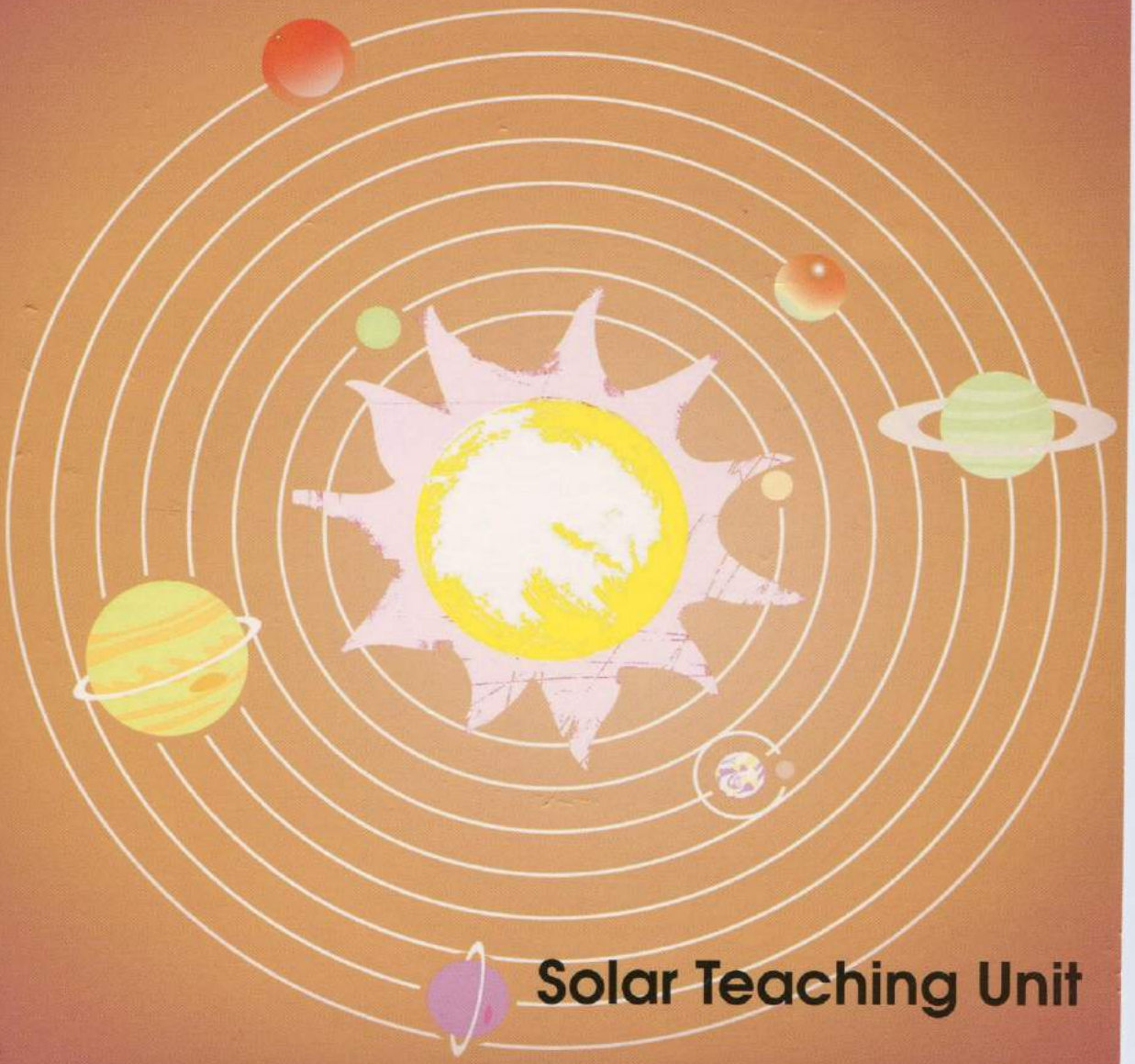
OXFORD

New Solar Generation

Renewable Energies



Solar Teaching Unit

RENEWABLE ENERGIES

A project by Deutsch -Tansanische Partnerschaft e.V. (DTP) & "weltwärts", Ministry of Economic Cooperation and Development (BMZ) supported by Deutsche Bundesstiftung Umwelt (DBU), August 2009 – November 2011

From Fossil/Nuclear Energy to Renewable Energy

For Hermann Scheer † 2010

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ABSTRACT

Today's youth is faced with the challenge of reshaping the global energy supply to avert the threat of climate change. It is very important to impart the required knowledge and strategies to young people at an early age.

Energy sources used for industrialisation and mobility like coal, oil and natural gas destroy the fragile balance of the global climate with their CO_2 emissions. Heat waves and drought, dwindling glaciers and devastating floods highlight the urgency of obtaining alternative accessible energy sources quickly.

Nuclear power - the promising new energy source of the 20th century - has turned out to be a dead end because nuclear waste carries unacceptable health risks and poses a huge threat to all human life.

What can be done to satisfy the growing global population's increasing hunger for energy?

There is a solution. Modern technologies for utilising solar energies like sun, wind, water, biomass and geothermal energy have been firmly established on the agenda of the 21st century. Any opportunity for re-integrating the global energy supply into the natural cycle can and must be exploited to secure the world's long-term energy supply and to prevent a climate crisis.

Technologically advanced countries have started to safeguard their energy-intensive lifestyles by increasing efficiency and by switching from fossil/ nuclear energies to renewable energies. For the sun-rich agrarian countries of the South, there is great development and economic potential in pursuing a localised solar energy supply to avoid economically crippling energy imports. Tanzania is a large, relatively sparsely populated country with around 2800 – 3500 hours of sunshine per year and a high insolation of 1.460 – 2.555 Watt per square metre. Particularly, rural areas are ideal locations for a decentralised energy supply from solar energies.

This book aims at educating pupils about the connection between fossil/ nuclear energy supply and climate change and to inform them about bio and CO_2 cycles as well as the endless opportunities offered by a range of modern technologies for the utilisation of renewable energies.

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ACKNOWLEDGEMENTS

The Deutsch-Tansanische Partnerschaft e.V. (DTP) has been working with young German volunteers in Tanzanian schools, vocational schools and NGOs since 2000. The main objective is to increase knowledge about the utilisation of solar energies. Young people can learn from each other by meeting and exchanging ideas. Bringing their different cultural backgrounds and experiences into a mix, they engage with each other and search for and experiment with new ways of using renewable energies.

Learning the national language, Swahili, plays a big part in this process of sharing ideas and working together.

In 2008, the DTP's volunteer programme for international understanding and climate protection was recognised as a "Worldwards Voluntary Service" by the German Ministry of Economic Cooperation and Development (BMZ).

By participating in the "worldwards", project jointly run by the BMZ and the German Environment Foundation (DBU), an idea that had been in the pipeline for many years was brought closer to realisation: a Solar Teaching Unit for young people.

As part of the "worldwards" project, the Zanzibar Solar Energy Association (ZASEA) started to test a model school programme for Tanzanian pupils.

The Solar Teaching Unit and the school programme were developed in cooperation with the volunteers working in the project locations of Kashasha, Zanzibar and Dar es Salaam and tested by the DTP volunteers in all project locations.

We would like to thank Dr. Ulrich Witte, Deutsche Bundesstiftung Umwelt (DBU) for initiating and supplying this project and Mr. Wolfgang Kuhlman for his administrative work. Many thanks also to the Zanzibar Solar Energy Association (ZASEA) and its members Ramadhan Said Omar, Mussa Abdi Khamis, Mohammed Saleh Ali and Mohammed Salum Ali and the worldwards volunteers in ZASEA Sophie Kloss, Tanja Mast, Maike Fröhner and Maresa Bussa. Their proactivity and initiative laid the foundations upon which a school programme can now be built.

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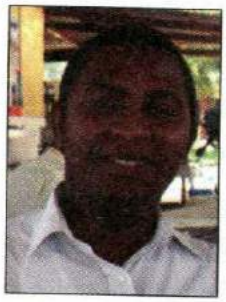

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1

THE SOLAR SYSTEM

For millions of years, the Earth has been circling around the Sun. The Earth is part of the solar system, just like the planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. All planets circle around the Sun on elliptical orbits. At the same time, the Earth rotates around its own axis.

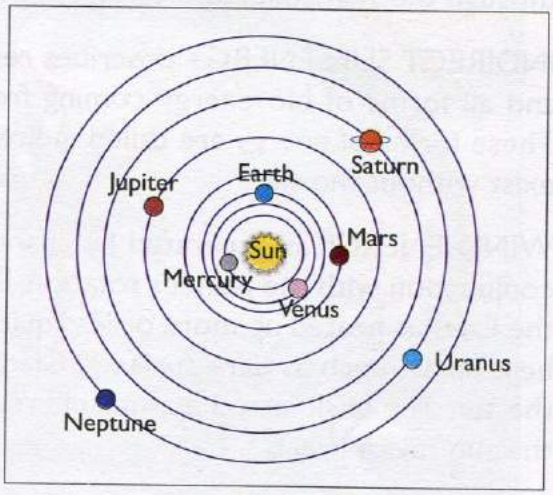


Fig. 1: The solar system

The difference in global temperatures and changing seasons are caused by the distance between Sun and Earth and the angle of insolation throughout the year.

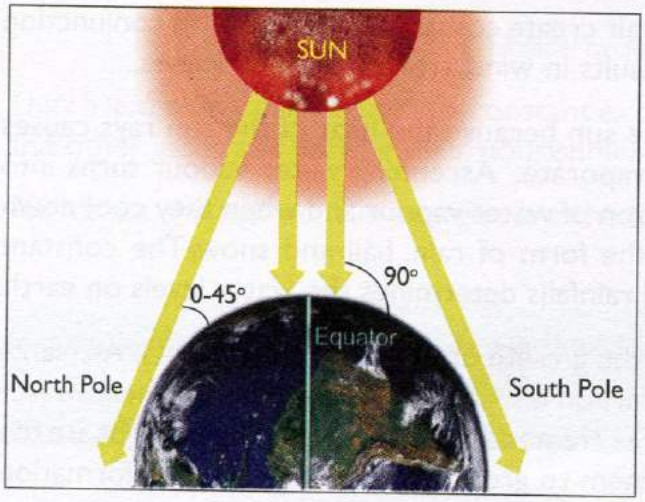


Fig. 2: Angle of Sun rays

An angle of 90 degrees leads to the maximum amount of sunrays per square metre like in the Equatorial region. The climate is tropical and hot.

The minimum amount of sunrays per square metre is found at the polar caps with an angle of only a few degrees.

The hottest regions are regions around the Equator.

The coolest regions are at the North and South Pole.

Direct and Indirect Sun Energy

The Sun is the only additional energy source of the earth. In the energy sector, the Sun's energy is divided into DIRECT and INDIRECT sun energy.

DIRECT SUN ENERGY describes sun rays which reach the surface of the earth. Direct sun energy is visible in the form of sun rays, which give all living things warmth and light and therefore life. Direct Sun Energy can also be used for human comfort with the help of modern technologies to generate heat through thermal collectors or electricity through photovoltaic solar cells.

INDIRECT SUN ENERGY describes resources like wind energy, hydro energy and all forms of bio energy coming from biomass of plants, trees and algae. These forms of energy are called indirect sun energy because they would not exist without the sun.

