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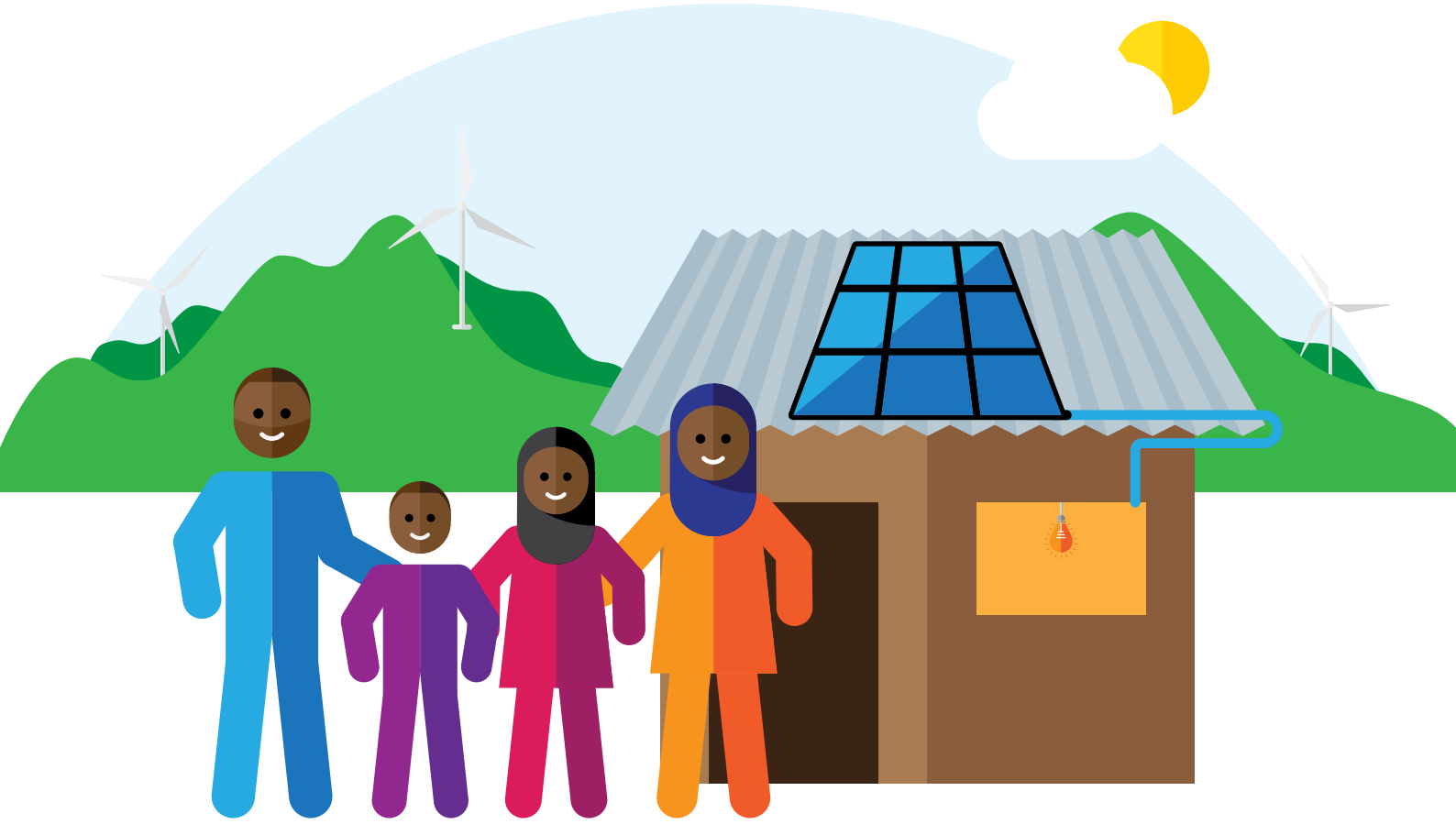


Teaching Guide 11

Energy

Healthy and Sustainable Schools Programme 2nd Edition

Preface

The Healthy and Sustainable Schools Programme is a result of Sazani Associates UK and Sazani Trust Zanzibar's ongoing partnership with the Ministry of Education to improve the quality of education and learning in Zanzibar.

The project is aligned with the Sustainable Development Goals and actively supports teachers and schools in achieving Global Education Target 4.7.

