailing all of the renewable energy options and a cost comparison to convince them to invest in renewable energy. Include any incentives that they might be able to use, such as tax exemptions or Feed-in Tariffs. You might find that over a few years these renewables options will turn out to be cheaper and it will be very easy to convince them to switch to renewable energy!

Do any other activity approved by your teacher or leader.

Age level: 1, 2 and 3

Glossary

Advanced biofuels – include second- and third-generation biofuels. Can refer to: biofuels that are produced from specific feedstock; biofuels that are produced through specific technologies; specific types of new biofuels e.g. 'drop-in' fuels; biofuels that have high greenhouse gas emission savings compared with fossil fuels.

Agroforestry – a land use management system in which trees or shrubs are grown around or among crops or pastureland.

Algaculture – is a form of aquaculture involving the farming of species of algae.

Anaerobic digestion – the biological processes in which microorganisms break down biomass in the absence of oxygen.

Biochar – is a type of charcoal made from biomass via pyrolysis that is used as a soil amendment for both carbon sequestration and soil health benefits.

Bioenergy – a renewable energy made from materials derived from biological sources.

Biofuel – a fuel produced from biomass; it sometimes only refers to renewable fuels for transport.

Biogas – a mixture of gases (mostly methane and carbon dioxide) produced from the anaerobic digestion of biomass.

Biomass – plant or animal material that can be used as feedstock to produce bioenergy

By-product – a secondary product derived from a production process, manufacturing process or chemical reaction.

Carbon footprint – A carbon footprint is the greenhouse gas (GHG) emissions caused by an individual, event, organization, service, or product, over a specific time period.

Carbon neutral – a carbon-neutral fuel is an energy fuel or energy systems that has no net greenhouse gas emissions.

Carbon sequestration – the long-term removal or capture of carbon dioxide from the atmosphere to slow or reverse atmospheric CO_2 pollution and to mitigate or reverse global warming.

Chemical energy – the potential of a chemical substance to undergo a chemical reaction to transform into other substances.

Circular economy – an economic system aimed at eliminating waste and the continual use of resources.

Climate change mitigation – actions to limit the magnitude or rate of global warming and its related effects.

Closed carbon cycle – a system where the net carbon dioxide emissions are zero.

Combined Heat and Power (CHP) – the use of a heat engine or power station to generate electricity and useful heat at the same time.

Conventional biofuels – biofuels produced from food crops. Also known as first generation biofuels.

Deforestation – removal of a forest or stand of trees from land which is then converted to a non-forest use.

Drop-in fuels – biofuels that are chemically equivalent to the fossil fuel equivalent and so can be used in a conventional engine without the need for modification.

Energy security – the uninterrupted availability of energy sources at an affordable price.

Esterification – a chemical reaction between alcohols and carboxylic acids to make esters. It is the process used to make biodiesel.

Feed-in tariff – a policy tool designed to promote investment in renewable energy sources through providing a high, fixed price for renewable energy.

Feedstock – a renewable, biological material that can be used directly as a fuel, or converted to another form of fuel or energy product.

Fermentation – a biochemical process that extracts energy from carbohydrates in the absence of oxygen. It is one of the reactions used to produce ethanol.

First generation biofuels – see conventional biofuels.

Flex-fuel vehicles – an alternative fuel vehicle with an internal combustion engine designed to run on more than one fuel.

Food security – a measure of the availability of food and individuals' ability to access it.

Gasification – a reaction that occurs at high temperature with a controlled amount of oxygen and no burning that produces a mixture of gases called syngas (carbon monoxide, hydrogen and carbon dioxide) from biomass.

Indicator – a metric that helps measure the state of a certain variable.

Livelihood – means of securing the basic necessities (food, water, shelter and clothing) of life.

Modern bioenergy – biofuel produced and used with efficient technologies for modern applications, such as clean cooking, space heating, electricity generation, combined heat and power (CHP), and transport.

Mulching – A mulch is a layer of material applied to the surface of soil. Reasons for applying mulch include conservation of soil moisture, improving fertility and health of the soil, reducing weed growth, reducing soil erosion and enhancing the visual appeal of the area.

Off-grid – not connected to energy grid infrastructure such as national electricity or gas grid.

Photosynthesis – the process in plants and other organisms that converts light energy into chemical energy through the synthesis of carbon dioxide and water in sugars.

Productivity – efficiency of production, e.g. the output per unit of input.

Renewable energy – energy that is collected from renewable resources, which are naturally replenished on a human timescale

Sustainable development – is the concept of ensuring human development while simultaneously sustaining the ability of natural systems to provide the natural resources and ecosystem services on which the economy and society depends.

Syngas – a mixture of hydrogen, carbon monoxide, and very often some carbon dioxide produced from gasification.

Trade-off – a decision that involves diminishing one quantity in return for gains in other aspects (i.e. if one option increases, the other option must decrease).

Traditional bioenergy – refers to the inefficient combustion of biomass in such forms as wood, animal waste and traditional charcoal.

Woodfuel – fuel such as firewood, charcoal, chips, briquettes, pellets, and sawdust.

Yield – In agriculture, the yield (also known as "agricultural productivity") is a measurement of the amount of a crop grown per unit area of land.

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