WIND ENERGY is generated by changes in the heat balance of the Earth in conjunction with the planet's rotation. Depending on reflectivity, the surface of the Earth is heated up more or less quickly by the sun rays. Light surfaces don't heat up as much as dark surfaces. Glaciers, snow and ice reflect up to 90% of the sun rays back into the atmosphere while dark surfaces keep up to 90% of the sun rays as heat.

Variations in the temperature on Earth's surface on land and oceans cause slow or quick changes between hot and cold. Hot air always rises and cold air always falls because of the difference in density.

Rising and falling of hot and cold air create constant fluctuations. In conjunction with the Earth's rotation, this results in wind, storms and hurricanes.

HYDRO energy is caused by the sun because the heat of the sun rays causes water on land and oceans to evaporate. Ascending water vapour turns into clouds. Clouds are an accumulation of water vapour and when they cool down the water returns to earth in the form of rain, hail and snow. The constant circle of evaporation and annual rainfalls determines the water levels on earth.

The BIOMASS cycle starts with the growth of green leaves on plants. All plants generate carbohydrates out of carbon dioxide (CO_2) in the atmosphere, water (H_2O) and sunlight. Carbohydrates created from CO_2, water and sunlight are the nutrition of plants and enable them to grow and flourish. This transformation releases oxygen. The process is called PHOTOSYNTHESIS. When plants grow, they produce biomass. Biomass has always been the most important renewable energy source for human beings.

The Ecological Circle of Life

Growing plants produce oxygen. Oxygen is essential for the survival of people and animals. They breathe in the oxygen because their cells need it to live and grow. People and animals on earth and in the water live in close symbiosis with plants, trees, algae and plankton.

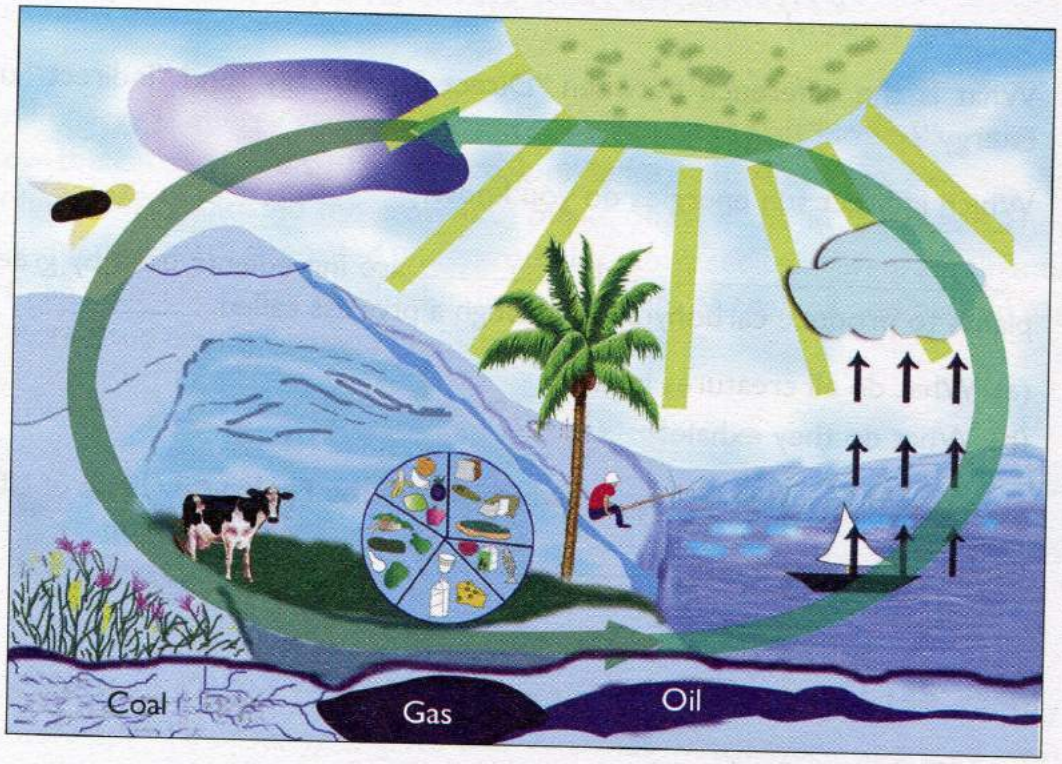


Fig. 3: Ecological circle of life

They live through each other in a constant exchange of oxygen, carbon dioxide and other gases and receive their nourishment from each other.

The direct and indirect sun energies are the basis of life on earth.

Human beings, animals and plants, wind and water are part of the Ecological Circle of Life which is caused by the Sun.

Review Exercise 1

Answer the following questions:

1. Why are temperatures highest along the Equator?
2. What are the reasons for the differences in global temperatures and changing seasons?
3. What is the difference between "Direct Sun Energy" and "Indirect Sun Energy"?
4. Which indirect sun energies do you know?
5. _____ , _____ and _____ are ingredients used by green plants to produce carbohydrate through a process called _____ .
6. (a) What do all creatures inhale?
   (b) What do they exhale?
7. Draw your own simple diagram which shows the Ecological Circle of Life.
8. Clouds are formed due to _____ .

2

FOSSIL ENERGIES: COAL, OIL AND NATURAL GAS

Fossil energy is energy generated from decayed plants that have accumulated below the earth. Millions of years ago, long before human beings existed, the sun had already initiated the growth of plants on land and in the ocean. They grew and died, were deposited underground and pressed by moving continents, earth and ice. The decay resulted in large amounts of coal, oil and natural gas as "stored sun energy" named FOSSIL ENERGIES.

Coal, oil and natural gas are fossil energy sources from millions of years ago.

Development through Fossil Energies

INDUSTRIALISATION started at the end of 18th century; and 19th century saw development of many engines and machines which were operated with fossil fuels. Since then, fossil resources like coal, oil and natural gas which were stored deep in the earth have been mined and used for energy production. Over the centuries, fossil-driven engines and machines have taken over work in all economic sectors; they speed up work and increase productivity.

Since the start of electricity generation and the supply of households by companies, people have used electricity to make their lives more comfortable. Light, washing machines, heating installations, cookers, refrigerators, radios, televisions, stereo equipment, computers and many more machines are standard today in most households in the industrialised nations.

In the 20th century, mobility through cars, ships and planes followed.

The more machines people use and the more mobile they become, the more fossil fuels are used.

Limitations of Fossil Energies

Even today the consumption of fossil fuels is constantly increasing because people in technologically less developed countries follow the example of technologically highly developed countries. They would also like to drive cars, watch TV, listen to the radio, use computers and make their work easier by using machines if the resources are available. Around 80% of the world's energy demand is covered by coal, oil and natural gas, and around 20% by nuclear power and renewable energies.

However, fossil fuel resources are limited.

It is currently assumed that fossil energies will last 192 more years for coal, 43 years for oil and 68 years for natural gas. The "Fossil peak" in *Figure 4* shows the turning point of increasing demand and limited resources which moves the end of coal, oil and natural gas resources forward into the 21st century.

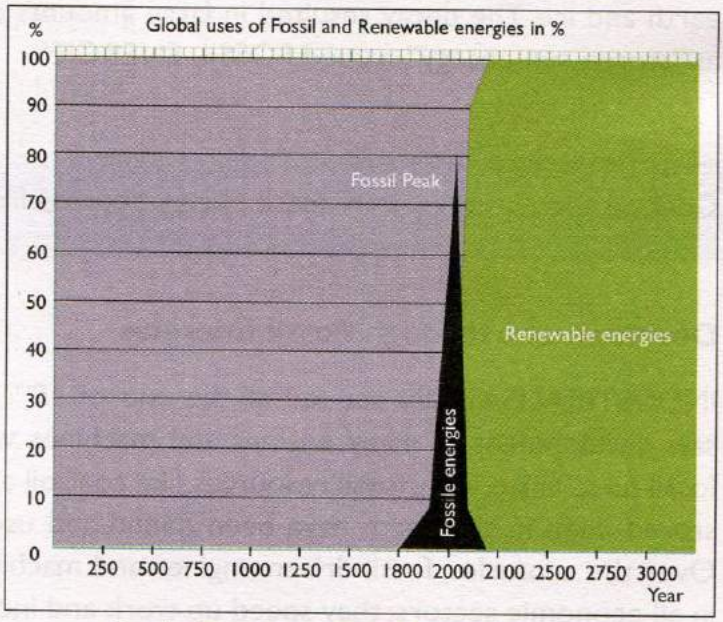


Fig. 4: Fossil peak and renewable energies

The fact that coal resources will last longer does not affect the necessity to find alternative energy sources to replace the fossils during the 21st century.

Dangers of Fossil Energies

It is not only the shortage and increasing price of oil, coal and natural gas that today threaten the national economies of the world. There is a bigger threat associated with fossil fuels.

Noticing temperature rises in parallel with increasing industrialisation, scientists

identified the greenhouse gas, carbon dioxide, as the main reason for increasing temperatures and climate changes. Growth of plants through millions of years absorbed carbon dioxide from the atmosphere. Compared to this very long period, the short era of industrialisation has increased carbon dioxide emissions very quickly due to the burning of fossil fuels. The accumulation of carbon dioxide in the atmosphere endangers the global climate and the heat balance of the earth.

Greenhouse Effect, Industrialisation and Climate Change

Sun's energy in the form of ultraviolet and visible light passes through the atmosphere and reaches the Earth's surface. One part of insolation is stored in form of heat, the other part is reflected back into the atmosphere in the form of infrared light and heat. The Earth's warming is regulated by layers of different gases in the ATMOSPHERE.

Part of the reflected heat is stopped by the umbrella of so called GREENHOUSE GASES in the atmosphere and reradiated towards earth. This is a natural process which is called GREENHOUSE EFFECT.

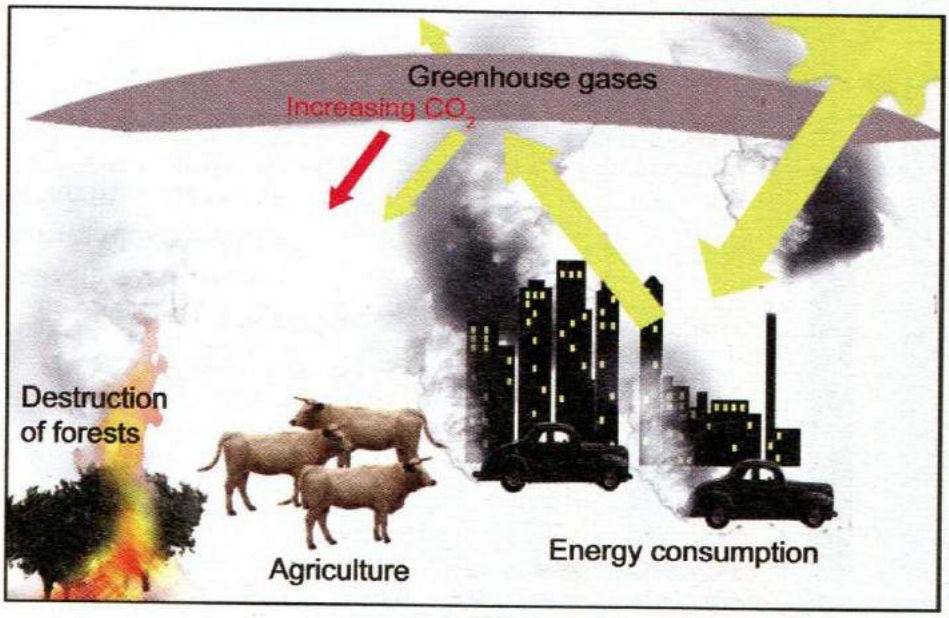


Fig. 5: Greenhouse effect and increasing CO_2

The most common greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrogen oxide (N_2O), chlorofluorocarbon (CFC) and ozone (O_3). All these gases have a different potential of permeability of sun rays and reflected heat. The biggest part of the greenhouse effect (61%) is caused by carbon

dioxide (CO_2) which is a result of burning coal, oil and gas. Methane follows with 15% from cattle and agriculture, CFC (11%) from irresponsible disposal of old fridges, N_2O through burning woods and nitric fertilizers.