By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development (UNSD, 2021).

Focusing on the combined importance of key skills and healthy and sustainable life skills, we have revised and updated our series of fifteen Teaching Guides to support competency based curriculum linked learning.

The teaching materials are suitable for use in the last two years of primary across the transition to the first two years of secondary school.

There are fifteen Teaching Guides in this series, themed around topics that contribute to healthy and sustainable life styles within the context of Zanzibar, as follows:

1. Why we need to eat well
2. Getting enough food
3. Keeping food safe and clean
4. Population and health
5. Water
6. Sanitation and waste
7. Tourism
8. Biodiversity
9. Agriculture
10. Fisheries and marine resources
11. Energy
12. Land transport
13. Land use
14. Climate change
15. Participatory action learning

Each Teaching Guide is themed and contextualized to bring Zanzibar and contrasting localities into a classroom setting and to make learning engaging and relevant to local livelihoods. Activities are gender responsive, participatory and proven to support numeracy, literacy, English language and critical thinking.

For more information please visit our website **www.sazani.org**

Acknowledgements

This series of fifteen Teaching Guides has been adapted from Sazani Associates HSSP topic books by Rajab S. Ali, Safia M. Abdalla, Mwanawije M. Makame, Patrick Rutledge, Nicola Shone, Joshua Shawe and Rashid O. Shehe, with editorial review by Marilyn James and Dr Cathryn MacCallum. Graphic design and layout by Seven Six Design.

Contents

1 Introduction

The learning content and activities in this Teaching Guide have been designed to be easily integrated across the curriculum. Throughout the resource, knowledge, skills, attitudes, and values are interlinked and are built into all the topic areas addressed.

We have revised and updated our series of fifteen Teaching Guides to support competency-based, curriculum linked learning and development by focusing on the combined importance of key skills including numeracy, literacy, critical thinking and English language for healthy and sustainable lifestyles. The teaching materials are suitable for use in the last two years of primary across the transition to the first two years of secondary school.

There are different methods of displaying this information, through text, tables, diagrams, images and activities. Each activity includes icons to illustrate which curriculum area and which key skills are used as summarised in the tables below.

Key skills				
Numeracy 	Literacy 	Critical thinking 	English language 	Creativity 

Activity / STD V-VI	Maths	English	ICT	Civics	Geography	History	Science	Religion	Arabic
Electricity consumption		X	X	X	X	X	X	X	
BINGO game	X	X	X	X	X	X	X	X	X
Reducing energy consumption letter					X	X	X		
Energy saving charades			X		X		X		
Supply of energy pie chart				X	X	X	X	X	

Activity / Form 1-2	Maths	English	ICT	Civics	Geography	History	Biology	Chemistry	Physics	Religion	Arabic
Electricity consumption		X	X	X	X	X	X	X	X	X	
BINGO game	X	X	X	X	X	X	X	X	X	X	X
Reducing energy consumption letter				X	X		X				
Energy saving charades			X		X		X	X	X		
Supply of energy pie chart				X	X	X	X	X	X	X	

2 Topic overview

Key words

Non-renewable resources: also known as finite resources, non-renewable resources do not renew themselves at a sufficient rate for sustainable economic extraction in meaningful human time frame e.g. coal, petroleum, fuel wood.

Renewable resources: provide energy which can be replaced after use because they can replenish with the passage of time through naturally occurring processes e.g. hydroelectric power, tidal energy, solar energy, wind.

Energy-efficiency: simply means using less energy to perform the same task – that is, eliminating energy waste. Energy efficiency brings a variety of benefits: reducing greenhouse gas emissions, reducing demand for energy imports, and lowering our costs on a household and economy-wide level.

Photosynthesis: the process by which green plants and some other organisms use sunlight to synthesize nutrients from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a by-product.

If you live in a house with electricity and often travel by car or bus, consider yourself lucky. The energy from petroleum oil that we enjoy today only became readily available about 100 years ago. Will it last for another 100 years? As the world's population grows, more and more energy is needed, but who is using the most? In North America, the average person uses twice as much energy as the average person in Western Europe, 60 times more than the average South Asian, and 400 times more than the average Ethiopian.

The reasons for this significant difference in energy use:

- Many people in rich countries own cars that consume lots of petrol.
- Many large businesses use large vans and lorries which require much more petrol than vehicles.
- Many people in richer countries have lots of appliances in their houses, such as washing machines, dishwashers, electric cookers, irons, TVs, computers, mobile phones and many other consumer devices powered by electricity.