For several thousand years, the atmosphere has been delicately balanced, with the levels of greenhouse gases relatively stable for creatures and plants. Since industrialisation and the rising of emissions, the "umbrella" formed by greenhouse gases is becoming stronger and stronger.

Less of the reflected heat from earth returns to the atmosphere and a lot is reflected back down to earth. The red arrow in Fig. 5 shows the additional amount of reflected heat which in turn heats up the atmosphere.

There are noticeable temperature changes on earth causing extra warming followed by CLIMATE CHANGES.

Increased carbon dioxide emissions on one hand and the fact that human activities have led to the destruction of many of the world's forests means that less carbon dioxide is used for photosynthesis. This leads to increased global warming.

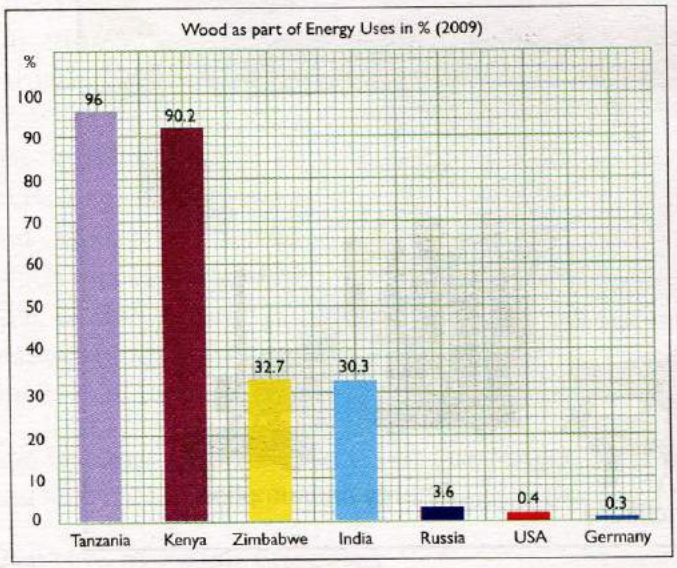


Fig. 6: Wood as a part of energy uses

Ten years with the highest global temperatures on record have all occurred since 1997.

Since industrialisation started, coal, oil and natural gas have been burned to provide energy for human consumption, and carbon dioxide has accumulated in the atmosphere. More heat is reflected back to earth. Global climate warms up.

Globally, more and more agricultural countries are changing into industrialised countries. The demand for electricity is increasing.

This comparison of countries like Tanzania, Kenya, Zimbabwe, India, China, Russia, USA and Germany, shows clearly that industrialisation and decreasing wood consumption per capita (*Figure 6*) as well as increased use of electricity (*Figure 7*) and CO_2 emissions per capita (*Figure 8*) go hand in hand.

Comparison between electricity consumption in Germany and USA shows that highly industrialised countries can save energy by using efficient technologies to reduce CO_2 emissions per capita.

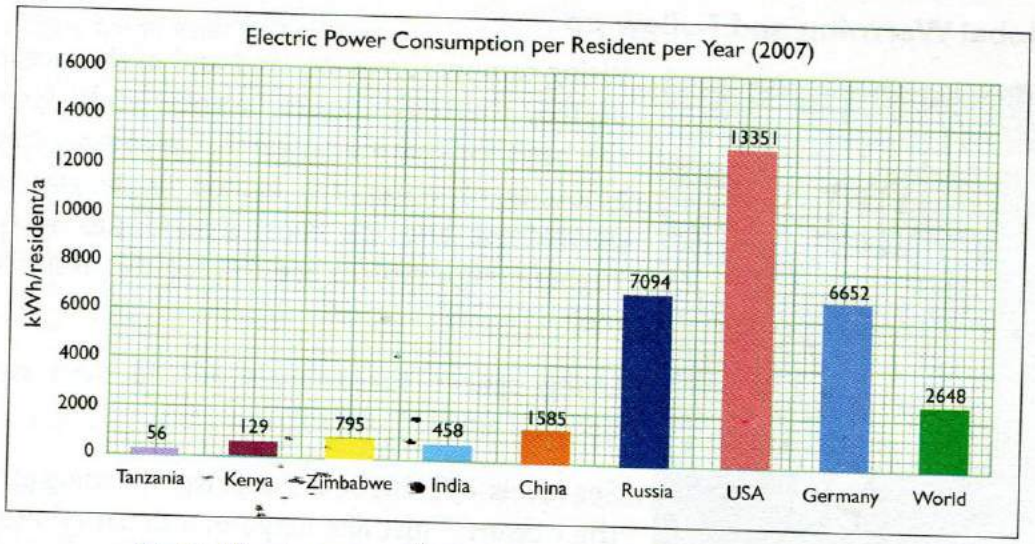


Fig. 7: Electric power consumption per resident per year 2007

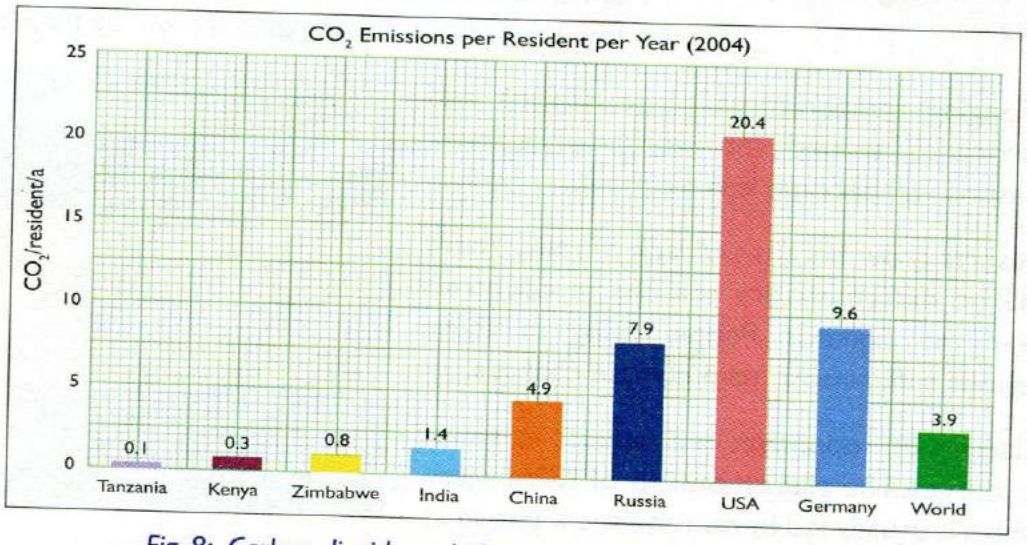


Fig. 8: Carbon dioxide emissions per resident per year 2004

In 2004, every person on earth produced an average of 3.9 tons of carbon dioxide per year. To slow down climate change, it is necessary to reduce emissions per capita to 2 tons of carbon dioxide per year.

Carbon dioxide emissions per capita in countries like Tanzania, Kenya, Zimbabwe and India are below this level. Countries like the US, Germany, Russia and China need to achieve a considerable reduction of carbon dioxide per head. Climate change due to burning fossil energies is mainly caused by people in industrialised countries.

Global Warming and Follow up

Fig. 9: Melting North and South Poles

Rising temperatures on land and in the oceans destroy the temperature balance which forms the basis for our life on earth. Up to now, large amounts of water are locked up in glaciers, permafrost and ice caps around the world. Higher temperatures are causing this water to melt.

Living spaces for animals at the pole caps become smaller and smaller.

Sea levels will rise because of the warming up of the oceans – just like liquid in a thermometer.

Small islands, coastal areas and countries with low level coasts like Bangladesh will be flooded.

Changing temperatures cause storms and hurricanes around the world, while rainy seasons will become less frequent.

Deserts grow because of lack of rain. There will be extremely dry seasons in countries near the Equator. People living in these regions suffer most from climate changes.

Glaciers on mountains will be lost as water resources. The glacier on top of Kilimanjaro, which is usually fed by rain and snow becomes smaller and smaller.

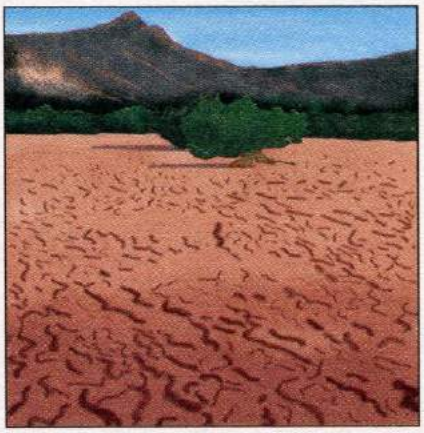


Fig. 10: Drought

Melting ice and glaciers, growing deserts, flooded small islands and low level ocean coasts are all results of rising temperatures caused by increased greenhouse gas emissions, particularly carbon dioxide.

Review Exercise 2

A: Answer the following questions:

1. Name fossil energy sources.
2. How and when were fossil energy sources created?
3. Why are fossil energies running out?
4. What do you know about the Greenhouse Effect?
5. What are the most common Greenhouse Gases?
6. Why does the release of large amounts of carbon dioxide change climate?

B: Write True if the statement is correct and False if the statement is incorrect:

1. There are plants both on land and in the oceans.
2. Development of machines helped to increase productivity and reduce air polution.
3. Carbon dioxide is the most destructive greenhouse gas.
4. One of the negative effects of the greenhouse gases 'umbrella' is that it prevents sunlight from reaching the earth's surface.
5. More and more glaciers are melting due to climate change.

3

NUCLEAR ENERGY: A "DEAD END"

In search of ways to avoid CO_2 emissions, many countries want to build new nuclear power stations to satisfy the demand for energy. But nuclear power stations are run on uranium. Uranium is an element of high radioactivity which is harmful to all living beings on earth. The danger is already apparent during uranium mining, because human habitats are destroyed and dangerous radioactivity is released and can cause cancer.

Furthermore, there is the unsolved problem of storing the radioactive waste after burning uranium. It needs to be stored safely underground without leakage for several hundred thousand years.

During the mining process and during the generation of power in nuclear power stations, large amounts of water are used for the cooling process and for cleaning. This water becomes contaminated.

The atomic fuel uranium is also used to produce nuclear weapons which threaten humanity with new wars. Also, uranium reserves on earth are limited.

Nuclear energy is a provisional solution with lots of hazards for all living beings. The accidents of Tschernobyl in Russia (1986) and Fukushima in Japan (2011) gave the warning.

4

RENEWABLE ENERGIES FOR A CLEAN AND PEACEFUL GLOBAL ENERGY SUPPLY

The world today faces a big conflict due to the limitations of global resources of coal, oil and gas. Rising energy prices threaten global economies. Furthermore, the burning of fossil energies and the production of carbon dioxide emissions cause weather and climate changes. Carbon dioxide emissions are the source of more and more dangerous changes for the living creatures on earth.

Because of the dangers of generating energy through nuclear power and the dangers of carbon dioxide emissions generated when burning coal, oil and natural gas, people in technologically highly developed countries are searching for alternative energy sources. They have developed new technologies to utilise the energy of the sun. Sun's energy is plentiful everywhere and is 6000 times the current global energy demand.

The solution to all energy problems like carbon dioxide emissions from burning coal, oil and natural gas and the dangers of nuclear power is the use of DIRECT and INDIRECT sun's energy called RENEWABLE ENERGY.

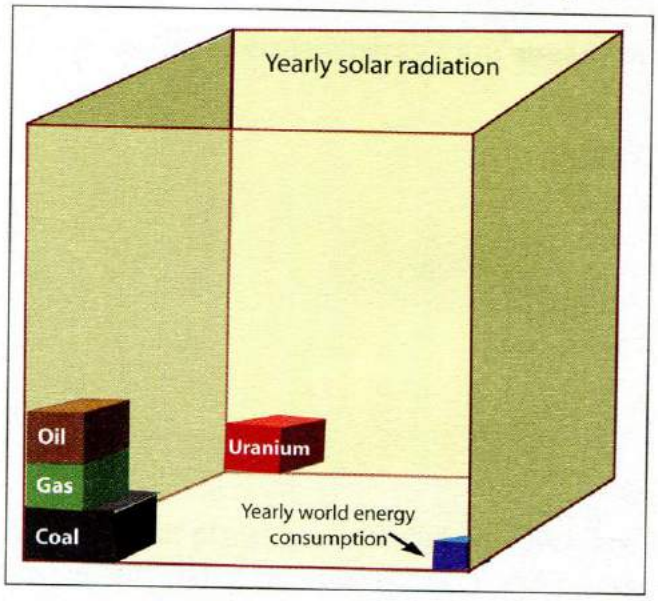


Fig. 11: Yearly solar radiation

Less developed countries in sun-rich regions like Tanzania have the chance to become energy-rich countries of the future, if they would start early on to promote modern energy supply through solar energy.

All problems caused by fossil and nuclear power can be solved by using 100% Renewable Energies.

Review Exercise 3 & 4

Answer the following questions:

1. Hydro-power depends on water but nuclear power depends on _____ .
2. Assess risks associated with nuclear power.
3. Give examples of nuclear disasters that occurred anywhere in the world.
4. How can we achieve a sustainable, risk-free energy supply?
5. (a) Which energy source is sustainable?
   (b) Why?

5

RENEWABLE ENERGIES

Renewable energies or sustainable energies are energy sources which don't have the same negative impacts in their production and usage as fossil and nuclear energies; neither to human beings, animals and plants nor to the environment in general. Renewable energies are part of the ecological system of the Earth. They are called "sustainable energies" because they are never ending energies. They will supply the current and the coming generations without limits. Renewable energies come from natural resources like wind, water, biomass and the sun. But all renewable energies depend on the sun, either directly or indirectly. Only geothermal energy comes from sources deep within the earth.

The following direct and indirect sun and geothermal energies are already in use:

1. Bio Energy
2. Solar Energy
3. Wind Energy
4. Hydro Energy
5. Tidal and Wave Energy
6. Geothermal Energy

5.1 Bio Energy

Bio energy is generated from the biomass of plants, trees and algae which are created from sunlight, carbon dioxide and water (photosynthesis). All plants grow and die in harmony with the biomass cycle.

Biomass is part of the carbon dioxide cycle which balances out the climate. Growing biomass absorbs carbon dioxide from the atmosphere. Burning biomass returns it. That means the system is carbon dioxide neutral if the cycle is closed within months or years by re-growing the burned resources.

Carbon dioxide neutral cycle means that the same amount of carbon dioxide released by burning biomass is absorbed from the atmosphere by newly growing renewable material.

To satisfy the increasing energy demand, availability of biomass has to be increased by planting additional biomass like "energy woods" and energy plants for heating and fuel.

Animal excrements and organic waste are also biomass which can be used to generate energy by converting it in the digestive system of humans or animals.

The following kinds of bio energy are used as renewable energies:

- Firewood
- Fuel from plants
- Biogas

Firewood

Since discovering the fire, humans have been using firewood as an energy source. Today, wood is the main energy source for cooking, heating and lighting in technologically less developed countries.

Wood is generally available for free in rural areas. People living in these areas cut wood for cooking and heating and produce charcoal to sell in cities for additional income. Often people forget to replant trees, and wood becomes rarer.

Wood is a renewable energy source if the same amount of wood is replanted after cutting - or if it is growing back by itself at the same rate as firewood is cut from bushes. The carbon dioxide cycle of growing and burning has to be closed to become a "balanced carbon dioxide cycle".

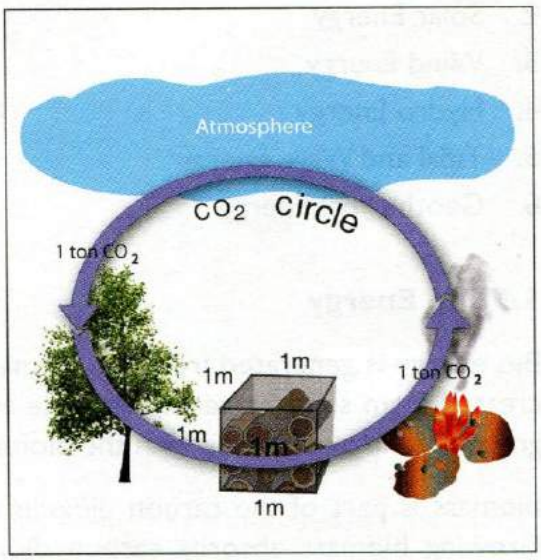


Fig. 12: Balanced carbon dioxide circle

Growing 1 cubic metre of wood absorbs 1 ton of carbon dioxide from the atmosphere. Burning 1 cubic metre of wood emits 1 ton of carbon dioxide into the atmosphere. It is carbon dioxide neutral.

Currently, wood-burning contributes around 15% of global warming.

Huge forest areas are burned for agricultural use without replanting.

Since the negative impacts of deforestation were first recognised, several measures have been introduced to save the remaining forest areas and to educate people on how to cut and replant wood. For example, people are taught through campaigns like "Cut a Tree, Plant Trees". The goal of sustainable aforestation will be reached by replanting a new tree directly after cutting an old one.

Fig. 13: Three stone fire

People also dry firewood before using it. Wood consumption is reduced by up to 50% through the use of dried wood and energy saving stoves, of which there are many.

The picture in *Fig. 14* shows a very good efficient stove which is used in households in Bangladesh. A chimney transfers smoke out of the house.

Fig. 14: Energy saving stove, Bangladesh

Cooking with dry wood or using energy saving stoves saves up to 50% of wood

Technologically highly developed countries have also returned to heating their homes with pellets or briquettes of wood and wood waste.

This way, people avoid oil and natural gas by using their local resources. With 1 cubic metre of wood you can generate 2000 kWh heat energy; the same amount of energy as with 200 l of oil.

Substituting oil with wood is reasonable if wood is replanted and the carbon dioxide cycle is closed again.

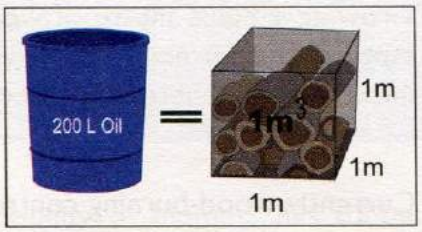


Fig. 15: 200 l Oil = 1 m³ wood

Bio Fuels

These are also known as agrofuels. These fuels are mainly derived from biomass or green waste. Currently, the main use of bio fuels is in the transportation sector. They replace fossil fuels. Asia, Europe and America are major producers and consumers of bio fuel. They plant renewable raw materials for producing bio fuel and biogas for transportation and electricity.

Brazil is number one in planting and using sugar cane as bio fuel ethanol – today, all fuel contains 25% bio ethanol.

Nowadays, there are even engines which run on 100% bio fuel. The following table shows the fuel/ oil amounts which can be generated per hectare of land by growing different renewable raw materials.

Plant/ Tree	Litre fuel/ oil per hectare
China herb	11700
Switch grass	9360
Sugar cane	6080
Palm oil	4210
Maize	3740
Coconut	2682
Jatropha nuts	1350
Rape seed	1141
Peanut	1020
Sunflower	917
Soy bean	430

Table 1: Biofuels per hectar

However, there are many problems associated with the production of bio fuels. Using land for bio fuel production minimises land available for growing food crops.

Less food increases the prices of food.

There is a growing global discussion about "food or fuel" which highlights the increasing problems in this sector.

Biogas

The smallest natural biogas plant in the world is the cow. The biogas methane is generated by chewing, ruminating and fermenting grass for a long time in the cow's seven stomachs.

Biogas is normally produced by using excrement of animals and humans or plants in a biogas digester, also known as a methane digester.

Fig. 16: New energy

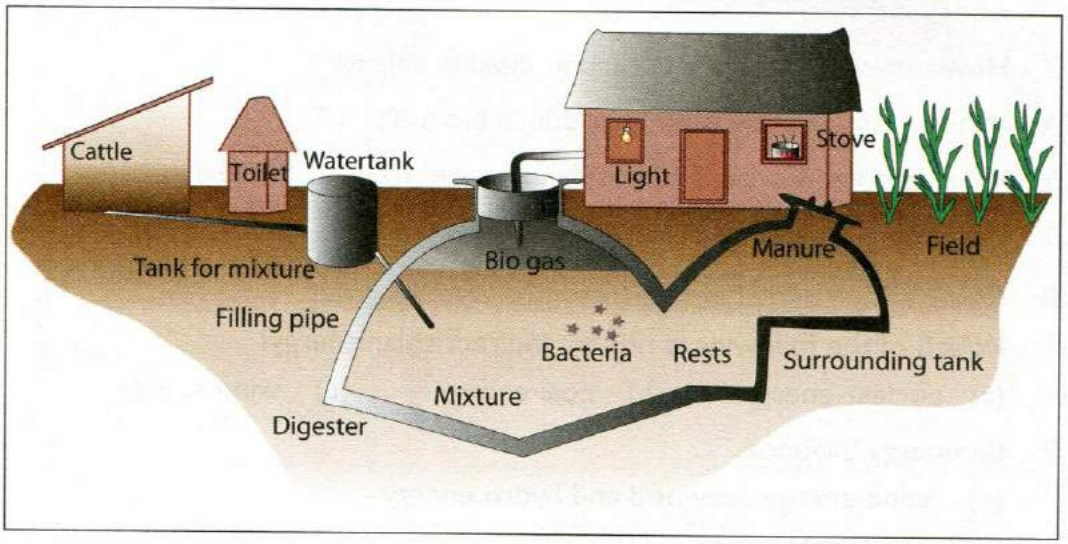


Fig. 17: Biogas plant

This supports decentralised energy uses because it is locally produced where it is needed.

The biogas digester relies on bacterial decomposition of biomass, waste materials and excrement to attract bacterial organisms which emit a number of distinctive gases in the process of digestion.

Digesters range from devices which can be used by a single household for cooking with biogas to industrial-scale production of electricity by turbines and generators.