Therefore, lots of cheap electricity and petrol is wasted in rich countries. However, there is more interest today from governments and citizens alike in becoming energy-efficient and using products that consume less energy.

2.1 Energy

Energy is one of the most critical resources in the world. It is used in everyday life to meet people's needs. Energy is used to run machines in the industrial, agricultural and transport sectors and is also used in cooking and facilitating photosynthesis in plants.

2.2 Fuel

A fuel is any material that can be made to react with other substances to release energy as heat energy or to be used for work. Fuels can be in a solid, liquid and gaseous state.

Solid fuel

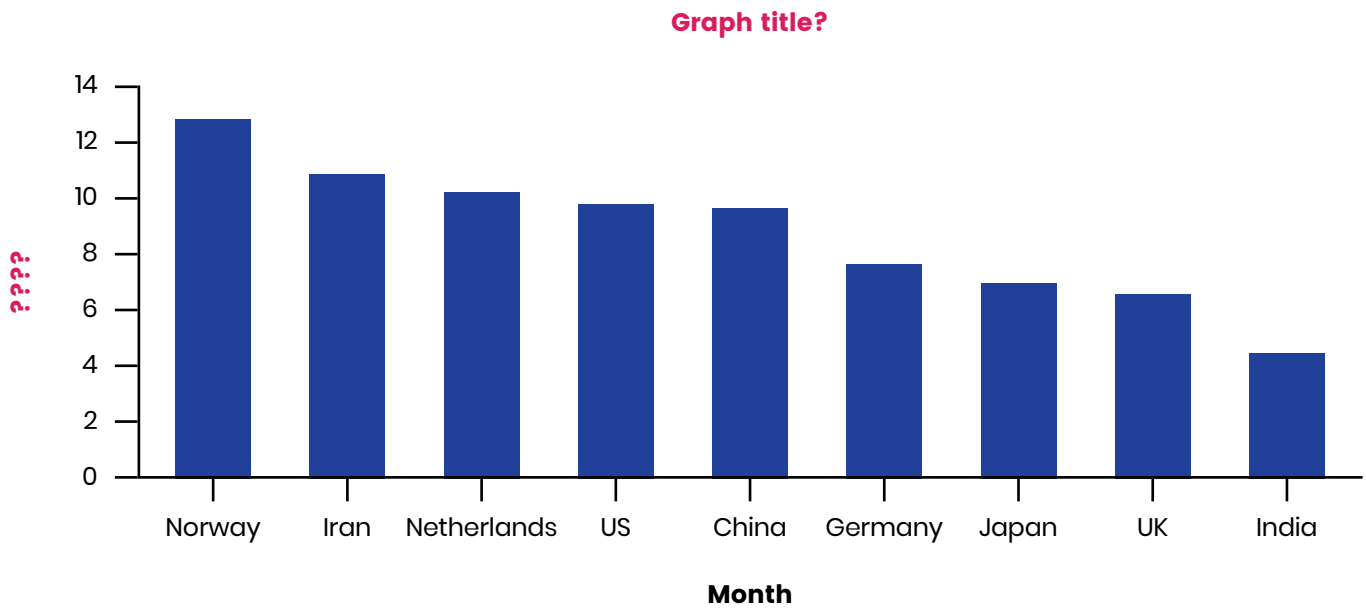
types of solid materials used as fuel, to produce energy and provide heat which in turn is released through combustion e.g. wood, charcoal, peat.

Liquid fuel

refers to combustible materials, harnessed to create chemical energy. It mostly produces kinetic energy e.g. diesel, gasoline, kerosene.

Gaseous fuel

under normal conditions these fuels are gaseous. Many gases from fuels are composed of hydrocarbons such as methane and propane. This is a source of potential heat energy. Gaseous fuels include coal gas, water gas, coke oven and propane.



3 Supply of energy in Zanzibar

Supply of energy

- Firewood (54%)
- Agricultural residues (3%)
- Charcoal (25%)
- Fossil fuels (14%)
- Electricity (4%)
- Other (< 1%)

	Biomass fuel	Petroleum products	Electricity consumption
Includes	Firewood, charcoal, coconut and agricultural residues.	Diesel, petrol, kerosene, LPGs, lubrication oils etc.	
Quantity	1.5 million m3	47,600 tones	445 GWh
Equivalent in Giga Joules	66 million Giga Joules	1.7 million Giga Joules	1.6 Giga Joules

Most of the energy supply in Zanzibar is derived from non-renewable energy sources, which include: firewood (54%), charcoal (35%), fossil fuels (14%) and agricultural residue (3%), and only 4% of energy is from electricity.

3.1 Energy use in Zanzibar

In households, electricity, candles and kerosene are used for lighting. Zanzibar depends on electricity from the national grid through Tanga and Dar es salam via an underwater cable, but Zanzibari legislators have been pushing the government to find other electricity sources and thus reduce high power dependency on the mainland. For cooking, households use firewood (mainly in rural areas), charcoal and gas (primarily in urban areas) and agricultural residue, all of which create indoor pollution, resulting in health problems. In recent years, there has been a sharp decline in firewood supplies because of increased deforestation.

4 An alternative: renewable energy

Key words

Biomass: is plant or animal material used as fuel to produce electricity or heat. It involves using firewood and other plant or animal materials to produce heat or power. Firewood is a renewable resource, as old as history itself, but burning it contributes to the co2 load in the atmosphere.

Solar power: involves using the sun's energy to heat panels and generate energy. Solar power (in the form of light) can be converted into electricity using photovoltaic cells

Wind power: involves using wind power to turn turbines and generate energy. Wind power is also pollution-free.

Hydro-power: involves using water trapped behind dams to generate electricity by turning turbines.

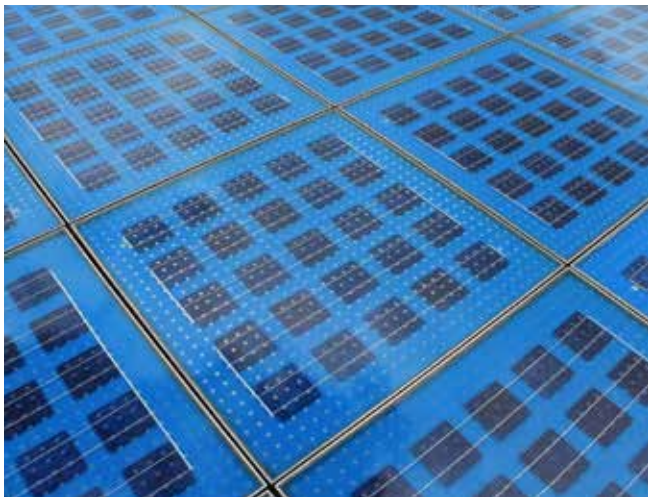
Seapower: involves using the energy of waves, tides and temperature differences in the ocean. Seapower includes the possibility of harnessing waves' energy (think of the power of waves crashing on the rocks).

4.1 Solar panels

A solar panel is a set of solar cells used to trap sunlight and convert the light into electricity which can be used to provide power for electrical loads.

Solar cells are an electrical device that converts the energy of light directly into electricity.

Solar panel



Solar cell

Uses of solar panels

Image	Solar panel used for
	Generating electricity for homes and appliances for streetlights.
	Generating electricity for homes and appliances.
	Portable panels that connect to small devices such as cell phone, GPS trackers, tablets, laptop, and solar radios.

Solar energy in Zanzibar

Umbuji in Zanzibar, followed by Kizimkazi village, was the first village to use solar power to electrify the public facilities and help spread this technology. In 2011 Zasea installed economic solar plants in villages such as Kitope and Dunga villages on Unguja Island and Fundo village on Pemba Island.

The government of Zanzibar is encouraging people to use alternative fuels, biogas and electricity, to reduce environmental pollution.

Note: Most Zanzibaris still use charcoal and firewood for cooking purposes, even though this leads to adverse environmental impacts.

4.2 Wind turbines

A wind turbine is a device that converts wind energy (kinetic energy) into electrical energy.

How do they work?

The wind turns the propeller-like blades of a turbine around a rotor spine, capturing some of the wind's kinetic energy and turning the central driveshaft that supports them. This spins a generator, which creates electricity. The wind speed varies depending on the direction, and temperature differences, e.g. between the sea surface and the land surface tend to be larger during the day than at night.