Electricity generated this way can be used locally or it can be fed into a grid.

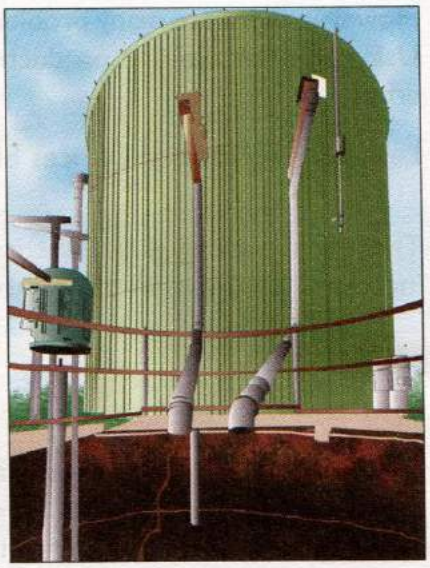


Fig. 18: Electricity from biogas plant

Review Exercise 5.1

A: Answer the following questions:

1. Name six renewable energy sources.
2. What happens to the atmospheric carbon dioxide balance when we fell trees?
3. How can we re-create the carbon dioxide balance?
4. Which plants can be used to produce bio fuels?
5. What problems arise if a lot of land is used to grow bio fuels?
6. What do we need so as to produce biogas?

B: Choose the correct answer from the options given:

1. Which of the following is not an indirect solar energy?
   (a) nuclear energy (b) coal energy (c) wind energy
2. Bioenergy includes _____ .
   (a) wind energy, firewood and hydro energy
   (b) geothermal energy
   (c) firewood, fuel from plants and biogas

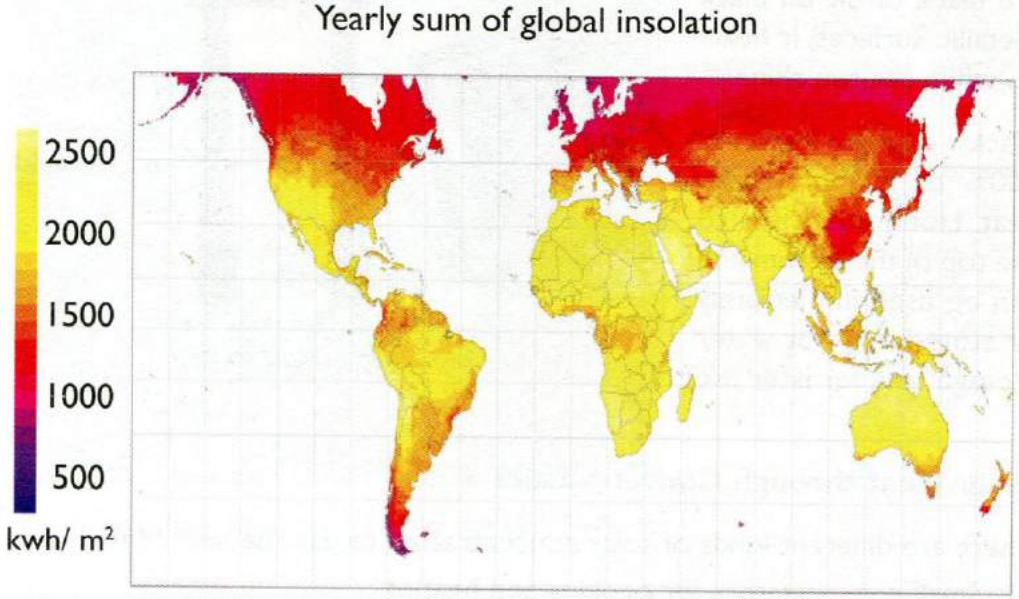
3. Aforestation will lead to _____ .
   (a) decreasing atmospheric CO_2
   (b) increasing atmospheric CO_2
   (c) decreasing of O_2

4. Digestion of biomas in a biogas plant is enabled by _____ .
   (a) electricity (b) bacteria (c) water

5.2 Solar Energy

Sun rays reaching the surface of the Earth are a combination of direct solar radiation and diffuse radiation from the sky. Diffuse radiation means sun rays which are reflected by clouds and other particles before they reach the Earth. Together, direct and diffuse radiation form the total of sun radiation, called "INSOLATION".

Tanzania, being close to the Equator, is a country with a high insolation of 1460 - 2555 kWh per square metre per year. In Germany for example, radiation is between 600 and 1400 kWh per square metre per year.



Map 1: Yearly sum of global insolation

Solar insolation can be used in two ways:

- SOLAR HEAT through collectors and concentrators
- Electricity through PHOTOVOLTAIC

Solar Heat through Collectors

Solar heat through collectors is based on two principles:

- Up to 100% of a sunray can be converted into heat if it reaches black surfaces
- Solar concentrators use reflective materials like metal or mirrors to bundle the sun rays

Solar water heater

For private households, commerce, industry and public buildings, hot water for daily use can be generated with solar heaters. If cold water is sent through pipes which are black or sit on black metallic surfaces, it heats up when the sun shines.

Black colour converts 100% of a sunray into heat. Hot water rises to the top of the system and can be used immediately or stored in a hot water storage tank for later use.

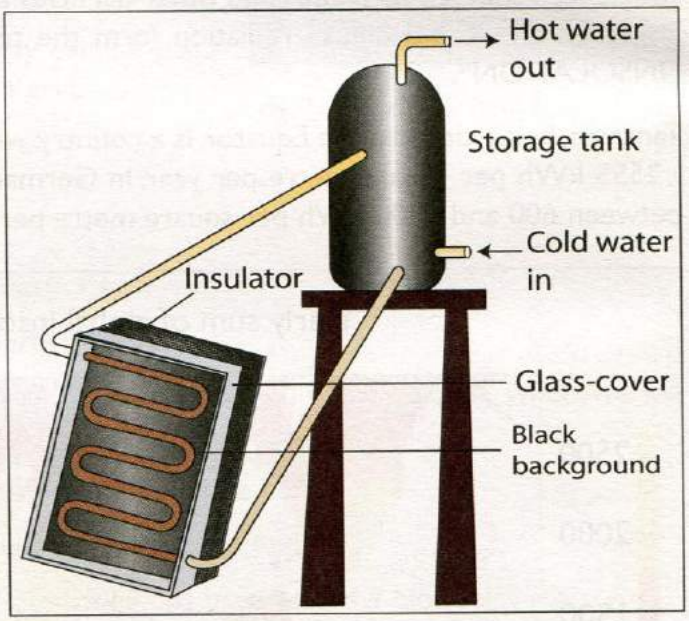


Fig. 19: Solar water heater

Solar Heat through Concentrators

There are different kinds of solar concentrators to use the heat of the sun:

- Small concentrators for cooking and heating
- Huge plants for electricity generation

Solar cookers

The simplest solar concentrators are solar cookers. Light from the sun is converted into heat in boxes or in parabolic concentrators for boiling water, cooking food and water pasteurisation. Cloudy days and hours are not suitable for the use of solar cookers. But every use during sunshine hours helps to save wood or fuel.

Fig. 20: Solar cooker

Concentrators for electricity generation

Solar heat through concentrators means concentrating sunrays into very small areas with the help of parabolic mirrors. By concentrating sunrays that way, temperatures up to 1000 centigrade can be reached. Parabolic troughs focus the sun rays onto pipes where water or oil is heated. Water steam with high pressure rises up and powers turbines which drive generators for electricity production.

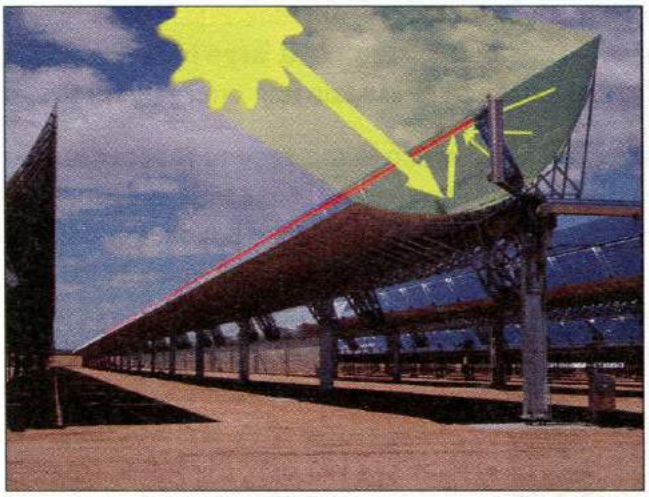


Fig. 21: Parabolic Powerplant, Kramer Junction, California

The first example of a huge solar heating plant can be found in the Mojave Desert in California, where it was set up in 1990 (Company Kramer Junction). Its capacity is 354 MW.

Another way is to use mirrors to focus sun rays onto one small surface that is connected to liquid or air, which becomes heated and transformed into steam. The steam is used to drive turbines and generators.

Solar heating plants for sun-rich countries have been tested in Spain on an area of 512,000 square metres since 2008 (Andasol I, II and III). The biggest plant on earth will be built in Blythe/ California with a power output of 1000 MW.

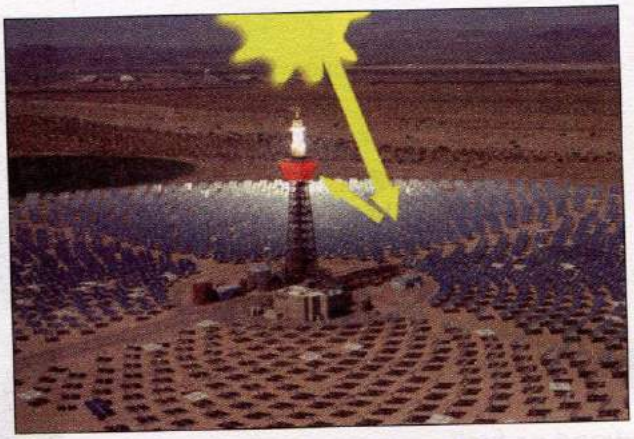


Fig. 22: Barstow/Mojave Desert/California

Photovoltaic (PV)

The word "photovoltaic" is composed of a Greek words, *photo* (light) and the surname of the physician Alexander Volta who discovered the electrical voltage.

The transformation of sun rays into electricity through the photovoltaic effect was discovered by a French physician Jacques Becquerel in 1839. In 1954, the first solar cells where developed in America. Solar cells are used for powering satellites in space. Since that time, the utilisation of the PHOTOVOLTAIC EFFECT has been developed continually through research and application.

Today, the production of PV panels and solar systems is a large industry which supplies the global demand of solar systems for sustainable energy uses.

The basic material for solar cells is silicone, which is the second most common element on earth. Silicone has to be highly purified before it can be used for solar cells. This procedure makes PV expensive. The more silicone is used to produce panels the more expensive they are. But also: the more silicone, the more electric wattage.

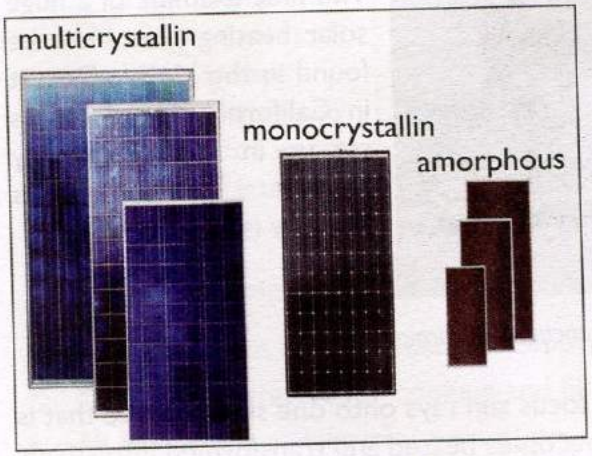


Fig. 23: Multicrystallin, monocrystallin, amorphous

There are three main types of solar cells: multicrystallin, monocrystallin and amorphous.