4.3 Hydro-electric power plants (HEP)

Hydro-electric power is electrical energy produced through the power of moving water. Most hydro-electric power comes from waterfalls or dammed water's potential energy, driving a water turbine and generator. However, the power extracted from the water depends on the volume and height between the source and the water's outflow. Therefore hydropower plants convert potential energy into mechanical energy through water turbines, which then generate electricity.

Hydropower in Tanzania

Hydropower remains a vital renewable energy for Tanzania due to heavy rains throughout the year. The rains fill dams, lakes and rivers, which results in electricity production with high voltage by the power plants. These power stations are built away from residential areas to avoid any dangers.

Rufiji Hydropower

Rusumo Hydropower

The table below shows the locations of Tanzania's Hydropower Stations.

Hydroelectric station	Region	Capacity (MW)	Year completed
Hale Power Station	Tanga	21	1964
Nyumba ya Mungu Power Station	Kilimanjaro	8	1967
Kidatu Power Station	Morogoro	204	1976
Mtera Power Station	Dodoma	80	1979
Uwemba Power Station	Njombe	0.8	1991
Kihansi Power Station	Morogoro	180	2000
Rusumo Hydroelectric Power Station	Kagera	80	2020 (Expected)
Kikonge Power Station	Ruvuma	300	2025 (Expected)
Songwe Power Station	Mbeya	180	2022 (Expected)
Julius Nyerere Hydropower Station	Morogoro	2,100	2022 (Expected)

5 Electricity in Zanzibar

Key words

Domestic sector: also referred to as an internal market or domestic trading, is the supply and demand of goods, services, and securities within a single country.

Megawatt (MW): a unit of power equal to one million watts, especially as a measure of the output of a power station.

Power station: an installation where electrical power is generated for distribution.

Zanzibar Electricity Corporation: is a state owned utility firm that provides transmission and distribution service of electricity in Zanzibar.

The domestic sector consumes less than half of all electricity consumption, and the remainder is used for commercial purposes, mainly hotels. Electricity demand is growing fast in both the domestic and commercial sectors, with a 75% increase in electricity consumption between 2000 and 2005.

Electricity in Unguja

In 1980 the main island of Unguja was connected to the Tanzania National Grid via a 132kV, 45MW sub-marine cable from Fumba substation to Mtoni station and distributed to regions of Unguja under Zanzibar Electric Company (Zeco), and the diesel generators were decommissioned.

Electricity in Pemba

In 1985 the government replaced the Tibirinzi power station and inaugurated the Wesha Power station. The power station had three diesel generators with a total capacity of 4.5 MW. Pemba was also connected to the national grid through a submarine cable from Pangani. The 33kV, 20 MW cable runs from Pangani, to Tanga to Ras Mkumbuu.

5.1 Electricity Customers in Zanzibar

How widely is electricity supplied throughout Zanzibar? The major electricity distribution company, Zanzibar Electricity Corporation (Zeco), had approximately 80,000 registered customers in 2012, including households and businesses. This compares with 69,000 customers in 2008.

Many people in Zanzibar still do not have access to electricity.

	2008	2009	2010	2011	2012
Customers (approximately)	69,000	71,286	73,446	75,000	80,000

6 What we have learned:

- Almost all electricity in Zanzibar is imported from mainland Tanzania.
- Energy demand continues to increase year by year.
- People in rich countries use much more fossil fuel energy than people in developing countries.
- Fossil fuels are a non-renewable energy source, and their use causes pollution.
- Renewable energy sources that use natural energy flows (sunlight, wind, waves, tides, plant growth) are an alternative to fossil fuels.
- Nature has a very efficient method of producing light, called bioluminescence.
- Tourists appear to use more fossil fuel energy than local people.
- People need to recognize how much fossil fuel energy they use each day.
- There are many ways in which we can reduce their use of electricity.

Knowledge and skills	Attitudes and values
Understand how we use energy; interpret data; assess energy use in the home; make responsible decisions about energy saving.	Adopt positive attitudes to energy use; learn to value and manage energy resources appropriately; learn the benefits of using renewable energy.

7 Learning activities

How How How activity

Refer to the **How How How activity** detailed in the "Participatory Action Learning" book to help the student explore different ideas and concepts and challenge each other's points of view.

Activity 1: Electricity consumption

Resources required:

- A sheet of paper (one per student)
- Pens and pencils
- Please note this may be done without paper and pen if learners relay answers verbally

Take home activity

Set up:

Ask learners to answer the below questions at home with the help of their parents or guardians.