The colours are dark blue to black. Solar cells are combined to form solar panels. Amorphous solar panels are also called "thin-film panels". Less of the highly cleaned silicone is needed for the production of thin-film panels, so the prices are lower-but the electricity output per square metre is low compared with multi and monocrystallin panels.

Uses of Photovoltaic

Electricity from solar plants can be used in three different ways:

1. Small solar LED lamps and other uses
2. Solar Home Systems or STAND ALONE systems which supply single households or machines far from the grid
3. Solar systems which are GRID CONNECTED and feed electricity into the grid

Small Solar LED Lamps and other Uses

Besides small solar electricity applications like calculators, watches etc, small LED solar lamps are a very useful substitute for kerosene lamps and candles. There are lots of lamps on the market.

In addition, there are more and more solar-powered appliances in constant use in public places like street lights and parking metres, signals and others.

Fig. 24: LED solar study light

Stand Alone Solar Systems

A system is called a STAND ALONE solar system if it is not connected to the grid. It stores electricity which is harvested during the day in a battery for use at night.

The table below shows components needed in a Solar Home System and their life span.

Components	Lifespan in years depending on maintenance
Solar panel Also called generator	10 – 25
Battery Stores electricity	2 – 10
Charge controller Avoids overloading and deep discharge of the battery	5 – 10
Inverter Converts DC to AC	3 – 5

Table 2: Components of Solar Home System (SHS)

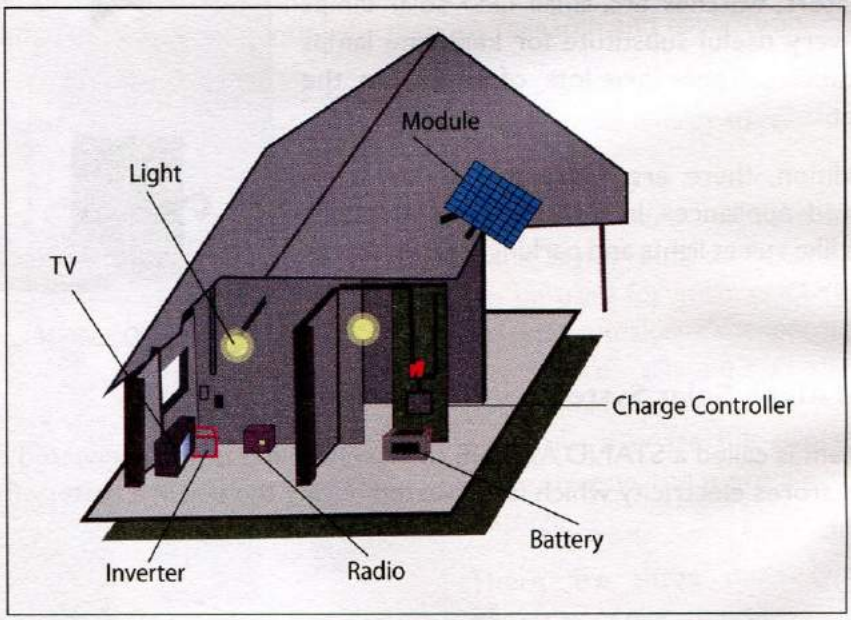
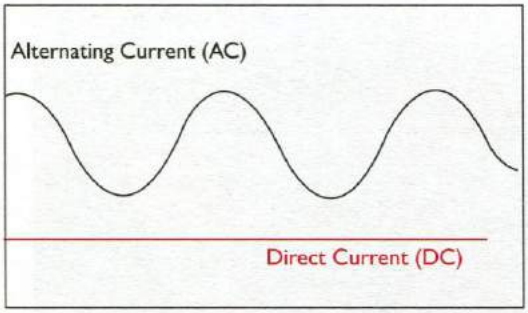


Fig. 25: A solar powered stand alone system of one house

STAND ALONE solar systems are the simplest and quickest solutions for bringing electricity to households at locations far from the grid.



Solar panels produce direct current electricity (DC) only. To change DC to alternating current (AC) for other appliances, an inverter is needed.

Fig. 26: Alternating Current (AC) – Direct Current (DC)

DC	AC	AC high consumers
LED lamps	Shaver	Colour TV
Fluorescent bulbs	Hair cutter	Fridge
Mobile phone	Loudspeaker	Engine
Black/white TV	Fan	Air condition

Table 3: DC and AC appliances for stand-alone-systems

Every appliance which is connected to the Solar Home System (SHS) is named "consumer" because it consumes electricity. The higher the consumption of electricity, the higher the price of the SHS.

Grid Connected Solar Systems

Countries with grid connections to every house, use solar systems to feed the harvested electricity into the grid. These solar plants don't need batteries because the grid is the store.

Electricity suppliers buy solar electricity from producers and pay the FEED IN TARIFF (FIT) per kWh. They can then distribute it to their customers, along with electricity from other sources.

Grid connected solar systems are sized from 1 kW/ Peak on roofs to many Megawatt/ Peak in big solar parks. Grid connected solar plants are refinanced by FIT.

Fig. 27: Lieberose, 53 MW power plant

If solar power generated on roofs or in big solar parks is fed into an existing grid, the system is called a grid connected system. The electricity fed into the grid is measured, paid for and then distributed to customers.

Solar technology is ranked number one in forecasting opportunities for renewable energy uses. Because of the huge solar insolation in countries with high populations in the sun belt of the Earth, solar energy will become their comparative advantage over northern countries.

Countries near the Equator with their high insolation achieve a comparative advantage by using the sun energy for electricity.

Review Exercise 5.2

A: Answer the following questions:

1. Which countries have high/ low insolation? Why?
2. How can direct sun energy be used?
3. Who discovered the photovoltaic effect?
4. What is the basic material for producing solar cells?
5. Which three types of solar cells do you know?
6. Name the components of a solar system.
7. What type of current do solar systems produce?

   (a) alternating current (AC) (b) direct current (DC)

B: Write True if the statement is correct and False if the statement is incorrect:

1. A solar cooker is a concentrator.
2. Concentrators cannot be used to produce electricity.
3. One example of a solar appliance is a LED lamp.
4. Stand alone solar systems are connected to grid lines.
5. Grid connected solar systems feed electricity into the grid.
6. Inverters change DC to AC.
7. Insolation is the amount of electricity per panel.

5.3 Wind Energy

Wind energy is listed as INDIRECT sun energy. 4000 years ago humans started to use wind to pump water into their fields. Later, they used windmills for grinding wheat. Today wind energy is used in advanced windmills to generate electricity.

Wind energy for electricity is generated by more and more productive, technically highly developed windmills. When the blades of the windmill turn, they drive turbines and these turbines drive power generators. Modern windmills are differentiated as:

- ONSHORE windmills on land
- OFFSHORE windmills on sea

Onshore – Offshore and Small Uses

Several windmills together form a "WIND MILL PARK". The number of windmills in modern wind mill parks depend on the area which is availabe on land or on sea.

One windmill of 2 megawatt produces up to 4 million kilowatt hours of electricity per year. Through research and development, the capacity of windmills is increased more and more. There are already ONSHORE windmills with 7.0 megawatt, producing 22.5 million kilowatt hours of electricity per year.

The higher the poles on which the blades sit, the better they reach calmer air layers. Above 100 metres, the airflow is more constant. This can help reduce interruptions of the flow and thereby reduce the strain on rotors and gear box. Repair and maintenance costs are reduced as well.

OFFSHORE windmills are installed in the sea close to the coast. They need to cope with more turbulent and stronger winds than onshore windmills. Proving and testing OFFSHORE windmills is more complex than ONSHORE windmills.

Electricity produced by big windmills is always fed straight into the grid. Producers sell electricity. They are paid by FEED IN TARIFF (FIT).

Fig.28: On land - "Onshore"

Fig. 29: Off land - "Offshore"

Before windmills are installed, long-term measurements are taken to assess the power of the wind throughout the year.

For some years renewed focus has been placed on small windmills as well. They are very good for mini grids in remote regions far from the national grid and for small FEED IN producers using them on roofs.

Wind energy from windmills takes the second place in worldwide electricity production from renewable energies after hydro energy.

Fig. 30: Small windmills on the roof

5.4 Hydro Energy

In 2010, hydro energy again took the first place in electricity production among renewable energies. 18% of the global energy supply comes from water power. Hydro energy is electricity generated by water power originated by

- falling, channelled water which powers turbines
- tidal power in the sea.

Electricity Production in Dams and Rivers

During the past decades and centuries, huge dams have been built to dam up the water of big rivers. The dammed-up water is channelled down through turbines which power generators for electricity production. The biggest hydro power plants are close to the border between Brazil and Paraguay (Itapu, 14 Gigawatt) and in China (Three Gorges Dam, 18.2 Gigawatt).

Fig. 31: Three Gorges Dam, China

Today there is no more support for huge hydro power plants because of the negative aspects. The unnatural flooding of land turns farmers into refugees, and farmers who live behind the dam and are used to water their fields with watering from the river lose the foundation of their existence.

In Tanzania, there are river turbines for hydro power for example at Ruvuma River, Rufiji River and Pangani Falls. 80% of Tanzania's electricity supply comes from hydro power. During hot seasons rivers carry less water and produce only 50% of their capacity. This situation causes interruptions in the electricity supply.

Fig. 32: Phillippines, Pico-Hydro Power, Propeller Type Turbine

There is a renaissance of small hydro power plants for 200 Watt and more in various turbine technologies in areas far from the grid around the world.

Tidal Power and Wave Energy Plants

Depending on the position of the moon, the water in the oceans flows to particular points on earth. High water levels (high tide) and low water levels (low tide) change by lunation.

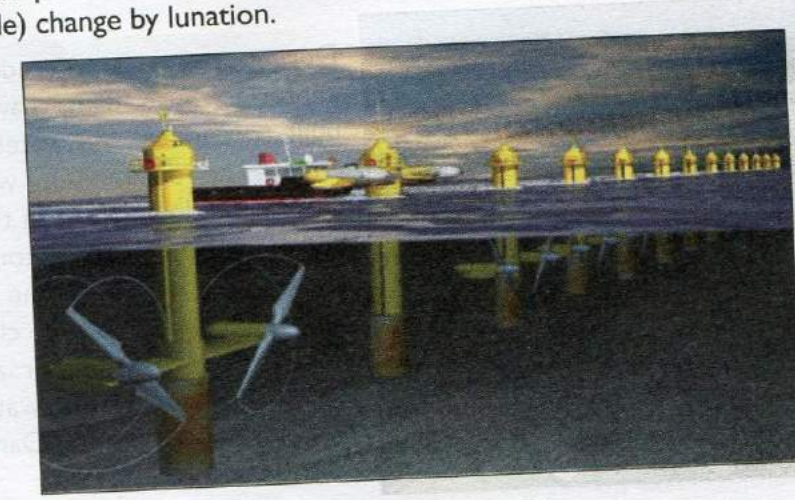


Fig. 33: Tidal power plant

These movements of the ocean depending on the moon are increased through movements of the water from wind and storms.