- What type of energy sources do you use in your home?
- Why do you use that type?
- How do you heat water in your home?
- What do you use hot water for at home?
- What energy source do you use for cooking food in your home?
- Does your family need to collect fuel for fires? How far do they need to travel?
- How many electrical appliances do you have in your home? (make a list)

Activity:

- Once the above questions have been completed, facilitate group discussions on energy use at home, using each question as a discussion point.

Review:

The following questions or points may be used to review the activity:

- Each group can feedback their answers to the rest of the class, where another group has already given the same example learners can demonstrate any additional points their group had.

Activity 2: BINGO game

Resources required:

- Colour pens or colour paper
- Paper

Set up:

Prepare sets of questions where the colour card represents the below questions.

Draw the table on the next page with five or six columns on the board where students go through the answer by putting the correct colour card on the table.

Activity:

- Organise students into groups of 5 – 6.
- Distribute questions to students then give them time to discuss.
- The teacher leads the session by reading the questions loudly and allowing the group to answer by showing the question's colour card.
- Students from the group will show the card; if it is correct, place the colour card on the board, this should be only a one-time attempt. If a student fails to answer, go to the next question.
- The group which fills the table first calls bingo then give them the star card as the winners.

Questions

- Name any three items which use solar power. **(yellow card)**
- What are the locations of hydro-electric power plants in Tanzania? **(red card)**
- Name the first village in Zanzibar that benefited from solar power. **(green card)**
- What are the parts of a wind turbine? **(black card)**
- Why should solar panels be placed on the roof of a building? **(blue card)**
- State the two uses of solar panels. **(yellow card)**
- What is the most energy power used in Zanzibar? **(red card)**
- What device changes kinetic energy to electrical energy? **(green card)**
- Name the substations which receive high voltage both in Pemba and Unguja island. **(black card)**
- What device converts light energy directly to electrical energy? **(blue card)**

BINGO Game Table

Group A	Group B	Group C	Group D	Group E
1.				
2.				
3.				
4.				
5.				
6				

Key

1 – blue	2 – yellow	3 – red	4 – green	5 – black

Activity 3: Reducing energy consumption letter

Resources required:

- A sheet of paper (one per student)
- Pens and pencils
- Please note this may be done without paper and pen and student can perform 'letter' as a monologue

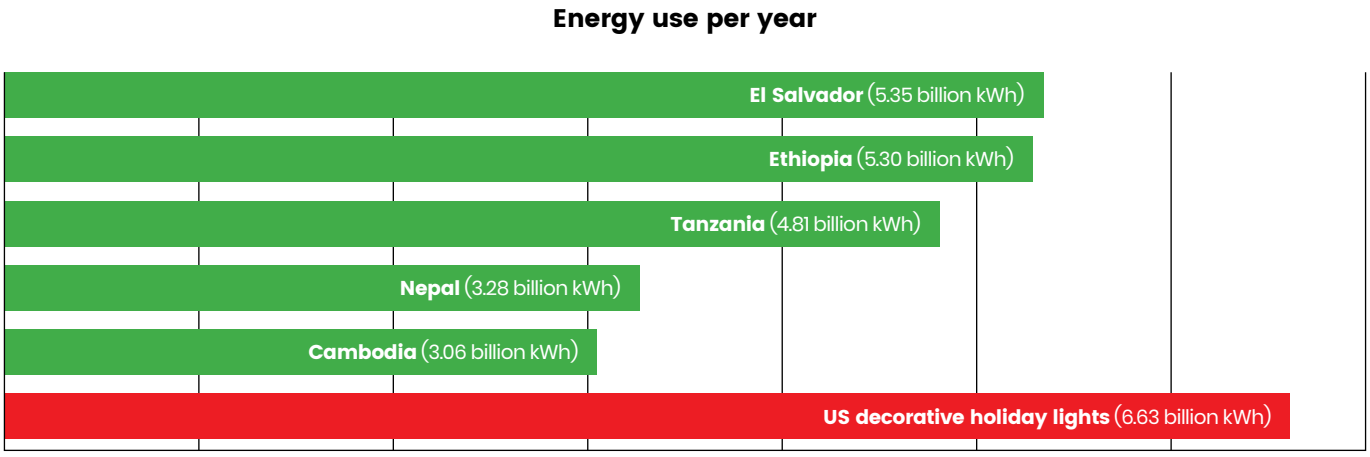
Take home activity

Set up:

Draw the table below on the board.