The flowing dynamics of the oceans are more or less intense but always available, which is why they are also used to produce electricity by turbines and generators.

Fig. 34: Wave energy plant

Independent of tides, permanent movement of waves can be used to run power plants close to the coast. Since 2004, different models have been tested in Great Britain, Portugal, Spain, Norway and Ireland. All plants are working with turbines and generators. The capacity of wave energy is rated highly for the future.

5.5 Geothermal Energy

The word *geothermal* stems from the Greek words *geo* (earth) and *thermal* (heat). So, geothermal energy is the energy generated by the flow of heat from the core of the earth to the earth's surface. It is the energy associated with areas of frequent earthquakes and high volcanic activity. Temperatures hotter than the sun's surface are continuously produced inside the earth by the slow decay of radioactive particles.

Generally, the geothermal energy comes from deep underground; usually with no visible clues showing above the ground. It can be used for:

- Heating and cooling in buildings or
- Conversion of geothermal energy into electricity.

Heating and Cooling in Buildings

With bore holes up to 100 metres deep, permanent temperatures of 15 degrees Celsius can be reached in summer and winter. A pump transfers a liquid down which warms up or cools down to 15 degree. So, in summer the warm inside

temperatures can be cooled down and in winter only 5 degrees more are needed to raise the room temperature to 20 degrees. By circulating the liquid in pipes into the deep and back into buildings, it can be used for low temperature heating or for cooling down the buildings during hot seasons.

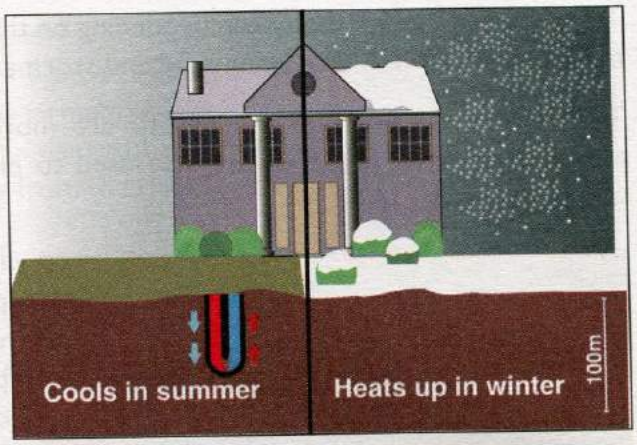


Fig. 35: Geothermal energy in buildings

Conversion of Geothermal Energy into Electricity

Geothermal energy can also be used to generate electricity. Geothermal power plants use hydrothermal resources which have two common ingredients: water (hydro) and heat (thermal). It needs bore holes from 3000 to 6000 metre depth. The electricity plants require high temperatures above 182 degrees Celsius. Water is converted into steam that is then directed to turbines that drive generators to produce electricity.

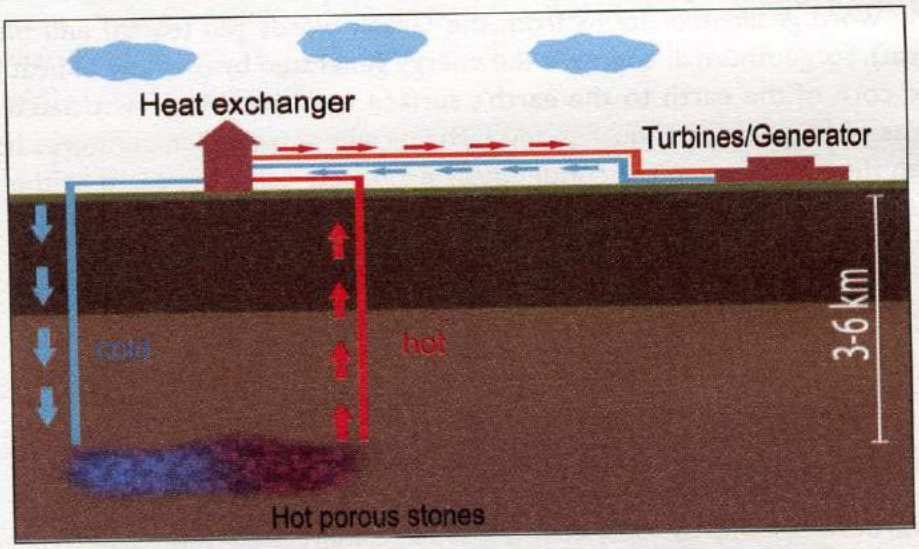


Fig. 36: Industrial geothermal power plant

Areas like Kilimanjaro and Olduvai in Tanzania and Rift Valley in Kenya are geologically well-structured to produce efficient geothermal systems.

The first geothermal electricity plant was built in Italy in 1904.

Since this form of energy is obtained in the earth's interior, it is necessary to drill through rocks. There has been some controversy surrounding geothermal technology because the bore holes can damage earth layers and trigger an inrush of water.

Review Exercises 5.3, 5.4 & 5.5

Answer the following questions:

1. What do the terms "onshore" and "offshore" wind power mean?
2. Wind power drives turbines, which then drive _____ .
3. A wind mill park is _____ .
4. A two megawatt wind mill can produce _____ kWh/year.
5. Offshore windmills must be stronger than onshore windmills because _____ .
6. Construction of huge hydroelectric dams is discouraged because _____ .
7. The biggest hydropower dam is _____ which is in _____ .
8. Tidal energy plants depend on _____ .
9. The word 'geothermal' means _____ .
10. Problems of hydropower plants in rivers can be _____ .
11. Geothermal energy can be used for heating and cooling buildings and for _____ .

6

HYBRID SYSTEMS OF RENEWABLE ENERGIES AND SMART GRID

Because the sun shines only during the day and wind is unpredictable and varies in strength, a variety of renewable energy sources is needed to ensure constant electricity production without the need for large storage capacities.

For example, it is possible to use a combination of wind, biomass, PV and bio fuel for powering generators. Depending on the local resources, a RENEWABLE ENERGY MIX has to be created to achieve reliable electricity supply throughout the day, including peak times.

In 2010, there were already more than 100 communities in Germany who achieved their own independent energy supplies by combining different renewable energy sources.

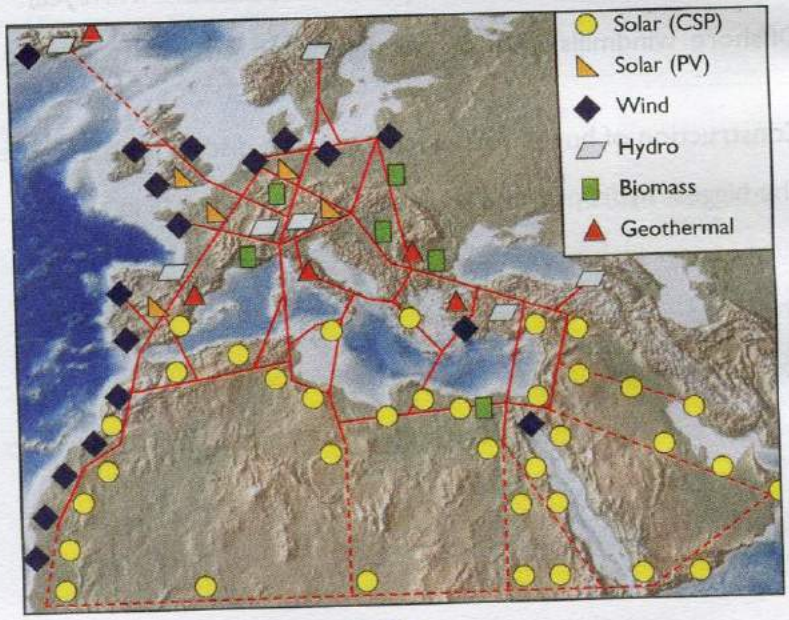


Fig. 37: Desertec

Since 2008, the biggest initiative in this respect is the "DESERTEC" project.

Companies and politicians from 15 European, African and Middle Eastern countries around the Mediterranean Sea are planning to combine Solar, Wind, Hydro, Biomass and Geothermal Energies to supply parts of Europe and Northern Africa with electricity 400 billion Euros are needed to realise this project.

To achieve 100% supply by renewable energies, a new form of energy load management and new intelligent grids are needed.

The name for a grid that delivers the right amount of electricity to cover consumer demands is SMART GRID.

Review Exercise 6

Answer the following questions:

1. What are the advantages of mixing different kinds of renewable energies.
2. (a) What is your understanding of DESERTEC?
   (b) How many countries are involved?
3. What is the name for the "intelligent" grid?

7

THE IMPORTANCE OF ENERGY EFFICIENCY

Economic development leads to increased energy demand. More technology, more mobility and higher energy demand from coal, oil and natural gas cause more CO_2 emissions. During the 1990's, this "natural" process stopped in some industrialised countries. Old inefficient engines were substituted with efficient modern engines.

Economic development is not necessarily followed by increasing energy consumption anymore.

Energy efficiency to "FACTOR 5"

Visionaries pointed out that it would be possible to have technologies which are five times more efficient compared with technologies of 1990 but offer the same performance. "FACTOR 5" could help to reduce the current use of coal, oil and natural gas by reducing electricity consumption.

Efficiency has two advantages: firstly, the risk of a climate crisis will be reduced; secondly, switching from fossil and nuclear energy to 100% renewable energies will be made easier.

EFFICIENCY is the bridge to reach the 100% renewable energy goal in the 21st century.

One example: Japan created the "TOP Runner Model". Every year, technological devices are measured to see how much electricity they use. The most efficient technologies become "TOP Runners". Other technologies with the same performance have to catch up in the following 5 years to reach the efficiency of the TOP Runner. This is a big motivation for research and development and offers new ways of successfully competing in the global market with new technologies.

The capital investment for buying new efficient technologies can be refinanced by saving energy costs. So, climate protection can pay for itself by using the most efficient technologies.

A modern fridge which consumes half the electricity of the old one is like a money box which is paid into every day. Protecting the climate can pay for itself.

The use of efficient technologies by "Factor 5" allows for five times the usage of technologies without increasing the danger of rising global temperatures and climate crisis through additional carbon dioxide emissions.

Review Exercise 7

Answer the following questions:

1. Economic development does not necessarily cause more energy consumption. Why?
2. What does "energy efficiency" mean to you?
3. What are "TOP Runners"?
4. Why can efficient technologies protect the climate and pay for themselves?

8

POLITICAL CLIMATE PROTECTION EFFORTS

Every day the world climate becomes more and more endangered. If technologically less developed countries use the same energy intensive way of development as the industrial countries in the past, humanity will fast find itself in a self-made climate crisis. That is why politicians are needed to reverse the current fossil/nuclear energy consumption, to promote efficiency and the use of natural ecological cycles of renewable energies.

Intergovernmental Panel on Climate Change (IPCC)

The **Intergovernmental Panel on Climate Change (IPCC)** in Potsdam, Germany, collects all data worldwide of changing weather and climate. The results of the changes are published annually. It warns about the dangers of constantly rising global temperatures produced by rising carbon dioxide gas in the atmosphere.

The effects of severe climate changes and global warming bring together politicians from all over the world. They all know that they have to achieve a reduction of greenhouse gases - mainly carbon dioxide emissions - and to avoid warming up the earth's climate by more than 2 degrees compared to pre-industrial times.