Activity:

- This teaching guide has highlighted the disparity between energy use in Tanzania and the United States, and Europe. This is evident in the graph below produced by the US Energy Department's Energy Information Administration (EIA).
- The graph shows that the United States use more electricity for their Christmas lights (6.63 billion kWh) than Tanzania's total annual electricity usage (4.81 billion kWh).
- Discuss with learner the broader issue this graph highlights i.e. disparity in electricity use between countries.
- Given the exorbitantly high use of electricity in countries such as the United States, ask learners to write a letter to someone in one of these countries. In the letter, ask learners to suggest ideas on how the recipient can reduce their energy use.



Sources: EIA, World Bank

Review:

The following questions or points may be used to review the activity:

- Select several learners to read their letters to the class.

Activity 4: Energy saving charades

Resources required:

- List of energy saving actions

Set up:

The below list of energy saving activities can be written on the board, put on worksheets or handed out as question cards.

Activity:

- If you can save energy in your home you will be saving money and helping to save the environment as well.
- The following actions may only save a little bit of electricity by themselves, but if everyone did them, it could make a big difference.
- Teachers select learners to act out an energy saving idea while other students try to guess which idea said learner is acting out. Continue until all ideas have been acted out.

1. Use energy-saving light bulbs (compact fluorescent light bulbs or CFLs). They cost more at the start, but they use 70% less electricity than ordinary light bulbs and last ten times longer.
2. Turn off the fan and the light when you go out of a room.
3. Put a lid on the pan while cooking (heat stays in the pan instead of getting lost).
4. Do not overcook food (it saves nutrients as well as energy!).
5. Turn off the TV or radio or VCR (especially if no one is watching or listening!), rather than leaving it on "standby".
5. Turn off the iron while you are ironing the last garment in the pile. There will still be enough heat in the iron to finish it properly.
7. Have you heard about wind-up torches and wind-up radios? If you ever get a chance to purchase one, you will no longer have to spend lots of money on batteries.
8. Boil only the amount of water you need unless you can save the extra water for drinking or in a thermos.

Review:

The following questions or points may be used to review the activity:

- Which energy saving action do you think would be the **most effective** at reducing energy use?
- Which energy saving action do you think would be the **least effective** at reducing energy use?

Activity 5: Supply of energy pie chart

Resources required:

- A sheet of paper (one per student)
- Pens and pencils

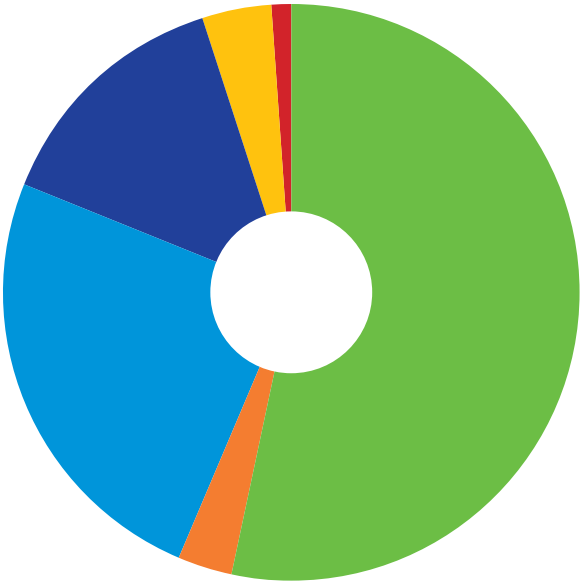
Take home activity

Set up:

Draw the pie chart of Zanzibars 'Supply of energy' on the board.

Supply of energy

- Firewood (54%)
- Agricultural residues (3%)
- Charcoal (25%)
- Fossil fuels (14%)
- Electricity (4%)
- Other (< 1%)



Activity:

- Teacher directs learners to copy the above pie chart.
- Once learners have drawn the pie chart direct them to identify problems resulting from the pie chart and write questions.
- Using these questions lead a discussion on the implications of Zanzibar's 'Supply of energy'.
- Conclude the discussion by asking whether the above energy composition is sustainable.

Review:

The following questions or points may be used to review the activity:

- How would the pie chart of a country such as the United States' energy use compare to Zanzibar?
- Which countries energy use is the most sustainable?
- Why do you think there are differences in energy use?

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