Kyoto Protocol

In 1997, the United Nations started the framework convention on climate change, the "KYOTO Protocol" in Kyoto/ Japan. 158 countries agreed to reduce the increase of greenhouse gases worldwide.

In annual meetings, governmental and non governmental representatives try to define fair conditions for the global community of rich and poor countries to reach agreements for climate protection.

One of the tools of the Kyoto Protocol is based on emission trading also known

as "cap and trade". Governments discuss and dictate limitations of greenhouse gas emissions by law for the producing sector in their countries. According to the limits, companies receive greenhouse emission certificates. If they go over their emission limits, they have two options. Either they can:

- reduce emission by investing in emission saving efficient technologies in their company, or
- buy certificates from other companies which have not yet reached their cap.

There is national and international emission trading. Firstly between European countries and secondly as "CLEAN DEVELOPMENT MECHANISM" (CDM) between industrialised countries and developing countries. Emission trading is a flexible tool to give incentives for countries and companies to act in projects to reduce greenhouse gas emission.

The target of "cap and trade" is a planned national reduction of greenhouse gas emission.

The concept of Emission Trading was created by John Harkness Dales in 1968. In 2005, it was introduced in the European Union. The second trading phase is planned for 2013.

Agreements such as the prohibition of large-area deforestation like the project **"Reducing Emissions from Deforestation and Degradation" (REDD)** or new tree plantations for absorbing CO_2 from the atmosphere are also part of the Kyoto Protocol. Reduction of greenhouse gases by saving CO_2 in trees has to be done additional to emission saving by energy sector.

Renewable Energy Act (REA)

The most successful tool for developing Renewable Energy Industries and uses worldwide is the Renewable Energy Act (REA) which was started by the German government in April 2000. The father of this law is Hermann Scheer. He died on 14th October 2010.

REA encourages individuals to produce electricity by using renewable energies. They receive credits to build their own solar, wind, water or biomass plants. The harvested electricity has to be fed into the grid. Energy suppliers are under obligation to buy this electricity paying fixed FEED IN TARIFFS (FIT) per kWh.

The FIT is calculated according to the technology used so that the decentralised producers of electricity are able to repay their credits over a period of around 10 years.

REA inspired fast-growing initiatives by people who aim at replacing dangerous nuclear power with renewable energies. In less than 10 years, a highly efficient technological and economical renewable energy sector was created in Germany with high employment potential and export opportunities. Growing markets and falling prices for renewable energy technologies benefit consumers worldwide.

The idea behind the REA is in the process of being transferred to more than 50 countries worldwide with different conditions. Tanzania is one of these countries.

The Renewable Energy Act (REA) promotes private initiatives for electricity production through renewable energies. It motivates researchers and economists, produces new market opportunities and jobs for a huge number of decentralised stakeholders.

Review Exercise 8

Answer the following questions:

1. How does the Intergovernmental Panel on Climate Protection (IPCC) work?
2. What is the aim of the international trade with greenhouse gas emissions written into the Kyoto Protocol?
3. What is the meaning of the terms "cap and trade"?
4. Who is the "father" of the Renewable Energy Act?
5. How does the Renewable Energy Act work?
6. Write the long form of the following:
   (a) REA (b) FIT (c) REDD (d) CDM (e) IPCC

9

ENCOURAGEMENT

Economy and ecology are united in their goal of achieving a renewable energy future that is 100% sustainable. Changing from the fossil/ nuclear energy age to a renewable energy age can avert the risks of climate change and nuclear power. It is a way to achieve modern living standards whilst escaping rising prices for oil and gas.

The more modern technologies for renewable energy uses are implemented, the faster the price of these technologies will decrease. Large scale equals small price!

Grid parity is already reached by water and wind energy (onshore) and solarthermic plants. That means the price for electricity production through renewable energies is equal to the price of fossil/ nuclear electricity production. Photovoltaic will also reach grid parity within the next years because of fast growing global markets.

Big efforts are under way to develop and produce **Electric Cars** so that people can be mobile whilst producing only little emissions. **E-Mobility** with renewable energies will liberate consumers from rising fuel prices in the future.

Only if industrialised countries aim to achieve an energy supply that is 100% renewable and exploit all technological possibilities for more energy efficiency, can they be reliable examples for countries which are on their way to using modern technologies.

The following two figures show two graphs. Firstly, the energy sources of the World Energy Consumption in 2007 from BP and secondly, the scenario 2050 from the Greenpeace Study "energy (r) evolution" of 2010.

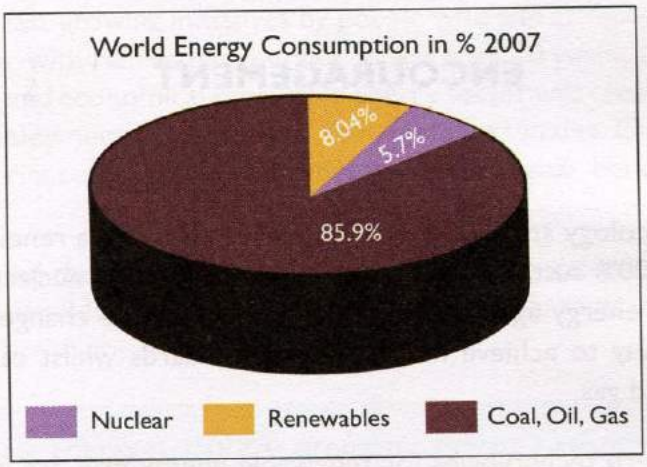


Fig. 38: World energy consumption in % 2007

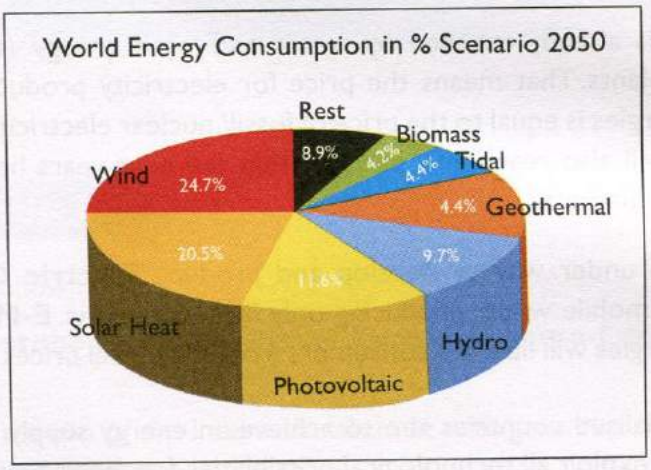


Fig. 39: Greenpeace Scenario, World energy consumption 2050

We all have to work together to protect our world because there is no other. The dangers of climate change can be prevented by using unlimited, free and peaceful renewable energies from the sun and by replanting trees.

Modern technologies for climate protection through increased energy efficiency and utilisation of solar energy anywhere and by anyone create enormous new opportunities for economy and ecology at the same time. Young people today have to be empowered to embrace these opportunities with hearts and minds.

The goal should be a sustainable global energy supply from renewable energies to allow future generations to survive in an ecologically balanced world. Energy from the sun is the friend of human beings, animals and plants.

Fig. 40: Friendly energy - the sun is your friend "Nishati Rafiki"

Moving from the fossil/ nuclear age into the solar age is a wonderful challenge and opportunity for the young generation of the 21st century.

Review Exercise 9

Answer the following questions:

1. What can we do to slow down carbon dioxide emissions and global warming?
2. (a) What does E-mobility mean?
   (b) How important is it in reducing energy crisis?
3. Why is energy from the sun a friend of human beings?

VOCABULARY

absorb	take or suck in something gradually
accumulation	collect a large number of things over a long time
alternative	something that can be chosen instead of another
amorphous	without a fixed form or shape
atmosphere	a mixture of gases surrounding the earth
biofuels	fuel from living things
blade	a thin flat part of a windmill
calculators	an electronic device used for doing calculations
cancer	a serious medical condition caused by uncontrolled growth of cells in the body
carbohydrate	food that green plants make through photosynthesis
carbon dioxide	a gas formed by combination of carbon and oxygen
century	a hundred years
charge controller	an electrical device that controls the amount of charges that reach an appliance
chewing	crushing food into smaller, softer pieces by teeth before swallowing
coal	hard black fossil substance dug from the earth which is burnt to produce energy
concentrator	a device that direct sunlight into a single point so as to produce a large amount of heat
diffusion	spreading of sunlight in different directions by clouds, vapour and dust material in the atmosphere
digester	a chamber in a biogas plant where organic material are broken down by bacteria

digestive system	organs of the body which break down food to enable the body to use it
ecological	the balanced relationship between air, land, water, animals, human beings, plants, etc in a particular area
efficiency	ability to operate quickly and effectively
equator	an imaginary line around the middle of the earth dividing it into two halves
exhale	breath out gas from the lungs
fossil	very old plant or animal remains preserved in rocks or earth
generator	a machine which produces electricity
global	of the whole world
greenhouse effect	increase in the amount of gases which cause extreme warming of the atmosphere
grid	a system of wires through which electricity passes to reach different regions
hectare	unit of measurement of an area of land
inhale	breathe air into the lungs
inverter	an electrical device that converts direct current electricity into alternating current
kilowatt	unit of power equal to 1000 watts
contaminate	spoil purity of something; make it inpure or harmful
Light Emitting Diode (LED)	an electronic device that produces light on electronic equipment
low tide	a moment when the sea level falls to the lowest point
megawatt	a unit of electricity equal to 1 000 000 watts
orbit	a curved path through which a planet move around the sun

oxygen	a gas that we breath
panel	a flat piece of cristalline, silicone changes sunlight into electricity
parabolic	that has a curved shape
photosynthesis	a process by which green plants use sunlight to produce their own food
planet	large round bodies that revolve around the sun
pole	either of the two points at the most northern or most southern ends of the earth
ray	a narrow beam of light from the sun
reflect	sending back light by a surface such as a mirror
renewable	that can be made new again; never ending
rift valley	a huge sunken space in the ground that has steep sides
rotate	turn in a circle around a fixed point
silicon	a chemical substance formed naturally in the ground
sleet	falling snow that is partly melted
snow	small soft white bits of ice that fall from the sky
solarthermic	heating water, oil by using black colour and sunlight
stand alone	that is not connected to something else
storm	an extreme weather condition with very strong wind, heavy rain, thunder and lightning
sustainable	that is able to continue in its present state
ton	a unit of weight that is equal to 1000 kilograms
turbine	a type of machine upon which liquid or gas flows and turns a wheel with blades so as to produce power
uranium	a radioactive material used for producing nuclear power

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Renewable Energies

Life on our planet is in danger of dissapearing if governments and individuals will not do all they can to change the way we live, especially with regard to energy consumption.

Renewable Energies covers a number of important issues that will save our planet from the threat of destruction posed by great climate change we are currently witnessing. These issues include the following:

- The natural ecological balance that existed on earth between living beings, air, water, trees and plants before industrialization.
- How industrial revolution opened a wide door for the use of fossil and nuclear energies.
- Rising of global temperatures due to the increase of greenhouse gases in the atmosphere, especially carbon dioxide.
- Effects of global temperature increase, for example floods, drought, rising sea level and submergence of islands.
- The available solution for avoiding the dangers we are facing by using safe and renewable energies, particularly sun energies; as well as restoring the ecological balance, for example through reforestaion.

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